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THE ANNUAL MEETING

THE 36th Annual Meeting held in New York, December 7-10, had the largest registration of any in the history of the Society. Of the thirty papers and reports presented, fourteen were contributed by committees and seven by Local Sections, indicating the wide participation of the membership. At the opening session, Dr. John A. Brashear's audience filled the large auditorium of the Engineering Societies Building, and this interest was sustained throughout. Enthusiastic conferences were held by representatives from the fourteen Local Sections and plans were laid for greater development of the Society. Abstracts of a portion of the papers and an account of the meeting appear in this issue.

SCIENCE IN ITS RELATION TO ENGINEERING

Presidential Address

BY DR. JOHN A. BRASHEAR, PITTSBURGH, PA.

The early history of engineering in at least three of its phases,—namely, civil, mining and mechanical,—has much of interest to the technical student of to-day, and we of the twentieth century would be false to our convictions did we not give our mead of praise to the pioneers who have left in evidence some of the monuments of their labors which stand almost unimpaired after the ravages of many centuries.

Some of the members of our Society had the pleasure of visiting the Panama-Pacific Exposition and participating in the celebration of the completion of the Panama Canal. It was a great event, but we should not forget that many centuries ago the possibility of building a canal to connect the Mediterranean and the Red Sea was seriously discussed by the engineers of that day. The project was considered impractical because it was suggested that there was a difference of level of over thirty-two feet between the two bodies of water, although the great mathematician La Place insisted that this could not be possible, since by the law of gravity there could be no difference in the mean level of large bodies of water on the earth.

Greek historians tell us that it was the fear of flooding Egypt with the waters of the Red Sea which prevented Darius from undertaking the canal project, yet this canal was successfully constructed centuries after the time of Darius.

The pyramid builders were certainly engineers of no mean type. The handling of those massive stones, many of them weighing as much as thirty tons, their transportation and the placing of them in position, were problems that would concern the engineers of to-day. As a matter of minor interest, it seems almost certain that hollow diamond drills were used at this early period.

I had the pleasure of a personal acquaintance with the astronomer Piazzi Smyth, who made a critical study of one of the great pyramids of Egypt; and while I cannot agree with his dictum that the base of the pyramid is the divine standard of measurement, I could not help being deeply impressed with his views of the engineering problems that were mastered in the erection of these wonderful structures.

I cannot refrain from mentioning a piece of engineering work of later date, namely the building of that splendid highway, the Via Appia. While the time element in its construction would be inexcusable in modern road building, and although it was probably never subjected to a tithe of the use and abuse of modern highways, the fact that it was in perfect repair nearly six hundred years after it was finished speaks volumes for the character of the engineering work done upon it. Three bridges and a small portion of the roadway still remain after the lapse of twenty-two centuries.

Roman engineers built more than forty thousand miles of such roadways through and out from the Roman provinces, and it is recorded that the water supply of the empire at the beginning of the Christian era would suffice for a population of seven million people. The aqueducts of Rome are considered among her grandest engineering works.

It would be impossible and, indeed, out of place to enumerate the achievements of the past in the many lines of civil, mining and mechanical engineering. My purpose in mentioning some of the work of our ancient brethren is to note the facts that what they constructed was largely upon an empirical basis; and that, nevertheless, their factors of safety were amply large. In many of the blunders of later date which, for want of a better name, may be styled scientific empiricism, "safety first" has unfortunately not always been the slogan.

In an admirable address given before the British Association of Science some forty years ago, Sir John Hawkshaw tells us that when knowledge in its higher branches was confined to the few, those who possessed it were called upon to perform various services for the community to which they belonged, and that mathematicians, astronomers, painters, sculptors and priests performed duties which now pertain to the professions of the architect and engineer.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies may be obtained; price 5 cents to members; 10 cents to non-members.

Thus while it is true that the methods which were followed up to, let us say for safety three centuries ago, were largely empirical, perhaps we can see in the work of the painters and sculptors the why of the beautiful types of architecture from which the architects of to-day are unwilling to depart.

I dare not undertake to mention in extenso the various steps in the evolution of scientific research and its correlation with engineering problems. I bow my head in reverence to the great geometers and mathematicians of the past, men whose names are household words to the engineer of to-day, Pythagoras, Euclid, Pascal, Gregory, Ptolemy, Huygens, Descartes, Newton, Hamilton, La Place, Napier. Great have been their contributions to human knowledge, giving us the key that has enabled other master minds to solve some of the mysteries of God's illimitable universe.

But the science of mathematics has many handmaidens for probing into the hitherto unsolved problems of this old round world. Astronomy, physics, chemistry, and kindred sciences, have and ever will have their place in the world's great workshop, and ever will hold a place of honor in the great field of engineering.

There is not a single problem in modern engineering that can not be more readily solved by a knowledge of facts developed by scientific study and research, and no man knows this better than the successful engineer of to-day.

Dr. Maclaurin tells us a story of Matthew Arnold, the apostle of Sweetness and Light, in which he is made to say, that when a candle burns the oxygen and nitrogen of the air combine with the carbon in the candle to form carbonic acid gas, *but who cares?* The story is told because it suggests an attitude to science that is far from rare, even amongst people of intelligence to-day. He recalls the poetic query of Keats when he writes of the rainbow: "Do not all charms fly at the mere touch of philosophy? There was an awful rainbow once in heaven, we know her woof and texture. She is given in the dull catalogue of common things."

"The complaint seems to be that science with its analysis robs us of the pleasing sense of awe and mystery, but if you dig deep, you will find enough mystery left to satisfy the keenest yearner after half lights and the obscure. At best, science replaces one mystery only by another of grander order."

Now, leaning for a moment from the purely utilitarian side of science, to the esthetic, there comes a joy to the lover of the beautiful that cannot be expressed in words, for he sees in the color of an American Beauty rose the same light waves that tint yonder red star, whose light waves, coming to him at the rate of 180,000 miles per second, left it a thousand years ago; he listens to the varying bell tone of the swiftly moving locomotive and translates it into the motion of stellar worlds, whose distances have never before been measured by the most refined modern instruments.

Does the photographic picture of your favorite landscape lose any of its beauty when you are told that during an exposure in your camera of only one-tenth of a second, from forty to eighty millions of millions of light waves have hammered upon your negatives tending to shatter them to pieces or change their molecular arrangement?

Maclaurin gives a charming illustration to help us better understand what it means when a ray of violet light impinges on our photographic plate for one-tenth of a second. "Imagine you are watching a log floating near the seashore, and that it strikes against a pier as it rises and falls with the waves, say, once in six seconds. In order to correspond to the number of light waves in one-tenth of a second, the log would have to beat against the pier for more than two million years."

But enough for the present of the esthetic side of science, though it has beauties in its every phase, whether it be in the flower or in the rainbow—whether it be in the structure of glass from which the prism is made, or the story it tells of yonder far-off stellar universe. But can we connect this science beautiful with our engineering problems? Why not?

It is a long way from the sun dial of Ahaz to the Riefler clock; a long way from the Pyramid of Cheops to the stately steel structure of our great cities; a long way from the cubit span and hand-breadth to the standard metre whose value is determined in light waves; a long way from the ox-cart with its wheels cut from the end of a log to the steam and electric locomotive; a long way from the log bridge across the narrow streams to the magnificent steel and concrete spans that now cross our widest rivers; a long way from the tiny Egyptian cedar boat, built without iron, steel or copper, to the majestic steel steamships that daily cross the ocean; a long way from the smoke balloon of Montgolfier to the dirigible, or the biplane that soars like a bird through our skies; yes, and all along the pathway of the evolution of these and other inventions of man are unwritten histories which, if told, would be filled with romance and ofttimes with tragedies,—aye, with the sacrifice of the lives of many of the world's noblest pioneers who have contributed to the treasures of our vast storehouse of knowledge.

We can look over time's vistas and learn that to Aristotle we owe the beginning of exact science and research, fostered by his love of experimentation. Indeed, Hale records that, although his theory of the fixity of the earth was based upon false premises, he left his impress so deeply upon the islands and borderlands of the Mediterranean that, after he had passed from his labors, there was a gradual separation of the investigations in natural science from the speculations of the philosophers, and that true scientific research, in the modern sense, developed with remarkable rapidity.

I have always had the conviction that we give too little thought to the pioneers in any line of research, and I have often bowed my head in reverence to those who, with the most limited means and equipment, by patient, persistent plodding, wrested the secrets of nature from their entanglement.

There has often arisen in my own mind, and no doubt in yours, the question: Where shall we draw the line between pure and applied science? For myself, I have been unable to find aught but a hazy line of demarkation, and in my long life I have known but few men who, in their mathematical researches and calculations, could see nothing in the way of an entity before them; indeed, but one great mathematician has told me it was his regret that he could see no picture of a beautiful comet while he was calculating its orbit, nor could he form a visual image of the planetary world whose perturbations he was computing by his wonderful mathematical formulae.

Nor can I see how pure science and its allies can be relegated to opposite poles. For a time apparently they may point in opposite directions, but at each end there lies some great truth. One may be a hitherto undiscovered law of nature and the other, let us say, something of an utilitarian character, that, material as we may call it, will cause these opposite poles to curve toward each other and add to the sum of human knowledge, human betterment and happiness.

Let me illustrate. When the velocity of the propagation of light waves was determined by scientific reasoning and experimentation of the most refined nature, and successively by

Roemer, Bradley, Fizeau, Foucault, and our own Newcomb and Michelson, the process of solving the problem remained for a long time in the domain of the exact sciences as a masterpiece of the human mind.

But who of us dreamed to what an utilitarian purpose these light waves would be made subservient? The genius of a Michelson carried them into the workshop, thence to the International Bureau of Weights and Measures at Sèvres, and gave us a value for the International metre in terms of light waves that will remain absolutely unalterable as long as this old world moves in the lumeniferous ether of the universe. And so we now know that our standard metre, measured in terms of the red radiations or wave length of cadmium, equals 1,553,163.5; for the green radiation, equals 1,966,249.7; and for the blue radiation, 2,083,372.1, in air at 15 deg. cent. and normal atmospheric pressure.

Michelson tells us that the absolute accuracy of these measures is one part in two millions, the relative accuracy, one part in twenty millions.

Getting nearer the utilitarian service of the scientific study of light waves, let me say that Dr. Anderson of the Johns Hopkins University has utilized them in making screws of hitherto unheard-of accuracy. Let me quote from a letter received from Dr. Anderson before writting this address:

In reply to yours of the 4th, I will say that from measurements made by using a Fabry and Perot Interferometer, the screws we have made for ruling purposes have the following accuracy:

1. The maximum variation in pitch along the screw did not exceed *one-ten millionth of an inch.* (By pitch, I mean the average value of the pitch as given by a well-fitting nut three or four inches long.)
2. The axis of the screw had a radius of curvature longer than *250 miles.*
3. The axis of each pivot or bearing coincided with the axis of the screw to within one two-hundred thousandth of an inch.

These are three important quantities as far as the screw itself is concerned.

When the screw is mounted ready for use, it is also important that it be prevented from moving endwise or longitudinally when it is rotated. Our mounting, using the flat ruby against a spherical steel surface, makes it possible to reduce this motion to something less than one millionth of an inch. Errors of the magnitude given above can be easily detected with the interferometer.

Our fellow member, George M. Bond, has given us a most valuable compendium of the development of measures of precision in his work on "Standards of Length," from which I quote as most interesting, and bearing forcibly upon this part of our topic:

It is worthy of note that a remedy for the evil complained of by master car builders, that nuts made by some firms or at some shops would not screw on bolts made by others, at first baffled the ability of the most prominent manufacturers of tools of precision in the country, and that to provide an adequate remedy it was necessary to secure the assistance of the highest scientific ability in the country, which was supplied through the coöperation of the Professor of Astronomy of the oldest and most noted institution of learning in the land. The man of science turned his attention from the planets and the measurement of distances counted by millions of miles, to listen to the imprecation, perhaps, of the humble car-repairer lying on his back and swearing because a 5/8 nut—"a leetle small"—will not screw on a bolt—"a trifle large." It is a striking example of the assistance which science can give in conducting the "practical" affairs of life.

Here I wish to pay a tribute to our American engineers who have developed instruments for mechanical measurements to such a high state of precision, which in their turn have been such valuable factors in the development of interchangeable machinery. I need not dilate upon these interesting topics, but I cannot refrain from offering a word of praise to these earnest men whose ideals have been of the highest—by their work we know them.

I am sure all will be interested in what may be called a paradoxical statement—but is not—namely, that through the marvelous precision atttained by Rowland, and later by Anderson, in the construction of accurate screws, we have made what must be considered an utilitarian use of pure scientific research. This utilitarian use of science has reacted, as it were, and enabled the scientific mechanician to produce an optical device that rivals, if it does not surpass, the telescope in unraveling some of the most profound secrets of the universe.

I hold in my hand (shows a diffraction grating) a little instrument called a diffraction grating. On the plane surface of this polished plate, made accurate to one-tenth of a light wave, or within one tenth of one forty-five thousandths of an inch, are ruled more than 45,000 lines between which there is no greater error than one two-millionths of an inch. With this delicate piece of apparatus, made possible *first* by rigorous scientific research, *second* by the skill of the artisan, *third* by a knowledge of and vigorous care to avoid temperature changes and *fourth* by the accuracy of the mechanism which includes the accurate screw mentioned above, the astrophysicist has been able to tell us the composition, temperature and distance of the stars. It is also possible for the physicist, the chemist, to tell us the purity of the material he is called to investigate; indeed, it makes itself subservient to many phases of engineering in the domain of metallurgy. And the end is not yet. Where can we then draw a sharp line of demarkation between pure science, and its relation to any and every form of engineering?

Twenty-seven years ago I was the guest of my friend Sir James Dewar, the worthy successor of Tyndall in the Royal Institution of Great Britain. Taking a tiny piece of apparatus out of the "holy of holies," and placing it in my hands, he told me it was the father and mother of all the dynamos and electric lighting systems of that day. *It was the first little dynamo made by Michael Faraday.* What has come to us since that visit, in the domain of the electric development through scientific investigation and mechanical devices!

Thirty-seven years ago I listened to the first faint telephone message over a few miles of wire. On the 24th of January last, through the courtesy of our friend Mr. Carty, chief engineer of the American Bell Telephone Company, and Dr. Bell, I listened to the voices of Watson and Moore across the continent. When this Society was the guest of the officials of the Panama-Pacific Exposition, I was taken to the private office of the telephone company in the Exposition building, where, through the courtesy of our friend Engineer Carty, I not only listened to cheerful words spoken in this city, but heard the sound of breakers as they dashed upon the shore of the Atlantic.

When we made the first little spectroscope to determine the moment when the last ounce of carbon had disappeared from the Bessemer converter, little did I dream that through science, aided by a delicately accurate instrument, devised by my good friend, Dr. George Ellery Hale, and made at "the little workshop on the hill," we would be able to plunge it, as it were, into a storm on the sun and photograph the burning hydrogen or any other element in that maelstrom of fire, the temperature of which this earth knows no correlative.

Here let me add some altruistic words of our good friend Dr. Pritchett:

The last fifty years have seen a greater betterment of the theoretical basis of physical science than ever before in the history of the world. This development has been marked by a notable stimulation of scientific research, a differentiation of scientific effort, and the creation thereby of a great number of special sciences or departments of science. The possession of a secured theoretical basis and the intellectual quickening which has followed it have resulted in the application of science to the arts and to the industries in such measure as the world has never before known. These applications have to do with the comfort, health, pleasure and happiness of the human race, and affect vitally all the conditions of modern life.

As members of this association we may well be proud of our Bureau of Standards, organized and brought to its present high state of efficiency by our fellow member, Dr. Stratton, and his splendid corps of associates. This scientific department of our Government, concerning as it does almost every phase of scientific research, valuable to the engineer of every calling, has made a record even greater than the Institute at Charlottenberg and the famous Bureau International des Poids et Mesures at Sèvres, though they have done splendid work for a half century or more. I am certain that every member of this association would place a very high value upon the scientific studies of our Bureau of Standards did they know how closely they are related to their profession.

Other scientific departments of the Government, such as the United States Coast and Geodetic Survey and the Smithsonian Institution, have in the past and are continually contributing to the sum of knowledge that is of value to the engineering profession in some of its many phases. Nor can we pass over the splendid research work of the Carnegie Institution at Washington without a tribute of praise for its great accomplishments in the past and its present activities in the domain of scientific investigation of the highest value to engineering and its correlated interests.

It would be a serious oversight in this paper did I not call attention to what I may name humanitarian engineering investigation, based upon a phase of scientific research we would probably consider far removed from engineering problems per se. I refer to the magnificent, and now classic applied scientific medical research of my dear departed friend, General Sternberg, and General Gorgas, who made possible the carrying out of one of the greatest engineering projects the world has ever known. All honor to these good men!

But I must stop. The great, the illimitable field of truth opens up before us; aye, I love to liken it to the "Widow's Cruse"; take from it as you will, it will never be emptied of its priceless treasures.

And is there not a splendid field opened up to us in the endowment of engineering research, now made possible by the gift of one of our honored presidents? I have said little of specific lines of investigation in relation to engineering, having given only a few instances to show their close and intimate relationship, and it needs no further words of mine to verify the aphorism that "the field is ripe for the harvest."

In closing may I quote from the recent publication by Dr. Hale, entitled: "National Academies and the Progress of Research:"

But the average man of business is much better able to appreciate the value of research directly applied to the improvement of manufactures than to comprehend the more fundamental importance of pure science. We must show how the investigations of Faraday, pursued for the pure love of truth and apparently of no commercial value, nevertheless, laid the foundations of electrical engineering. If we can disseminate such knowledge, which is capable of the easiest demonstration and the most striking illustration, we can multiply the friends of pure science and secure new and larger endowments for physics, chemistry and other fundamental subjects.

Dr. Hale's valuable brochure can be found in our library and is worthy of our careful study. Here we have a striking note of the value of scientific research, and a touch of its utilitarian value, but after all is said, a knowledge of the true and beautiful, whatever its bearing may be, stands for human progress, human betterment and human happiness.

May I also quote from a letter received from the same gentleman by the donor of our research fund:

I am delighted that you, with a thorough knowledge of the situation, agree with me in thinking that the time has come for much closer coöperation between engineers and men of science. Previously I have not been able to judge the matter from the standpoint of the engineer, but it was plain to me that the separation between pure and applied science, which seems to have been increasing, must be harmful to both. The man of science is liable to underestimate the importance of practical applications of his subject, while the engineer is in danger of forgetting that if research were conducted only in the hope of securing profitable ends, most, if not all, of the great discoveries which lie at the very foundation of both pure and applied science, would never be made.

Thus every effort should be made to encourage and develop research in both pure and applied science, for neither can be neglected without loss to the other. The dual nature of this problem is thus perfectly evident. Sound strategy requires that the attack be made simultaneously from both sides, since in this way all difficulties can be overcome far more quickly than by two successive attempts.

These difficulties are likely to be due mainly to the conservative tendencies of both engineers and men of science. By establishing your research fund you have provided means to obviate the chief practical hindrances on the engineering side, where the way has always been paved by the successful research of the General Electric Company and various other large corporations. It now remains to accomplish an equally important advance on the side of pure science.

Dr. Hale is very anxious that there shall be a closer relationship with the National Academy of Sciences, and I think I can say without hesitation that it will be a wise move upon the part of all engineering societies to appoint a special committee to act in conjunction with the Academy toward this most desirable affiliation.

In my desire to be brief, I have refrained from going into the many, very many fields where pure science may take the hand of fellowship of the engineer, and now that there has come to us a grand opportunity, fostered by the splendid research fund placed in our keeping, may we look forward with hope to the day when science and engineering will join hands for the betterment of our loved profession.

"To-day we are learning but single notes, to-morrow we will blend them into chords, the hour will chime when all humanity shall know the law of harmony—when every note in every chord shall find its part in the sublime oratorio of the universal life."

DESIGN OF FIRE TUBE BOILERS AND STEAM DRUMS

BY F. W. DEAN, BOSTON, MASS.

Member of the Society

As is now generally understood, the most prolific cause of explosions of fire tube boilers has been lap longitudinal joints, and the use of butt joints with inside and outside covering plates has, so far, prevented such explosions. The lap joint makes the boiler non-circular at and in the vicinity of the joint; and when pressure is applied the plate, in its effort to become circular, bends somewhat, and on the reduction or removal of pressure, it tends to return to its original form. The frequent repetition of these actions causes the plate to crack and finally to become too weak to stand the stress caused by the working pressure. Boiler plates with lap joints have often cracked entirely through for a greater or less distance, and the escape of steam has given warning in time to prevent an explosion.

THE DESIGN OF BUTT JOINTS

The joint which has a narrow butt strap on one side of the shell and a wide one on the other is one-sided, and its center of resistance does not coincide with the center of pull of the shell plate. That part of the wide strap which extends beyond the narrow one is riveted to the shell, and this outer part of the joint is a lap joint with its peculiar defects. The rivets in this part of the joint are overhung and in service tend to tip over and bend the joint. This is only another way of stating that the joint is a non-central resisting device, and must cause the plate in and near the joint to bend when the boiler is subjected to pressure. Fig. 1 shows how this bending occurs when such a joint is tested to destruction, this being the result of several actual tests.

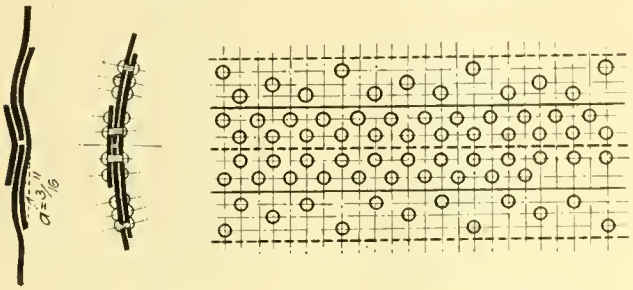

Fig. 1 Bending of Butt Joint Tested to Destruction

In order to prevent a joint from bending, a butt joint with straps of the same width and with all rivets in double shear should be used, as is always done in Europe. The center of resistance of such a joint coincides with the center of pull in the shell. The joint when tested to destruction remains straight, without bending; and by its use the only probable cause of boiler explosions so far as the design of the joint is concerned is eliminated. There are various designs of such joints ranging from the simplest joint with double covering plates of equal widths, to the joints shown in Figs. 2 and 3.

Fig. 2 illustrates a design which is used largely in marine practice in this country and abroad and which has a theoretical efficiency of about 85 per cent. Fig. 3 shows a more efficient joint, having a theoretical efficiency of from 92 to 94 per cent. In the joint in Fig. 3 the outer strap is cut away between the rivets in order that it may stand caulking; the high efficiency is secured by the wide pitch of the outer rows of rivets.

BRACES

Boiler head braces of the crow foot or similar types are usually designed so thin that they bend in service where the foot joins the rod, and are likely to break finally at this point. This detail should be made stiffer than is commonly done.

Through rods above the tubes of horizontal return tubular boilers should be supported so that they cannot vibrate, and the supports should be stiff enough to prevent movement in any direction, instead of merely supporting the weight. If any braces are used below the tubes, through or head-to-head braces, rather than braces riveted to the shell, should be employed. Such braces should not, however, pass through the back head on account of the nuts being in contact with the fire. The rods should be secured to angles riveted to the back head but separated from it 2 to 4 in. by ferrules around the rivets, in order to permit the removal of dirt between the angles and the head.

Although not related to safety, it is best not to have the rods above the tubes pass through the back head, because the nuts interfere with an efficient method of covering the back connection with fire brick. There are various ways in which nuts can be avoided, and Fig. 4 shows methods of staying both above and below the tubes. In the former case diagonal braces are used for staying the upper parts of the tube plates in order to give more room for inspection, and the heads are stiffened by riveting on thick plates. In England plate gusset stays are preferred to through rods or diagonal stays, but in this country they are seldom used. There is, however, no reason to doubt their efficiency, although any head stay attached to the shell tends to bend the latter and throw it out of equilibrium. Nevertheless I have never heard of a rupture coming from this cause.

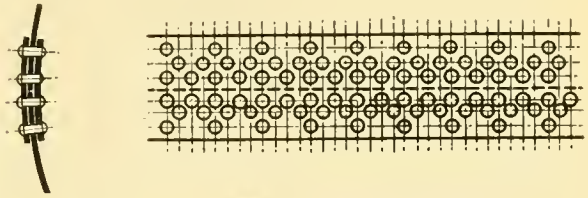

Fig. 2 Butt Joint used in Marine Practice. Efficiency about 85 Per Cent

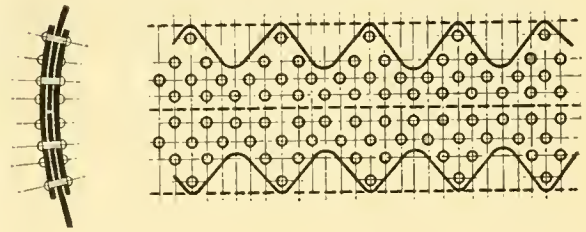

Fig. 3 Butt Joint with Efficiency of 92 to 94 Per Cent

RIVET HOLES AND RIVETING

Riveting is now generally done by hydraulic machines, which have shown themselves superior to any other kind. In consequence of the slow movement of a hydraulic plunger the rivets have time to enlarge and fill the holes; and from the solidity of action and steady holding power of the machine the plates are firmly pressed together, with the result that joints riveted by this type of machine are tighter than those made by any other.

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 1915. Pamphlet copies without discussion may be obtained; price 5 cents to members, 10 cents to non-members.

It is the common practice in this country to punch the holes of boilers 1/8 in. or 1/4 in. small and then to drill them to size with all plates and covering plates in place. This is a great advance in practice over punching to size, but it is not satisfying to the imagination and it may be one reason why plates exposed to the hottest gases crack between the rivets and their edges. Another reason for such cracking may be bulging caused by too much pressure by the riveting machine on the rivet. Sometimes such bulging is very apparent. A still further advance in practice is to punch one butt strap for each joint with small holes and use it as a template for drilling not only itself but the main plate and the other butt strap. Similarly, the holes in one plate of a circular seam may be punched small and used for a template for drilling the other holes. The best way, however, and the one which I hope to see adopted everywhere, is to drill all holes from the solid.

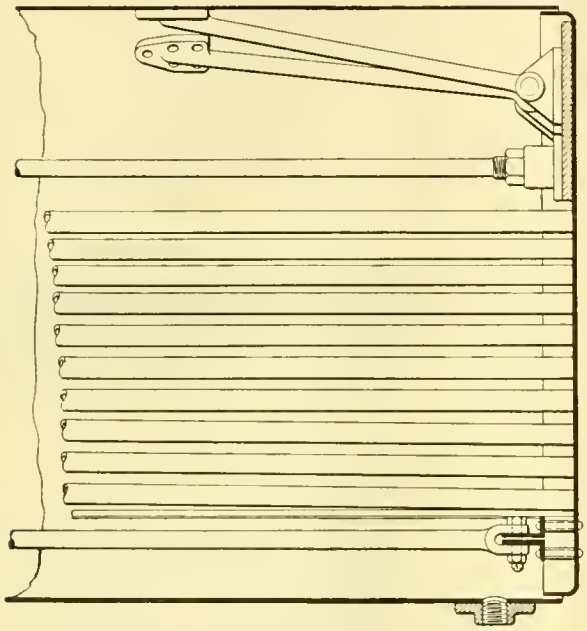

FIG. 4 DIAGONAL AND LONGITUDINAL STAYS WITHOUT OUTSIDE NUTS

I think it will be found that with proper tools this is the cheapest method.

The conical rivet head is being displaced by one of more or less spherical form which has the advantage over the former in having a thicker edge and increased holding power.

REINFORCING PLATES FOR THE OUTSIDE FIREBOXES OF VERTICAL BOILERS

Above the staybolt level of vertical boilers the outside fireboxes are subjected to the full stress that comes from the steam pressure, unreduced by any connection to the inside firebox by the staybolts. In some designs the whole outside firebox is made of the thickness required to stand the pressure as if unstayed; in other designs there is a short course of increased thickness just above the staybolts, and in still another design the outside firebox plate is thin for its whole height and is reinforced above the staybolts by riveting a band of steel around the inside of the plate.

I disapprove of the last of these methods and mention the fact here because the object of this paper is to point out the causes of boiler explosions and to advocate methods of construction that will reduce, if not do away with them. I have already stated that shell explosions are nearly always caused by the bending of the plates, and the inside reinforcing plates of vertical boilers, just described, can do no good without bending. They cannot then prevent the main plates from being overstrained, and they are therefore possible causes of explosions.

REVERSED FLANGES IN VERTICAL BOILERS

Still further in accordance with the object of this paper, I shall describe the action of that type of vertical boiler which is changed in diameter above the firebox by means of a reversed flange, Fig. 5. On account of the ease with which this flange bends, this type of boiler elongates when subjected to pressure, and, under test pressure, to a considerable extent. Even the pulsations in pressure coming from the opening and closing of the inlet valves of steam engines cause the boiler to change its length each time, and this action and others have caused many of the reversed flanges to crack. The effect has

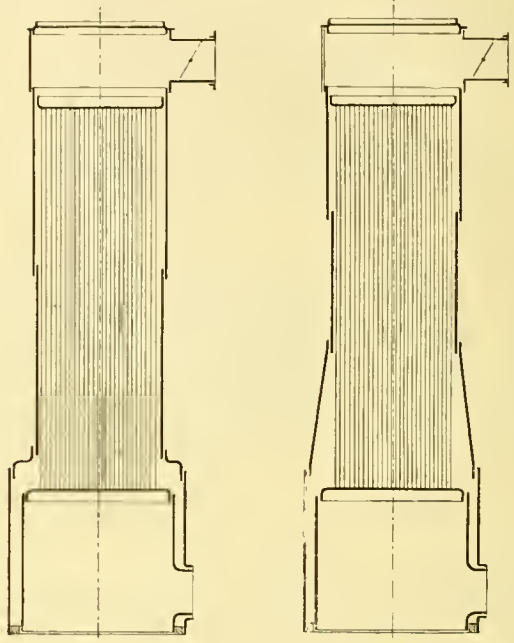

FIG. 5 FIG. 6

FIG. 5 VERTICAL BOILER WITH REVERSED FLANGE
FIG. 6 VERTICAL BOILER WITH CONICAL COURSE

been reduced by making this flange of a less flexible form and increasing its thickness. It is not a good plan, however, to have flexible means of connecting the ends of boilers, and when the flange is made so thick that it is not flexible its object is no longer accomplished.

Another harmful effect of the elongation of boilers of this type is the bending of the lower tube plate upward and the upper one downward. This tends to pull the outer tubes from the tube plates and may cause explosions.

In order to obviate the two defects described, the reduction in diameter should be made, as it has been many times, by a conical course, Fig. 6, instead of by a reversed flange. An incidental advantage of this is that the circulation of the water is a little freer.

DISHED HEADS FOR STEAM DRUMS

Several explosions have been caused by dished heads cracking around the edges where they join the spherical portions. Apparently it has been thought by designers in general that if a head is pressed into spherical form and flanged, the radius being made equal to the diameter of the drum and the thickness equal to that of the drum, nothing more is necessary. There is no doubt, however, that such heads breathe and that

the cracking is due to this. It is the same phenomenon that causes the rupture of lap joints and breaks staybolts. I believe that such heads should be made of thinner plates than usual and braced like flat heads. The braces should be strong enough to carry the total pressure on the heads, and thin plates would stand the flanging process better than thick ones and with less liability of being injured at the corners.

In regard to the method of bracing such heads I am inclined to think that radial plate gussets would be best, and, if placed at equal distances completely around the drum, the latter would not be distorted by supporting the head. I think that anybody who has a boiler with unbraced drum heads should view them with anxiety.

FLUSH HEAD HORIZONTAL RETURN TUBULAR BOILERS

In New England, horizontal return tubular boilers are always built with the front tube plate flanged forward, but in other parts of the country it is frequently if not usually flanged backward. The latter is known as the *flush head* or *New York* boiler. I consider the New England method the better because all the riveting can be done by machine. With the other construction, one circular joint must be riveted by hand or pneumatically. Another advantage of the New England method is that it makes a tight smokebox, while the other, especially if the boiler has a brick smokebox, which is usually the case, is likely to leak air. A leaky smokebox diminishes draft and cools the gases, and thus diminishes the effect of an economizer if one is used.

The object of the flush head boiler is to have the joint between the front head and the shell plate always in contact with water so that if it is not protected by brickwork it will not be injured by heat. In the New England design, there is, however, no difficulty in keeping the joint protected, and there probably has never been a case of burning the joint.

BRICKWORK

Generally speaking, brickwork will stand without cracks in boiler settings unless it is pushed by the boiler; and it is only necessary to so place it, and have such details about the boiler, that it will not receive any serious pushing. The brickwork should not touch the boiler anywhere, and the space between it and the boiler should be stuffed with asbestos fibre. Although this filling may tend to leak air, the covering over the top of the boiler, which rests on the brickwork, prevents this. The front end of the boiler should be fixed, and the other end should have attached to it some back connection covering device which will slide and not tend to push the back wall over. Such a device has been made by Oroseo C. Woolson, Mem. Am.Soc.M.E., and is reproduced in Fig. 7.

The vertical thickness of the brickwork on the sides of the boiler, and almost in contact therewith, should not, I think, be more than 12 in. It has been made 24 in., and in such cases I have seen the part raised bodily, apparently by the expansion of the boiler. This part of the brickwork is usually above the center of the boiler, but it should be equally above and below the center as thereby there is less chance of any of its weight being supported at all by the boiler. If the boiler supports it there is a chance that its weight will bend the plates, and the arguments against this have already been given.

It is common to use buckstays on the sides of boiler settings, but I also use them on front and back in order to prevent cracks. Buckstays should be usually of 8-in. I-beams of the lightest section, instead of cast iron which is unreliable.

USE OF AIR SPACES IN BOILER BRICKWORK

It has always been customary in this country to build the side and back walls of boiler settings with air spaces in order to diminish loss of heat by radiation. It is probable that these spaces cause loss of heat by convection and leakage, and it has been proved by experiments carried out by the United States Bureau of Mines (Bulletin 8) that this is true. If it is advisable to use spaces in the walls in order to prevent cracking of the brickwork, it is best to fill them with some material, such as ashes, crushed brick, sand or other loose material, which will entrap air but diminish its movement. Solid brick walls form a better non-conductor than walls with air spaces.

METHOD OF SUPPORTING HORIZONTAL RETURN TUBULAR BOILERS

The method of supporting horizontal return tubular boilers is of more importance than is usually realized. Such boilers, no matter what their length or size, should be supported at no more than four points. If boilers are long it is common to support them at six points. In order to prevent the end supports from leaving their bearings, springs are often placed under the middle brackets, but this does not render the pressures on the supports equal and is only a makeshift.

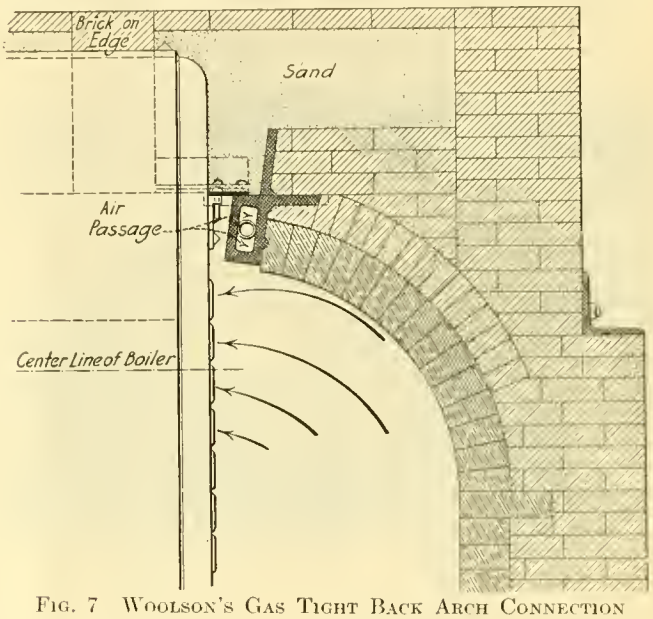

Fig. 7 Woolson's Gas Tight Back Arch Connection

It is a principle in mechanics that if a body rests on three points the pressures on these points can be determined and will not change even if the points change their positions or levels. A 3-legged stool always rests properly on its legs, even when it rests on an irregular floor, but a stool with more than three legs never presses equally on each.

This shows that in supporting a horizontal boiler the three-point principle should be applied. To obtain this effect and yet have the boiler held up at four points, two points at one end are supported in the usual manner and the other two are connected by links to an equalizing lever working on a pin passing through overhead supporting beams. This was first done by Mr. Woolson, as described in a paper by him before the Society[1] in 1898. When a boiler is supported in this way the stress in the plates due to the weight can be made proper and will never change no matter how much the brickwork may settle, but if this system is not used the stress at one point may be sufficiently great to be a serious matter.

[1] Hanging and Setting of Horizontal Fire-Tube Boilers, O. C. Woolson, Trans.Am.Soc.M.E., Vol. 19, p. 781.

THE HEAT INSULATING PROPERTIES OF COMMERCIAL STEAM PIPE COVERINGS

BY L. B. McMILLAN, MADISON, WIS.
Junior Member of the Society

THERE are on the market at the present time a large number of commercial pipe coverings made up ready for use. It is customary to use one of these forms and for that reason, the investigations described in this paper are confined to such commercial coverings. However, as will be shown in the mathematical treatment of the subject, the results of the experiments confirm theoretical laws which may be used to extend the scope of the work so as to include the entire field of heat insulation.

An enormous amount of effort has been expended in attempts to determine accurately the savings effected by the use of non-conducting coverings on steam pipes. But, even with the results of all these investigations available, little reliable information is on hand regarding the efficiencies of pipe coverings in commercial use at the present time.

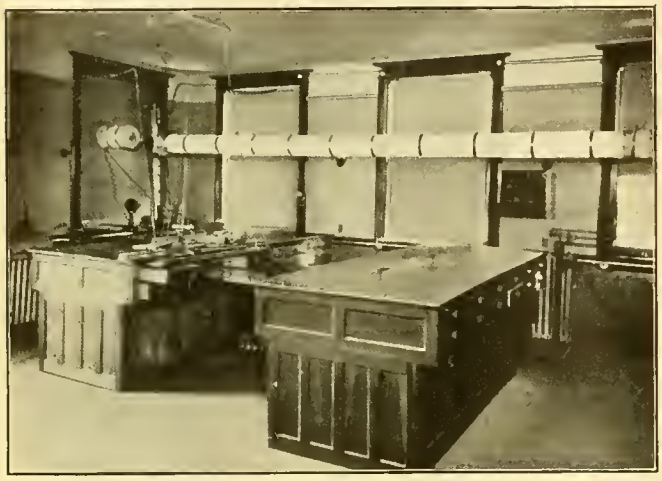

FIG. 1 APPARATUS USED FOR PIPE COVERING TESTS

FUNDAMENTAL METHOD OF TEST

It was proposed to heat a section of covered pipe by means of an electric heater made up of resistance coils immersed in oil inside the pipe, and to calculate the amount of heat lost through the covering by measuring the energy required to hold the outside metal of the pipe at a constant known temperature. Under such conditions it is evident that just enough energy is being supplied to compensate for the losses through the covering; otherwise the excess or deficiency of energy will cause the pipe to heat up or cool off as the case may be. This must be true for, according to the law of conservation of energy, all the energy entering must appear as heat since none is transformed into any other form and none is lost. Fig. 1 is a photograph of the apparatus used for the tests.

The objection will be raised that the results of the tests by this method do not represent actual operating conditions, since in actual practice the pipes contain steam and not hot oil. The conditions of operation in practice are these: The covering is placed on a pipe containing steam at some practically constant pressure; therefore the metal of the pipe has some definite constant temperature. The surrounding air may be either still or in motion, and it too has practically a constant temperature over a limited period. If the temperature of the pipe is higher than that of the air, or vice-versa, there will be a flow of heat, the quantity of which will be a function of the difference of temperature and certain constants, one of which is the conductivity of the material. Now it is so simple as to be considered axiomatic that this flow of heat will be independent of what the pipe contains so long as the temperature difference between the pipe surface and the air remains the same.

In order to maintain the temperature of the pipe constant, however, heat must be supplied from some source if heat is passing out through the covering. If steam is the heating medium the temperature gradient *inside* the pipe, that is, from the steam to the surface of the pipe, will be less than for oil; for the material having the higher conductivity will require the lower temperature gradient for the delivery of a given amount of heat. But the different effects of oil and steam will cease here.

The accuracy of any conductivity test depends upon being able to maintain constant conditions, and this may be done by electrical means better than by any other. It is necessary, however, to have a very accurate means of knowing not only when the temperatures are constant, but also the correct values of such temperatures. For room temperatures, high grade mercury thermometers were considered satisfactory. For the pipe temperatures, however, after a great deal of experimenting with various arrangements, it was decided to use copper-constantan thermo-couples and the potentiometer method of measuring the e.m.f. of the couples. The instruments were sensitive to about 0.2 deg. fahr. change of temperature, which was well within the requirements of the case.

TEMPERATURE GRADIENT INVESTIGATION

In the foregoing the fact was brought out that the drop in temperature from steam to the outside surface of a pipe was probably different than from oil to the same point on account of the different conductivities of these substances. The method of test provided for the measuring of the temperature of the *outside* of the pipe and not of the oil, so that in order to make the results applicable directly to steam conditions it is only necessary to establish a relation between the temperature of steam in a pipe and that of the outer surface of the pipe wall. This difference of temperature has been entirely neglected by most investigators, being accurately measured by none and considered not to exist by most.

With steam in the pipe, the temperatures of steam and of outside surface of pipe were measured very accurately. A photograph of the apparatus in use is shown in Fig. 2. The pipe P is arranged so that steam may be brought to it from the main at any pressure up to 130 lb. per sq. in. gage. The supply pipe is ½ in. in diameter, and for a distance of about 20 ft. it is left bare in order that no superheat due to the expansion of the steam would carry over into the test pipe. The small pipe p just below the test pipe is the drain, and a little steam was allowed to flow through it continuously in order that no air or water would collect in the test pipe.

The temperature measuring instruments are shown also. T is one of the thermo-couples on the outside of the pipe. L, L are the leads to the couples; the leads on the left go through the plug in the end of the pipe to a couple in the steam. I is an ice bath serving as the cold terminal of the couples. M is a slide wire potentiometer and a variable re-

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sistance is used in connection with it. C is a Weston standard cell, and B is a chloride accumulator or storage battery furnishing current for the potentiometer circuit. G is a very sensitive low resistance galvanometer.

Temperatures of steam and of outside of pipe were taken simultaneously at various steam pressures ranging from atmospheric to 130-lb. gage. This was done first with the pipe covered with one inch thickness of *Sectional 85 per cent magnesia* and later with pipe bare. In the first case from one to two hours' interval was allowed each time the pressure was changed for the temperatures to become constant before readings were taken, but the temperatures did not vary noticeably after the first few minutes. In case of the bare pipe only half an hour was allowed, for the temperature of the pipe surface reached its new value very quickly after the steam pressure was changed.

The results of the above described tests are given in the form of curves in Fig. 3*a* and *b*.

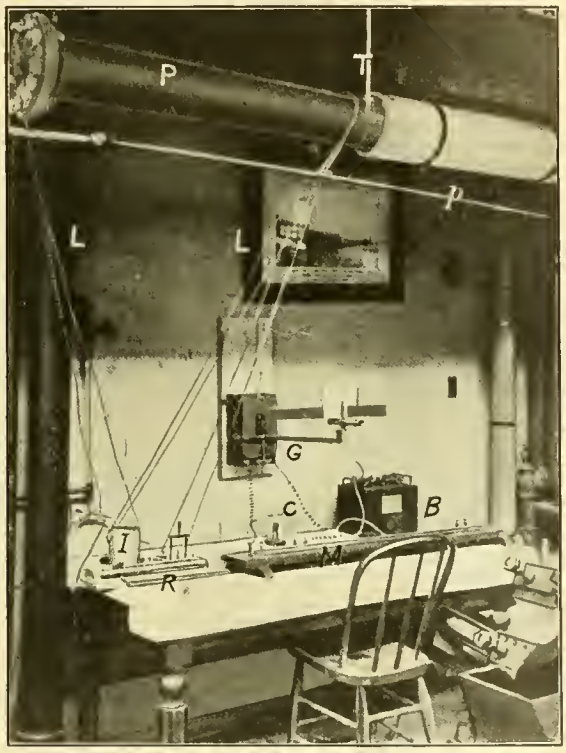

Fig. 2 Apparatus for Investigating Temperature Gradient in the Wall of a Steam Pipe

The drop through the metal of the pipe was so small as to be difficult of accurate measurement, and it was therefore calculated from the temperature gradient required to cause a known amount of heat to flow through the wall of pipe.

The dotted curve, Fig. 3*b*, is constructed on the evidence given by a single test by Eberle.[1] It shows that the drop in temperature from steam to pipe is about ten times as great when the steam is superheated as when it is saturated at the same temperature. This accounts in a very large measure for the higher economy obtained by the use of superheat.

Fig. 4*a* is a section through the wall of a steam pipe showing the relative magnitudes of the temperature drops at various points when the pipe is not covered and its temperature is 300 deg. at the outside. Fig. 4*b* shows the same as the above for pipe covered with 1-in. of 85 per cent magnesia and for both saturated and superheated steam. This figure is of particular interest because it shows the effect of different substances in a pipe whose outside temperature is constant. The temperature gradient is greatly changed on the *inside* of the pipe, but not affected *outside*.

[1] Mit über Forschungs-Arbeiten auf dem Geb. des Ing., heft 78.

Description of Apparatus for Tests of Coverings

The general arrangement of apparatus used for the tests of pipe coverings is shown in Fig. 5. The test pipe is a 16-ft. section of standard 5-in. steel pipe closed at the ends and filled with gas engine cylinder oil. It contains also resistance coils which serve as an electric heater and a stirring device for

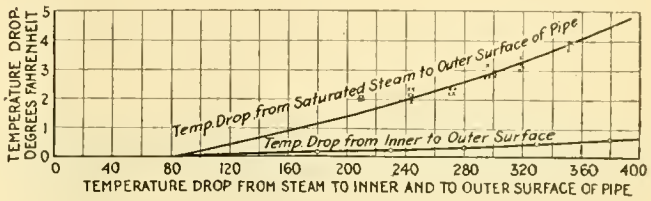

Fig. 3*a* Covered Pipe

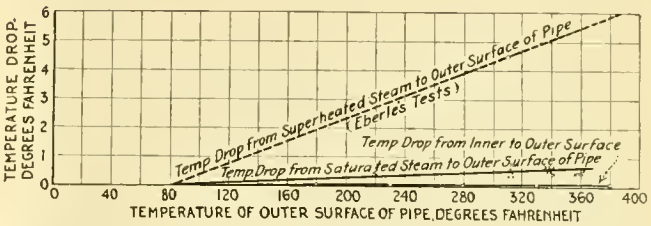

Fig. 3*b* Uncovered Pipe

Fig. 3 Temperature Drop from Steam to Inner and Outer Surfaces of Pipe

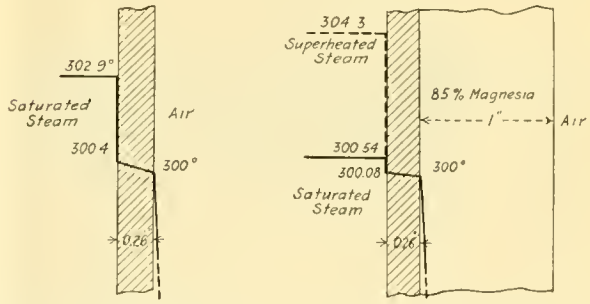

Fig. 4*a* Uncovered Pipe Fig. 4*b* Covered Pipe

Fig. 4 Temperature Drop from Steam to Outside of Pipe

keeping the oil in circulation. The remainder of the apparatus consists of the electrical instruments for measuring the energy input, a small electric motor for driving a circulating propeller in the pipe for keeping the oil in circulation, the thermometers for room temperature, and the thermo-couples and potentiometer for measuring the temperature of the pipe.

The fittings closing the ends of the large pipe are welded on to prevent the oil leaking out. At one end the pipe is closed by a cast iron cap welded to the pipe and at the other a flange is welded on and the end is closed by a blank flange bolted to the other with a gasket between. This blank flange has screwed into it the stuffing box for the shaft of the circulating propeller, two insulated terminals for the electric leads to the heating coils inside and a nipple leading to an overflow pipe which receives the oil expelled by the expansion of the large volume of oil that the test pipe contains. The arrangement of the stirrer and the electric leads may be seen in Fig.

5, and the overflow and the refilling chamber for keeping the pipe full of oil are shown in Fig. 6.

About 5 in. at each end of the test pipe is covered with *Sectional 85 per cent magnesia* 1-in. thick, leaving exactly 15 ft. of the central portion of the pipe as the test section, which will accommodate five lengths of standard pipe covering. The remaining surface of the ends is covered with *Plastic 85 per cent magnesia* to a depth of about an inch. The pipe is suspended in a horizontal position by wires from the ceiling attached to steel bands placed around the short end sections just described. These remained in place throughout the entire series of tests, and the only covering changed was the five lengths on the 15-ft. test section.

Since the covering of the ends was the same for all the tests of one inch coverings, some means of correcting for the losses through these end portions had to be devised. The device used in measuring the amount of this correction is the short pipe shown at the lower left hand corner of the upper diagram, Fig. 5. It is an exact reproduction of the permanently covered ends of the test pipe. Therefore, the difference between the loss from the test pipe and that from the short pipe represents the exact loss from the 15-ft. section covered with five standard lengths of commercial covering.

For the thickness tests, where thickness up to 3 in. were tested, the ends of the test pipe were covered with double standard thickness of *85 per cent magnesia* covering, and the short pipe was covered in the same way. A test was made on the short pipe under these conditions and the new end correction determined.

The thermo-couples are placed on the top, side, and bottom of the pipe, as shown in Fig. 5, and with this arrangement the average temperature of the outside of the pipe may be obtained with great accuracy. Each couple is imbedded in the metal of the pipe. A shallow hole, just large enough to admit the point forming the junction of the two metals of the couple, was drilled into the pipe, and after insertion the steel was forced down against this point by means of a center punch. The absolutely sure metal to metal contact secured in this way reduced to a minimum the chances for a drop in temperature from the metal of the pipe to the couple.

Direct current at 110 volts was used to supply the energy for the tests. It was obtained from a 25-kw. Curtis turbo-generator in the steam laboratory of the University of Wisconsin, and as the electric heater and the control rheostats were the only load on the machine, a very steady voltage was maintained.

In Fig. 5 is shown an instrument which gave warning of fluctuations of voltage. It consists of a solenoid in series with the heater coils, and a soft iron core hanging inside the solenoid at the short end of a balanced lever. This instrument is so sensitive that it may be relied upon to give warning of a change of voltage of 0.1 volt in either direction.

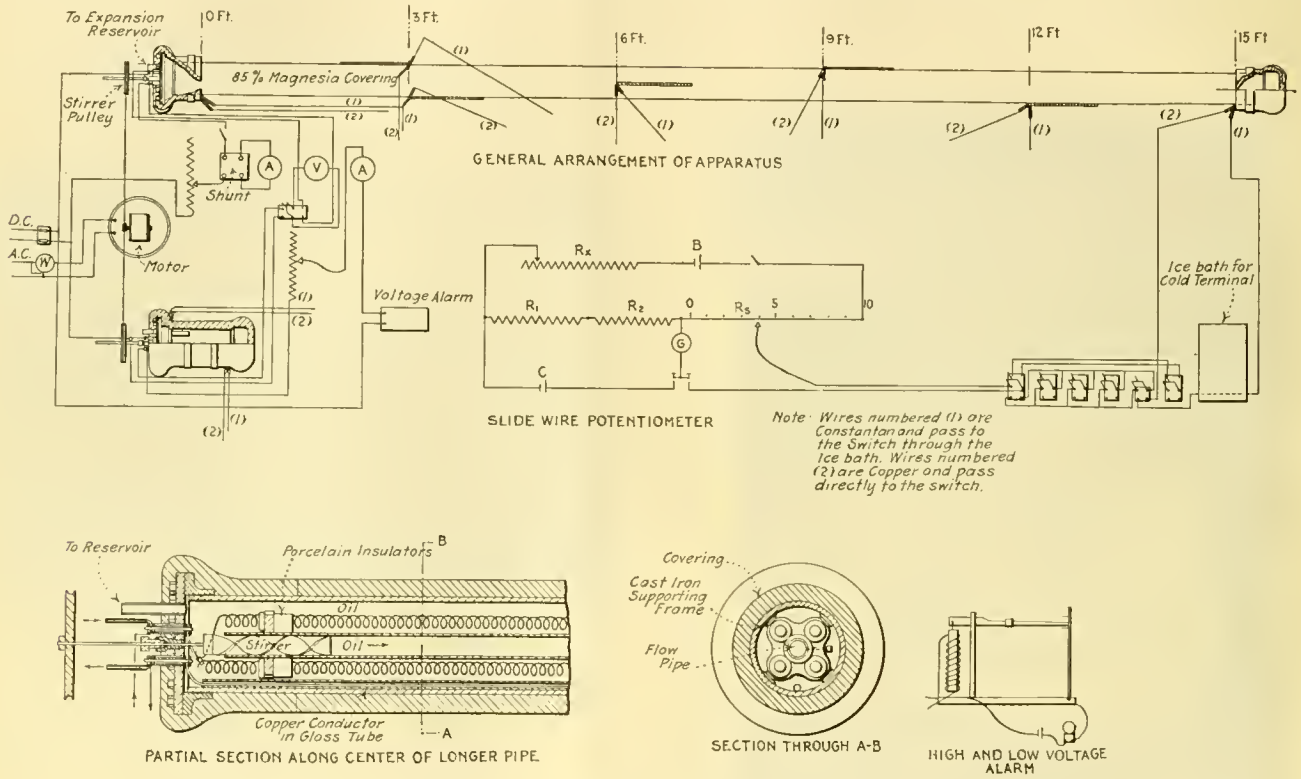

FIG. 5 APPARATUS FOR OBTAINING HEAT LOSSES THROUGH PIPE COVERINGS

For regulating the current, there is a wound wire rheostat with three coils which may be used either all in parallel with a capacity of 75 amp. or all in series for currents less than 25 amp. The finer adjustments are made by means of a small wire rheostat in series with a lamp bank and both in parallel with the large rheostat.

Fig. 7 shows the instruments and electrical control apparatus used in the tests.

METHOD OF PERFORMING THE TESTS

The coverings, before being tested for their heat insulating qualities, were placed on the steam pipe, Fig. 2, and allowed to dry for a week. Before being placed each was weighed and its thickness at each end was measured. The thickness so measured is called the actual thickness in the tables. The sections were fitted carefully. The circumferences of the bare pipe and of outside of all coverings were measured and from these data were calculated the apparent thicknesses of the

coverings, that is the distances from outside of pipe to outside of coverings. Where the covering was made up of soft sheets, as of felt, etc., pinned together, only the apparent thickness was measured.

A comparatively high current was passed through the pipe until it was heated to near the desired temperature, and then the current was lowered to such a value as would just hold the temperature of the outside of the pipe constant. When the temperature had remained practically constant for an hour, readings were taken of pipe temperature, room temperature, current in heater, and voltage across heater terminals. Then the current was diminished by about half an ampere and the temperature allowed to fall until it reached a value where the losses were just equal to this smaller amount of energy supplied, and readings were taken as before. The product of volts and amperes gave the energy in watts supplied to the heater. To maintain that current and voltage for one hour required an equal number of watt-hours, and the values of watt-hours were transformed into B.t.u. by multiplying by 3.413. The resulting losses in B.t.u. per hour were plotted against difference between temperature of outside of pipe and room temperature. Such a curve is shown in Fig. 8.

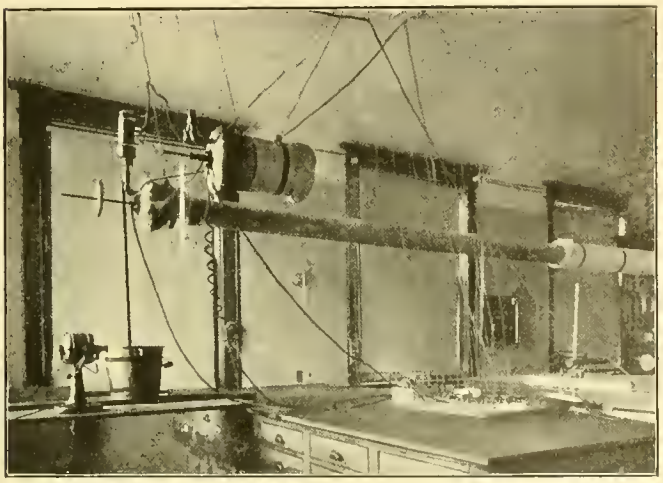

Fig. 6 View of Short Pipe and Front End of Test Pipe

The three factors most important in determining the amount of heat that will be transmitted by a given insulating material are (1) the character of the material or, in other words, its conductivity; (2) the temperature difference between its two boundaries, and (3) the thickness of the layer of material. Two others of lesser importance are the character of the surface and the velocity of air fanning that surface. These last two were kept constant during all tests.

The character of materials was varied while temperature range and thickness were kept constant by making tests of 17 different pipe coverings of approximately the same thickness and subjected to the same temperatures. Tests were made at pipe temperatures ranging from 175 to 575 deg. fahr., and at least eight or ten tests were made on each material. The excellent agreement of so many tests on the same covering is the best indication of the accuracy of the work. For two different materials the thickness was varied from 0 to 3 in., while in each case material and temperature range were constant.

DESCRIPTION OF COVERINGS TESTED

All the coverings tested were bought on the open market. A brief description of each of the 26 coverings tested follows. The statements as to whether the covering was recommended for high or low pressure or superheated steam pipes were furnished by the manufacturers and are not conclusions drawn from the tests. The weight per foot in each case is the average weight per lineal foot of 5 in. covering, and the thickness given is the average thickness.

I *J-M 85 Per Cent Magnesia.* Molded sectional covering for high pressure steam pipes. 85 per cent by weight of magnesium carbonate and the remainder principally asbestos fiber. Weight per foot 2.92 lb. and thickness 1.08 in.

II *J-M Indented.* Layers of asbestos felt with indentations, about 1¼ in. in diameter and ⅛ in. deep, spaced very close to each other in staggered rows. For pipes containing high pressure steam. Weight per foot 3.46 lb. and thickness 1.12 in.

III *J-M Vitribestos.* Asbestos air cell covering made of alternate layers of smooth and corrugated vitrified asbestos

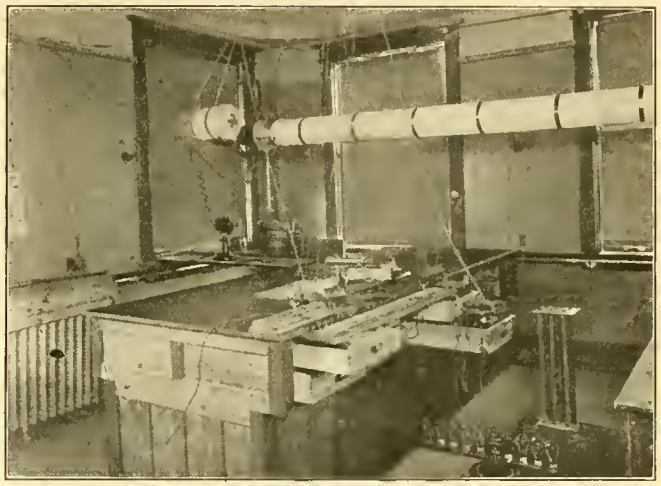

Fig. 7 View of Instruments and Electrical Control Apparatus

sheets. Corrugations about ¼ in. deep and run lengthwise of the pipe. For use on high pressure and superheated steam pipes and for stack linings, etc. Weight per foot 4.05 lb. and thickness 0.96 in.

IV *J-M Eureka.* For low pressure steam and hot water pipes. Made of ¼ in. of asbestos felt on the inside of the section and the balance of alternate layers of asbestos and wool felt. Weight 4.60 lb. per ft. and is 1.04 in. thick.

V *J-M Molded Asbestos.* Molded sectional covering for use on low and medium pressure steam pipes. Made of asbestos fiber and other fireproof material. Weight per ft. 5.53 lb. and thickness is 1.25 in.

VI *J-M Wool Felt.* A sectional covering made of layers of wool felt with an interlining of two layers of asbestos paper. May be used on low pressure steam and hot water pipes. Weight per ft. 2.59 lb. and thickness 1.10 in.

VII *Sall-Mo Expanded.* A covering for use on high and low pressure steam pipes. Made of eight layers of material, each consisting of a smooth and a corrugated piece of asbestos paper, the corrugations being so crushed down to form small longitudinal air spaces. Weight 3.47 lb. per ft., and thickness 1.07 in.

VIII *Carey Caroeel.* Composed of plain and corrugated asbestos paper firmly bound together. Corrugations are approximately ⅛ in. deep and run lengthwise of the pipe. For use on medium and low pressure steam pipes. Weight 3.06 lb. per ft. and thickness 0.99 in.

IX *Carey Serrated.* For high pressure steam pipes. Composed of successive layers of heavy asbestos felt having closely spaced indentations. Weight 5.66 lb. per ft. and thickness 1.00 in.

X *Carey Duplex.* For low pressure steam and hot water pipes. Alternate layers of plain wool felt and corrugated asbestos paper firmly bound together. Corrugations run

lengthwise of the pipe and make air cells approximately ¼ in. deep. Weighs 1.79 lb. per ft. and 0.96 in. thick.

XI *Carey 85 Per Cent Magnesia.* For high pressure steam and similar in composition to No. I. Weight per foot 2.74 lb. and thickness 1.10 in.

XII *Sall-Mo Wool Felt.* Similar to No. VI except without interlining asbestos paper. For low pressure steam and hot water pipes. Weight per foot 3.73 lb. and thickness 1.01 in.

XIII *Nonpareil High Pressure.* Molded sectional covering consisting mainly of silica in the form of diatomaceous earth—the skeletons of microscopic organisms. For high pressure and superheated steam pipes. Weights 2.96 lb. per ft. and is 1.16 in. thick.

XIV *J-M Asbestos Fire Felt.* Asbestos fiber loosely felted together, forming a large number of small air spaces. For high pressure and superheated steam pipes. Weight per ft. 3.75 lb. and thickness 0.99 in.

XV *J-M Asbestos Sponge Felted.* Made from a thin felt

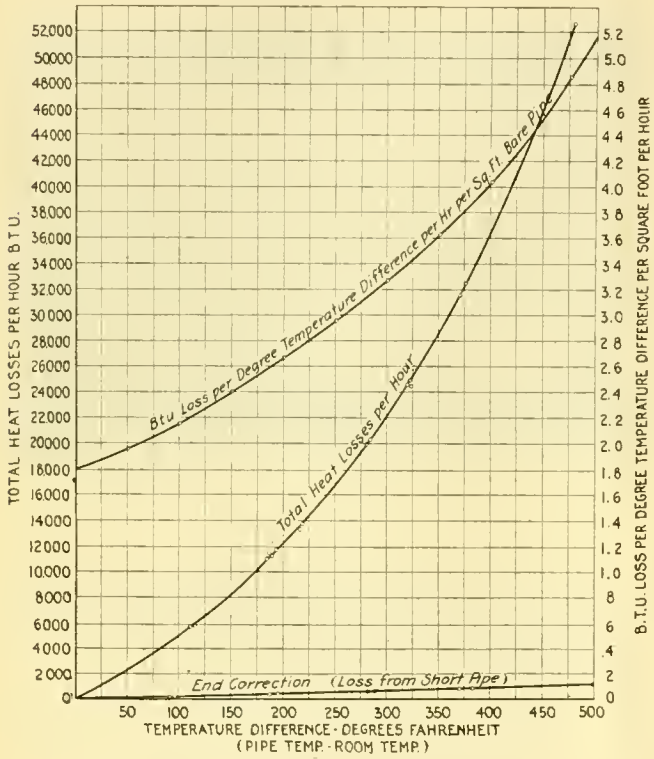

FIG. 8 TEST OF BARE PIPE

of asbestos fiber and finely ground sponge forming a very cellular fabric. 41 of these sheets per in. thickness; air spaces are formed between the sheets in addition to those in the felt itself. Specially recommended for high pressure and superheated steam pipes. Weight per ft. 4.04 lb. and thickness 1.16 in.

XVI *J-M Asbestocel.* For medium pressure steam and heating pipes. Alternate sheets of corrugated and plain asbestos paper forming air cells about ⅛ in. deep that run around the pipe. Weight per ft. 1.94 lb. and thickness 1.10 in.

XVII *J-M Air Cell.* Corrugated and plain sheets of asbestos paper arranged alternately so as to form air cells about ¼ in. deep running lengthwise of the pipe. For medium pressure steam and heating pipes. Weight per ft. 1.55 lb. and thickness 1.00 in.

XVIII ½-*In. J-M Plastic 85 Per Cent Magnesia.* For fittings, valves, irregular surfaces, boiler coverings, etc. Similar in composition to the sectional 85 per cent magnesia, but applied in the form of a cement or plaster. Thickness 0.51 in. for the first test and weight per ft. 1.51 lb.

XIX 1-*In. J-M Plastic 85 Per Cent Magnesia.* Thickness 1.05 in., weight per ft. 3.33 lb.

XX 1½-*In. J-M Plastic 85 Per Cent Magnesia.* Thickness 1.48 in., weight per ft. 5.23 lb.

XXI 2-*In. J-M Plastic 85 Per cent Magnesia.* Thickness 1.99 in., weight per ft. 7.46 lb.

XXII 3-*In. J-M 85 Per Cent Magnesia.* The two inches of plastic covering of No. XXI and one standard thickness layer of sectional covering outside of that. Thickness 3.24 in., weight per ft. 11.67 lb.

XXIII ½-*In. Sall-Mo Air Cell.* Similar in composition and uses to No. XVII. Thickness 0.51 in. and weight per ft. 0.99 lb.

XXIV 1-*In. Sall-Mo Air Cell.* Thickness 0.95 in., weight per ft. 1.57 lb.

XXV 2-*In. Sall-Mo Air Cell.* Thickness 1.86 in., weight per ft. 3.58 lb.

XXVI 3-*In. Air Cell.* Two inches of *Sall-Mo* and one inch of *J-M Air Cell.* Thickness 3.04 in., weight per ft. 6.66 lb.

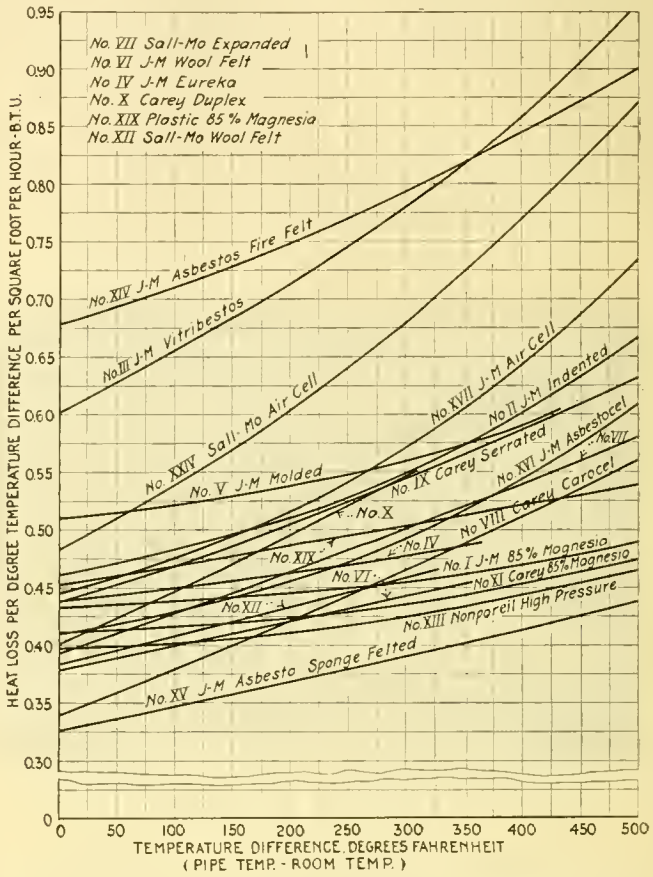

FIG. 9 SUMMARY OF RESULTS ON SINGLE THICKNESS COVERINGS

The total loss curve in Fig. 8 is plotted directly from the data obtained during the test. The ordinate of any point is the total heat loss per hour, which is the equivalent of the electrical energy required to maintain the pipe at the given temperature, and the abscissa is the difference between pipe temperature and room temperature. On the same sheet is plotted a curve of heat losses per hour from the short pipe at various temperature differences; this curve is called "end correction." The difference of ordinates between the two curves at any value of temperature difference gives the net heat loss per hour from the 15-ft. length of bare pipe. This net loss divided by the temperature difference and the area of test section (22.03 sq. ft.) gives the heat loss per degree temperature difference per square foot per hour.

The curve of net heat losses per degree temperature difference per square foot per hour is shown in Fig. 8 to a much larger scale. This curve shows that the heat loss per degree temperature difference is far from being a constant at all temperatures as has been assumed or implied by most former investigators.

According to Nusselt[1] the conductivity of many poorly conducting substances increases nearly as the absolute temperature instead of remaining constant. The tests described in the present paper establish the fact that the conductivity does not remain constant, but in no case except in that of the bare pipe did it increase quite as rapidly as the absolute temperature. Conductivity in this sense is rate of heat conduction per degree temperature difference per square foot per inch thickness per hour.

The net heat loss curves from all the tests of coverings 1 in. thick are assembled in the form of a general summary in Fig. 9. From the curves shown in this figure, one can tell at a glance what coverings are the more efficient at any temperature. Of all the coverings tested, the four best, at temperatures of 200 to 600 deg. fahr., are *J-M Asbestos-Sponge Felted, Nonpareil High Pressure, Carey 85 Per Cent Magnesia and J-M 85 Per Cent Magnesia,* ranking in the order named with the first well ahead of all the others. Those losing the greatest amount of heat were *J-M Vitribestos* and *J-M Firefelt.* The first of these latter is little used as a pipe covering, being employed mostly for stack linings, etc., while the virtue of the second is in its being a heat-proof material suitable for use as the layer in contact with a pipe carrying superheated steam, where the better insulating material used for the outer layers could not stand the temperature of superheat.

The saving in dollars per year due to use of covering has been calculated for each of the coverings tested and the results appear in Table 1. Also, the first cost of the covering is taken account of and values of net saving and per cent saving on investment are given for values of temperature differences of from 1 to 500 deg. fahr. The saving in B.t.u. per degree temperature difference per square foot per hour was first found for each temperature by subtracting from the bare pipe loss at that temperature the loss from covered pipe at same temperature. Then the total saving per square foot for a year of 365 twenty-four hour days was found by multiplying the saving per degree per hour per square foot by 8760 and by the temperature. The cost of heat was taken at $0.30 per million B.t.u., which is nearly equivalent to $0.30 per 1000 lb. of steam. The first cost of covering was ascertained from the manufacturers, and 10 per cent of list price was added for erecting and 10 per cent more for painting. The cost of covering *per year* was taken as 14 per cent of the total first cost, the 14 per cent including interest, depreciation, repairs, insurance, etc. The difference between the total saving per year and the cost of covering per year is the net saving per year.

The data in Table 1 have been plotted in the form of curves, shown in Fig. 10, for the first three coverings tested. All the data for the other coverings has been computed and any curve desired may be plotted in a very short time, by anyone wishing it.

The facts brought out by these curves are that the efficiency and saving increase with the temperature on account of more rapid increase, with temperature, of losses from bare pipe than of losses from covered pipe.

Fig. 11 shows the variation of losses with thickness at temperature difference of 100, 300 and 500 deg. fahr. and for thicknesses from 0 to 5 in. These curves were plotted from data calculated from the theoretical equation using constants determined in the tests. The points marked *o* are values from the actual experiments and they fall on the calculated curves with remarkable regularity except at the ½-in. and 3-in points. The ½-in. thickness cracked and checked considerably when heated up and this naturally decreased its insulating value, so that the values of losses would be greater than those calculated from the equation which made use of conductivities obtained at greater thicknesses where conditions were more nearly uniform. The outer one inch thickness on the test of 3-in. covering was not plastic, but was sectional magnesia covering which has a lower conductivity than the plastic.

Results of similar tests of different thicknesses of air cell covering, chosen because of their being representative of the two classes of materials—those with very small air spaces and those with rather large air spaces—are plotted in curve form in the paper.

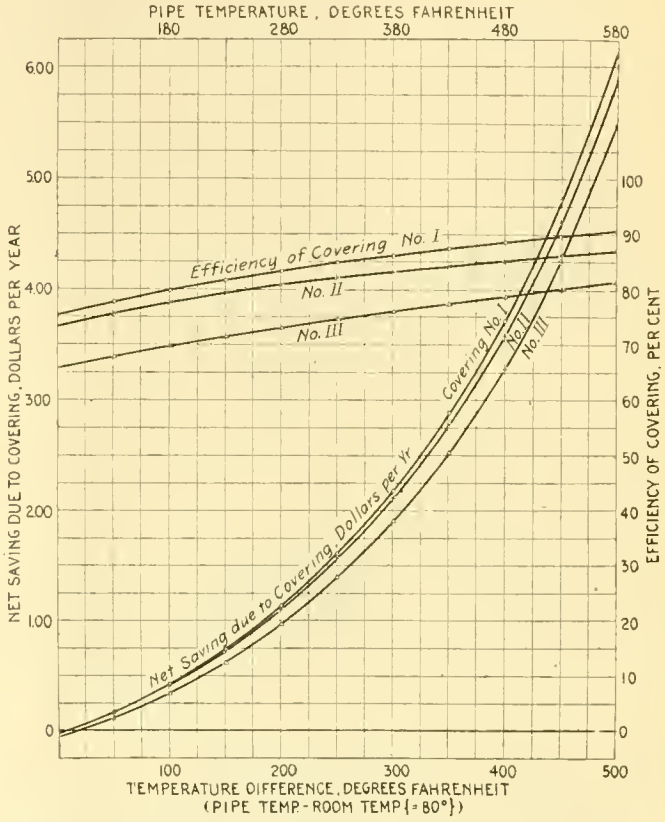

Fig. 10 Efficiency and Net Savings Curves for Coverings I, II, and III

The net savings in dollars per year were calculated for various thicknesses of *J-M Sectional 85 Per Cent Magnesia* at temperature differences of 100, 300 and 500 deg. fahr. This was done in exactly the same manner as already described for single thickness coverings. These values were used in computing the cost per year of the various thicknesses of covering and results are given in Table 2. The curves for net savings per square foot per year in Fig. 11 show rapid increase in savings as the thickness is increased up to a point of maximum savings after which there is a decrease owing to the rapid increase in cost of covering. Fig. 11 shows the proper thickness for the maximum net saving at any temperature difference from 0 to 500 deg. fahr.

The chart for proper thickness mentioned above applied only to the case where steam costs $0.30 per 1000 lb. and is on 365 days in the year. Fig. 12 is a chart for proper thickness of magnesia covering to be used at any temperature, any price of steam and any number of hours service per year. The chart does not show values for length of service, but to use it for other periods than 365 days at 24 hours a day, multiply

[1] Zeit d. Ver. deut. Ing., vol. 52, p. 906.

TABLE 1 DATA ON EFFICIENCIES AND SAVINGS FOR SINGLE THICKNESS COVERINGS

Covering No.	Kind of Covering	Temperature Difference (Pipe and Room)	Actual Temperature (Room = 80 deg. fahr.)	B.t.u. Loss /Sq. ft./Deg. Temperature Difference/Hr. Bare Pipe	Covered Pipe	B.t.u. Saving Due to Covering/Deg./Sq. ft./Hr.	Efficiency of Covering—Per Cent	Saving Due to Covering in B.t.u./Sq. ft./Yr.	Saving in $/Sq. ft./Yr.	First Cost of Covering/Sq. ft.	Cost of Covering/Sq. ft./Yr.	Net Saving in $/Sq. ft./Yr.	Interest on Investment
I	J-M 85% Magnesia	50	130	1.950	0.435	1.515	77.7	664,000	0.199	0.238	0.033	0.166	69.7
		100	180	2.152	0.438	1.714	79.6	1,502,000	0.451			0.418	175.5
		200	280	2.665	0.446	2.219	83.3	3,887,000	1.165			1.132	475
		300	380	3.260	0.455	2.805	86.1	7,370,000	2.212			2.178	914
		400	480	4.035	0.469	3.566	88.4	12,490,000	3.750			3.717	1560
		500	580	5.180	0.488	4.692	90.6	20,560,000	6.165			6.132	2575
II	J-M Indented	50	130	1.950	0.472	1.478	75.6	647,300	0.194	0.214	0.030	0.164	76.6
		100	180	2.152	0.483	1.669	77.6	1,462,000	0.438			0.408	190.5
		200	280	2.665	0.309	2.156	80.9	3,777,000	1.133			1.103	515
		300	380	3.260	0.519	2.711	83.2	7,120,000	2.136			2.106	983
		400	480	4.035	0.603	3.432	85.1	12,020,000	3.608			3.578	1676
		500	580	5.180	0.666	4.514	87.1	19,780,000	5.935			5.905	2760
III	J-M Vitribestos	50	130	1.950	0.626	1.324	67.9	580,000	0.174	0.381	0.053	0.121	31.8
		100	180	2.152	0.654	1.498	69.6	1,312,000	0.394			0.341	89.6
		200	280	2.665	0.715	1.950	73.2	3,417,000	1.025			0.972	255.0
		300	380	3.260	0.781	2.481	76.0	6,519,000	1.955			1.902	500.0
		400	480	4.035	0.856	3.177	78.8	11,130,000	3.340			3.287	865.0
		500	580	5.180	0.967	4.213	81.4	18,450,000	5.540			5.487	1442.0
IV	J-M Eureka	50	130	1.950	0.440	1.510	77.4	661,000	0.198	0.262	0.037	0.161	61.5
		100	180	2.152	0.451	1.701	79.0	1,490,000	0.447			0.410	156.6
		200	280	2.665	0.464	2.201	82.6	3,860,000	1.158			1.121	428.0
		300	380	3.260	0.478	2.782	85.4	7,310,000	2.192			2.155	824.0
		350	430	3.627	0.487	3.140	86.6	9,620,000	2.888			2.851	1090.0
V	J-M Molded	50	180	1.950	0.517	1.433	73.4	627,600	0.188	0.190	0.027	0.161	55.5
		100	180	2.152	0.522	1.630	75.8	1,428,000	0.428			0.401	211.0
		200	280	2.665	0.539	2.126	79.8	3,725,000	1.117			1.090	574.0
		300	380	3.269	0.561	2.699	82.8	7,088,000	2.126			2.099	1105.0
		400	480	4.035	0.596	3.439	85.2	12,050,000	3.615			3.588	1888.0
VI	J-M Wool-Felt	50	130	1.952	0.386	1.564	80.2	684,700	0.205	0.214	0.030	0.175	81.8
		100	180	2.152	0.400	1.752	81.4	1,535,000	0.460			0.430	201.0
		200	280	2.665	0.421	2.244	84.2	3,930,000	1.179			1.149	537.0
		300	380	3.260	0.442	2.818	86.4	7,400,000	2.220			2.190	1023.0
		350	430	3.627	0.453	3.174	87.6	9,730,000	2.919			2.889	1349.0
VII	Sall-Mo Expanded	50	130	1.950	0.409	1.541	79.0	674,600	0.202	0.248	0.035	0.167	67.3
		100	180	2.152	0.427	1.725	80.2	1,511,000	0.453			0.418	168.5
		200	280	2.665	0.464	2.201	82.6	3,856,000	1.156			1.121	452.0
		300	380	3.260	0.503	2.757	84.6	7,240,000	2.172			2.137	852.0
		400	480	4.035	0.541	3.494	86.6	12,240,000	3.672			3.637	1466.0
		500	580	5.180	0.581	4.599	88.8	20,140,000	6.042			0.007	2421.0
VIII	Carey Carocel	50	130	1.950	0.358	1.592	81.6	697,000	0.209	0.195	0.027	0.182	93.4
		100	180	2.152	0.378	1.774	82.4	1,555,000	0.467			0.440	226.0
		200	280	2.665	0.421	2.244	84.2	3,932,000	1.180			1.153	592.0
		300	380	3.260	0.466	2.794	85.7	7,340,000	2.202			2.175	1116.0
		400	480	4.035	0.510	3.525	87.4	12,350,000	3.705			3.678	1886.0
		500	580	5.180	0.562	4.618	89.2	20,220,000	6.066			6.039	3100.0
IX	Carey Serrated	50	130	1.950	0.454	1.496	76.7	655,000	0.197	0.214	0.030	0.167	78.0
		100	180	2.152	0.468	1.684	78.2	1,475,000	0.443			0.413	193.0
		200	280	2.665	0.506	2.159	81.0	3,782,000	1.135			1.105	517.0
		300	380	3.260	0.546	2.714	83.3	7,132,000	2.140			2.110	986.0
IX	Carey Serrated	400	480	4.035	0.587	3.448	85.4	12,075,000	3.622			3.592	1680.0
		500	580	5.180	0.634	4.546	87.8	19,900,000	5.970			5.940	2780.0
X	Carey Duplex	50	130	1.950	0.423	1.527	78.3	669,000	0.201	0.162	0.023	7.178	110.0
		100	180	2.152	0.447	1.705	79.2	1,494,000	0.448			0.425	252.0
		200	280	2.665	0.498	2.167	81.3	3,798,000	1.139			0.116	689.0
		300	380	3.260	0.548	2.712	83.2	7,128,000	2.140			0.117	1307.0
		350	430	3.627	0.574	3.053	84.2	9,360,000	2.808			2.785	1720.0
XI	Carey 85% Magnesia	50	130	1.950	0.413	1.537	78.8	673,000	0.202	0.200	0.028	0.174	87.0
		100	180	2.152	0.418	1.734	80.5	1,519,000	0.456			0.428	214.0
		200	280	2.665	0.424	2.241	84.1	3,929,000	1.179			1.151	576.0
		300	380	3.260	0.436	2.824	86.6	7,420,000	2.226			2.198	1099.0
		400	480	4.035	0.454	3.581	88.8	12,550,000	3.765			3.737	1869.0
		500	580	5.180	0.472	4.708	90.9	20,610,000	6.183			6.155	3078.0
XII	Sall-Mo Wool-Felt	50	130	1.950	0.395	1.555	79.8	681,000	0.204	0.190	0.027	0.177	93.3
		100	180	2.152	0.401	1.751	81.4	1,535,000	0.461			0.434	228.0
		150	230	2.400	0.421	1.979	82.5	2,600,000	0.780			0.753	396.5
		200	280	2.665	0.433	2.232	83.8	3,910,000	1.173			1.146	604.0
		250	330	2.951	0.455	2.506	84.9	5,484,000	1.645			1.618	852.0
		300	380	3.260	0.459	2.801	85.9	7,360,000	2.208			2.181	1150.0
XIII	Nonpareil High Pressure	50	130	1.950	0.399	1.551	79.5	679,000	0.204	0.224	0.031	0.173	77.2
		100	180	2.152	0.402	1.750	81.3	1,533,000	0.460			0.429	92.0
		200	280	2.665	0.412	2.253	84.6	3,950,000	1.185			1.154	516.0
		300	380	3.260	0.426	2.834	86.9	7,448,000	2.234			2.203	985.0
		400	480	4.035	0.444	3.591	89.0	12,580,000	3.774			3.745	1673.0
		500	580	5.180	0.465	4.715	91.0	20,640,000	6.190			6.159	2752.0
XIV	J-M Fire Felt	50	130	1.950	0.694	1.256	64.4	550,000	0.165	0.333	0.047	0.118	35.4
		100	180	2.152	0.711	1.441	67.0	1,262,000	0.379			0.332	99.7
		200	280	2.665	0.749	1.916	71.9	3,360,000	1.008			0.961	288.6
		300	380	3.260	0.795	2.465	75.6	6,480,000	1.944			1.897	570.0
		400	480	4.035	0.845	3.190	79.0	11,175,000	3.353			3.306	993.0
		500	580	5.180	0.901	4.279	82.6	18,740,000	5.620			5.573	1675.0
XV	J-M Sponge Felted	50	130	1.950	0.336	1.614	82.7	707,000	0.202	0.333	0.047	0.165	49.5
		100	180	2.152	0.347	1.805	83.8	1,581,000	0.474			0.427	128.0
		200	280	2.665	0.369	2.296	86.2	4,035,000	1.211			1.164	350.0
		300	380	3.260	0.391	2.869	88.0	7,540,000	2.262			2.215	665.0
		400	480	4.035	0.414	3.621	89.8	12,690,000	3.809			3.762	1132.0
		500	580	5.180	0.439	4.741	91.5	20,770,000	6.230			6.183	1860.0
XVI	J-M Asbestocel	50	130	1.950	0.418	1.532	78.5	671,000	0.201	0.262	0.037	0.164	62.7
		100	180	2.152	0.429	1.723	80.0	1,510,000	0.453			0.416	159.0
		200	280	2.665	0.454	2.211	83.0	3,876,000	1.163			1.126	430.0
		300	380	3.260	0.493	2.767	84.8	7,272,000	2.181			2.144	820.0
		400	480	4.035	0.544	3.491	86.5	12,230,000	3.670			3.633	1388.0
		500	580	5.180	0.609	4.571	88.2	20,020,000	6.006			5.969	2280.0
XVII	J-M Air Cell	50	130	1.950	0.459	1.491	76.4	655,000	0.196	0.190	0.027	0.169	89.0
		100	180	2.152	0.475	1.677	77.9	1,469,000	0.441			0.414	218.0
		200	280	2.665	0.515	2.150	80.7	3,769,000	1.130			1.103	581.0
		300	380	3.260	0.571	2.689	82.7	7,066,000	2.120			2.093	1101.0
		400	480	4.035	0.643	3.392	84.1	11,885,000	3.568			3.541	1865.0
		500	580	5.180	0.733	4.447	85.8	19,475,000	5.841			5.814	3060.0

the price of steam by the number of hours per year the steam line considered is in service and divide by 8760 and, using the result as the price of steam on the chart, find the proper thickness.

MATHEMATICAL TREATMENT OF HEAT FLOW IN INSULATING MATERIALS

The problem of insulating objects against the flow of heat is one which, when the necessary constants are known, is capable of very complete mathematical solution, but the mathematical treatment cannot take the place of all experimental work, since the conductivities of the materials must be determined by actual experiment; but once these are known, further tests are not required for the accurate determination of the losses from any thickness whatsoever.

TABLE 2 DATA ON EFFICIENCIES AND SAVINGS OF VARIOUS THICKNESSES OF 85 PER CENT MAGNESIA COVERING

Temperature Difference	Thickness	B.t.u./Sq. ft./deg. dif./hr.			Saving	Efficiency	Total Saving/yr.		First Cost of Covering	Cost of Covering/yr.	Net Saving
		Bare Pipe	Plastic 85 per cent Magnesia	Sectional 85 per cent Magnesia			B.t.u.	Dollars (Steam at 30c/1000 lb.			
100	0.5	2.152	0.735	0.691	1.461	67.8	1,280,000	0.384	0.125	0.018	0.366
100	1.0		0.492	0.462	1.690	78.4	1,481,000	0.414	0.238	0.033	0.411
100	2.0		0.319	0.300	1.852	85.5	1,622,000	0.486	0.341	0.048	0.438
100	3.0		0.248	0.233	1.919	89.1	1,681,000	0.504	0.528	0.074	0.430
100	4.0		0.209	0.196	1.956	90.8	1,714,000	0.514	0.851	0.119	0.395
100	5.0		0.185	0.174	1.978	91.9	1,733,000	0.520	1.215	0.170	0.350
300	0.5	3.260	0.805	0.757	2.503	76.8	6,579,000	1.975	0.125	0.018	1.957
300	1.0		0.524	0.493	2.767	84.9	7,270,000	2.181	0.238	0.033	2.148
300	2.0		0.335	0.315	2.945	90.4	7,740,000	2.322	0.341	0.048	2.274
300	3.0		0.260	0.244	3.016	92.5	7,922,000	2.377	0.528	0.074	2.303
300	4.0		0.219	0.206	3.054	93.7	8,026,000	2.408	0.851	0.119	2.289
300	5.0		0.192	0.181	3.079	94.4	8,090,000	2.427	1.215	0.170	2.257
500	0.5	5.180	0.895	0.842	4.338	83.7	19,000,000	5.700	0.125	0.018	5.682
500	1.0		0.557	0.524	0.656	89.9	20,410,000	6.125	0.238	0.033	6.092
500	2.0		0.350	0.329	4.851	93.6	21,260,000	6.380	0.341	0.048	6.332
500	3.0		0.273	0.257	4.923	95.0	21,570,000	6.470	0.528	0.074	6.396
500	4.0		0.229	0.215	4.965	95.8	21,750,000	6.525	0.851	0.119	6.406
500	5.0		0.199	0.187	4.993	96.4	21,880,000	6.560	1.215	0.170	6.300

In the case of flat surfaces, where the two boundaries of the insulating material are parallel planes, the application of the mathematical treatment is very simple. In this case the quantity of heat conducted is given by the equation

$$Q = k\frac{\theta_1 - \theta_2}{x} A\, t \ldots\ldots\ldots\ldots\ldots [1]$$

in which Q is the quantity of heat conducted, θ_1 and θ_2 the temperatures of hotter and colder surfaces respectively, x is the thickness in in. of the layer of material, A is the area in sq. ft. of the surface considered, t is the time in hr. and k is the conductivity of the material in B.t.u. per degree temp. difference per sq. ft. per in. thickness per hour. The reason for strange mixture of feet and inches in the equation is the irrational definition, in the English units, of conductivity, since in it the square foot is made the unit of area and the inch the unit of thickness.

The tests of pipe coverings now under discussion involved cylindrical surfaces rather than flat ones, so that a more extensive explanation will be made of this class of problems. The rate of heat flow through the material of a pipe is given by the equation

$$W_1 = \frac{k(\theta_1 - \theta_2)}{r\,(\log_e r_2 - \log_e r_1)} \ldots\ldots\ldots\ldots\ldots [2]$$

in which W_1 is the rate of heat flow per sq. ft. of pipe per hr.; k is the conductivity; θ_1 and θ_2 are the temperatures; r_1 and r_2 are the radii of the inner and outer surfaces of the pipe respectively, and r is the outside radius of the pipe. The entire equation is rational and contains nothing of empirical nature except the conductivity, k, which must be determined by experiment. The data obtained from the tests described in the paper form an excellent basis for the calculation of these conductivities.

Below is given an example of the computation of the conductivity, k. The material is *J-M 85 Per Cent Magnesia;* temperature difference between pipe surface and air is 300

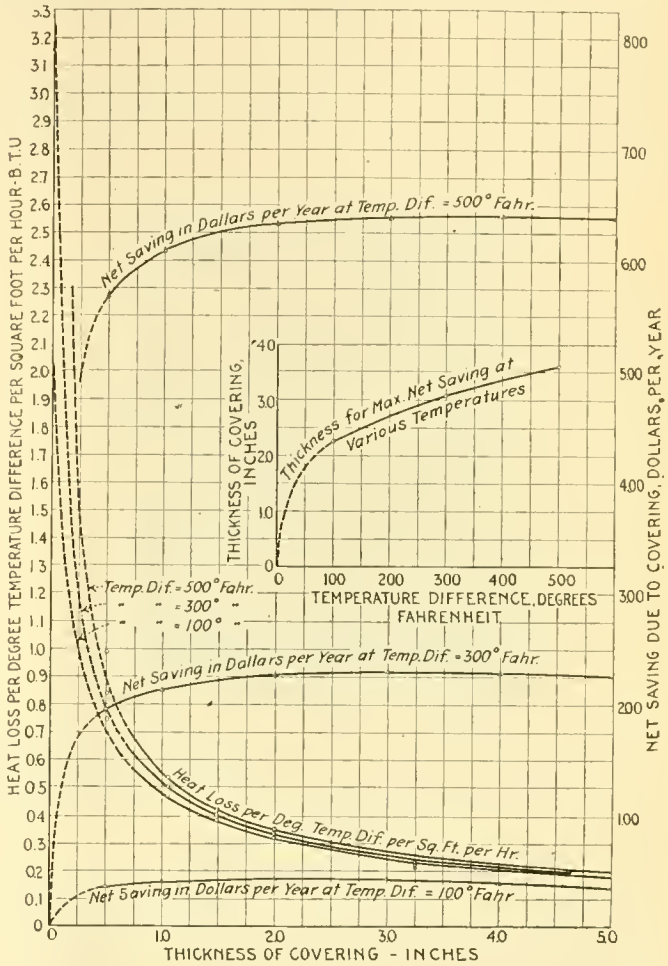

FIG. 11 THICKNESS-SAVINGS CHART FOR 85 PER CENT MAGNESIA COVERINGS

deg. fahr.; thickness of covering, 1.13 in.; outside diameter of pipe, 5.6 in. The rate of heat loss per degree temperature difference per square foot per hour is found from Fig. 9 to be 0.455 B.t.u. Therefore, W_1, the total loss per sq. ft. per hr., is equal to $300 \times 0.455 = 136.5$ $W_2 = 136.5 \times 2.8 \div (2.8 + 1.13) = 97.2$ B.t.u.

From the curve, Fig. 13, the temperature difference between outer covering surface and air corresponding to a loss of 97.2 B.t.u. is 65 deg. Therefore, the temperature difference between inner and outer covering surfaces is $(300 - 65) = 235$ deg.

$$k = \frac{W_1\, r\,(\log_e r_1 - \log_e r_2)}{\theta_1 - \theta_2}$$

$$= \frac{136.5 \times 2.8\,(\log_e 3.93 - \log_e 2.8)}{235}$$

$$= 0.551$$

The conductivity of *J-M 85 Per Cent Magnesia* at 300 deg

temperature difference is therefore 0.551 B.t.u. per deg. temp. difference per sq. ft. per in. thickness per hr.

Conductivities have been calculated at 300 deg. temp. difference (pipe temperature—room temperature) for all of the coverings tested. The values are given in Table 3. This table is the best basis on which to compare coverings, because here all differences due to different thicknesses are done away with and the coverings may be compared under exactly the same conditions.

For finding the heat loss through any thickness of any material of which the conductivity is known, and at any temperature difference between pipe and room up to 500 deg. fahr., a modification of equation [2] may be used.

CONCLUSION

In conclusion it may be said that in most cases it pays to use the best commercial pipe covering obtainable; because

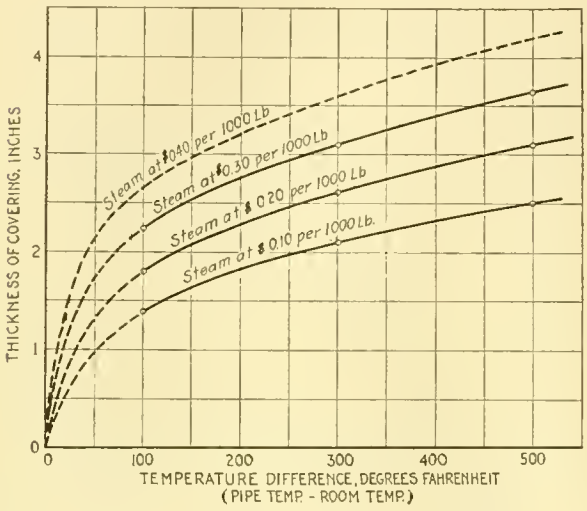

Fig. 12 Chart for Determining Proper Thickness of 85% Magnesia for Maximum Net Savings at Various Temperatures and Prices of Steam

where the material is paid for many times over during the first year by the saving effected by its use, the first cost loses much of its weight as a determining factor in the selection of type of covering to be used. In view of the results of the thickness tests, it is a deplorable fact that few steam lines at the present time are provided with thick enough a covering for the greatest net saving. However, where fuel is cheap and the lines are in use only a small percentage of the time, the cheaper coverings have their advantages. Also there are places, as on some heating systems, where the heat lost through the coverings is not wasted and the object of covering the pipes at all is to keep tunnels, etc., cool enough that men may work in them. Therefore, a careful study of conditions is necessary before a certain type of covering can be recommended for a given piece of work. However, it is hoped that the data given in this paper will be of assistance to engineers in deciding upon the material to be used under certain con-

TABLE 3 CONDUCTIVITIES OF PIPE COVERINGS AT 300 DEGREES TEMPERATURE DIFFERENCE BETWEEN PIPE SURFACE AND ROOM

No.	Kind of Covering	Conductivity
I	J-M 85 Per Cent Magnesia	0.551
II	J-M Indented	0.686
III	J-M Vitribestos	1.087
IV	J-M Eureka	0.549
V	J-M Molded Asbestos	0.778
VI	J-M Wood Felt	0.521
VII	Sall-Mo Expanded Asbestos	0.598
VIII	Carey Carocel	0.540
IX	Carey Serrated	0.682
X	Carey Duplex	0.636
XI	Carey 85 Per Cent Magnesia	0.546
XII	Sall-Mo Wool Felt	0.510
XIII	Nonpareil High Pressure	0.543
XIV	J-M Asbestos Fire Felt	1.093
XV	J-M Asbestos Sponge Felted	0.468
XVI	J-M Asbestos Cell	0.596
XVII	J-M Air Cell	0.718
XVIII to XXII	Plastic 85 Per Cent Magnesia	0.587
XXIV	Sall-Mo Air Cell	0.802

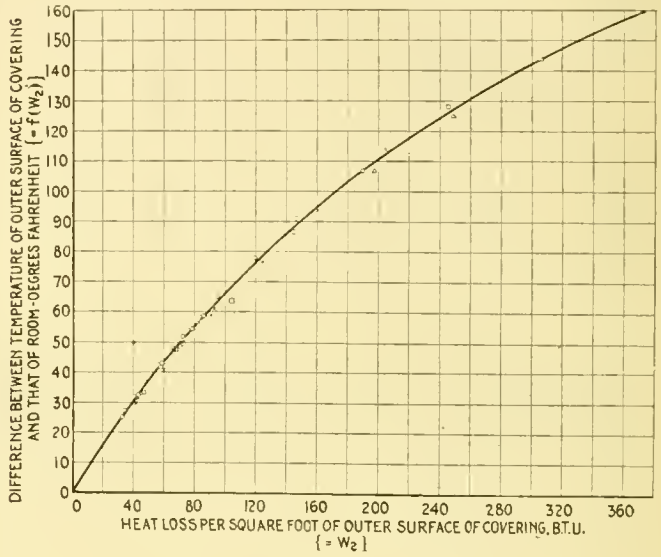

Fig. 13 Curve Showing Relation of Heat Losses to Temperature Difference between Covering Surface and Surrounding Air

ditions, and in calculating heat losses on installations already in use.

The durability of materials used for pipe coverings is a very important factor in determining the most economical covering for a given set of conditions. It has already been pointed out that the proper basis for comparing costs was the cost per year and not the first cost of the material. This is true because the covering giving the greatest length of service for a given first cost and efficiency is obviously the one to select. In general, fibrous coverings are more durable than the molded forms; since the latter tend to revert to their original powdered state due to vibration and rough usage, while those made of fibrous material firmly felted together show no such tendency.

CIRCULATION IN HORIZONTAL WATER TUBE BOILERS

BY PAUL A. BANCEL, NEW YORK

Junior Member of the Society

WITH high combustion rates and high furnace temperatures, the load on boiler surfaces exposed directly to the fire is very intense. For a furnace temperature of 2500 deg. fahr. and a boiler temperature of 400 deg. fahr., the rate of radiation per square foot of boiler surface is about 100,000 B.t.u. per hr.; for 2750 deg. fahr., 150,000 B.t.u., and for 3000 deg. fahr., 200,000 B.t.u., corresponding approximately to loads of 100, 150 and 200 lb. of steam per sq. ft. respectively, whereas the load averaged for all the surface in a boiler is usually only 3.5 to 10 lb. per sq. ft.

It is important that the tubes subjected to these loads have ample circulation of water, and be kept clean of scale as well, otherwise the resistance to heat transfer on the water side of the tube will increase, causing an increase in the temperature of the metal, which, if high enough, will result in rupture. An increase in tube temperature will also decrease the heat absorbed by radiation and reduce the efficiency. It is only in the region of these tubes that the velocity of circulation can have any appreciable effect on the efficiency of heat absorption.

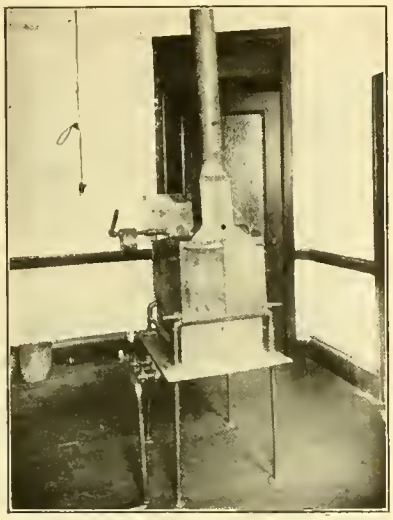

Fig. 1 Model Boiler Set Up for Test with Metal Cover Plates on Front and Glass Cover Plates on Rear, as shown in Fig. 2

In a simple U-tube circuit without resistance, the velocity of a homogeneous mixture would be $v = \sqrt{2\,g\,H}$ where H is the head measured in terms of the steam-water mixture. The velocity may also be expressed in terms of the total volume of steam and water circulating, the cross section and time, giving the expression:

$$v = \phi \sqrt[3]{\frac{V\,h}{A}}$$

where V is the volume of steam per hour, h the distance from center of heating of tube to water level, A is the cross section area and ϕ is a coefficient dependent on slip and resistance. This expression indicates that, if the coefficient remained constant, the velocity would increase as the cube root of the steam volume or load, that is, if the load were doubled the velocity would increase 1.26 times. But this condition does not exist, except in the frictionless U-tube circuit without slip, and is far from being attained throughout the entire circuit of commercial boilers.

MODEL BOILER FOR STUDYING CIRCULATION

In order to study circulation and the nature of the flow in different types of horizontal boilers, a model was constructed as shown in Figs. 1, 2 and 3.

The boiler was built in two units, each complete with drum headers and tubes. There were 75 half-inch outside diameter No. 18 B. & S. brass tubes about 2 ft. long, of a total surface of 17 sq. ft. in each unit. The headers were rectangular as in an Edge Moor boiler, and by inserting suitable strips of brass the design could be changed to represent the different constructions of Figs. 4*A* to 4*F*. Glass covers were placed on the front and back headers to permit observation of conditions and the taking of photographs. Rubber packing formed of split rubber tubing was placed on the edge of the strips under the glass.

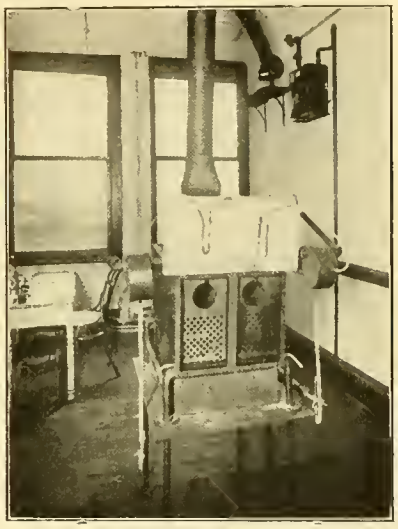

Fig. 2 View of Model Boiler, showing Outlet Pipes with Separators on Each Half of the Boiler and Gages for Measuring Output

The boiler was set with a slope of 1 in. to the foot over a gas furnace consisting of three large burners capable of burning 200 cu. ft. of gas per hr. One-inch asbestos lined the furnace and boiler casing. The baffling for the gases was of the parallel type in two passes. The boiler was set so that the gases entered at the rear of the bottom pass, Fig. 3*a*, and also with the relative position of furnace reversed, the gas entering the first pass directly in front, as shown in section of Fig. 3*b*. An induced draft fan drew the gases through the boiler.

PHOTOGRAPHS OF THE BOILER CIRCULATION

Photographs of the moving steam and water in the headers were taken at a speed of approximately 1/100 sec. with flash-light illumination.

When the circulation is poor and steam is slipping through the water the latter shows up transparent and the header appears almost empty, whereas where the steam and water are well mixed or emulsified, there is a distinct whitish color and marked contrast in the photographs.

Before a photograph was taken, the water was brought to the same level in each header without having the burners on. The level was slightly below the bottom of the drum in the front header as shown in Fig. 14.

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members, 20 cents to non-members.

Wherever bubbles of steam appear to be at rest in the photographs, it may be assumed that their velocity was no more than 1 ft. per sec., while streaks indicate higher velocities.

Steam was generated at atmospheric pressure and the volume was measured by orifices in the outlet pipes on each half of the boiler. As the volume of steam at atmospheric pressure is very great compared to that at 200 lb. (for example) a low load in pounds per square foot per hour on the model corresponds to a high load in terms of steam volume. The equivalent loads given in connection with the pictures are based on a boiler pressure of 200 lb., at which the steam volume is about 0.08 that at atmospheric pressure.

A greater proportion of the steam was generated in the bottom tubes. The relative loads in different rows was probably about the same as the average in an actual boiler, wherein the distribution varies considerably depending on the furnace temperature.

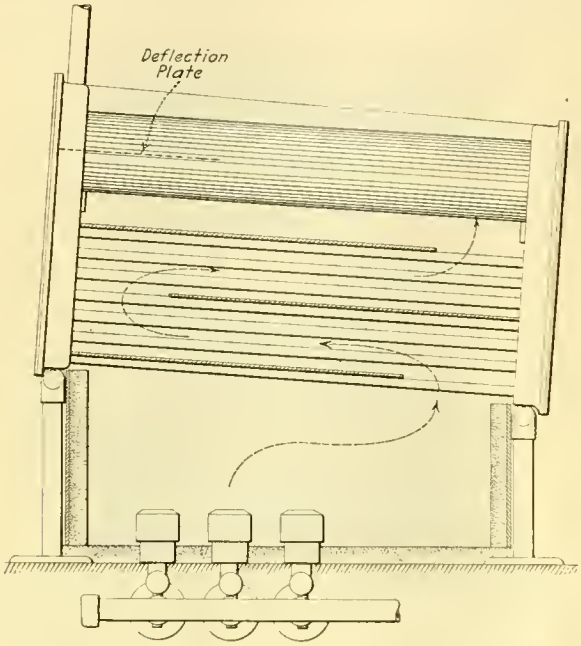

FIG. 3a MODEL WATER TUBE BOILER

Fig. 5 shows the circulation in the front headers at about 85 per cent of rating. On the left is a header with a flue for increasing circulation in the bottom tubes, and on the right the square header.

In the left hand half of Fig. 5, the greater evaporation is obviously taking place in the bottom tubes connected into the circulation flue where there is a well directed upward flow. The upper tubes of the boiler discharge into their compartments of the header very quietly and the steam slips up through the water and is liberated in the header. The pumping action, as in an air lift, is shown clearly in the central flue. The discharge is vigorous enough to strike the horizontal deflection plate in the center of the drum.

The right hand half of Fig. 5 illustrates how slip occurs in a header of relatively large area; the steam slips up through the water and is liberated largely in the header as indicated by the wide belt of foam formed at the surface of the water, which is to be contrasted with the quiescent conditions on the left. The steam and water issued from the bottom tubes as a homogeneous mixture filling the bore of the tubes and preserved this state as it turned up, but after a short distance it seemed to be absorbed by the comparatively large mass of water in the header. The tubes carrying lighter loads discharged steam and water from the upper part of the tube only.

A rotary flow can be seen in the square header, Fig. 5. The current rises at the left and falls at the right, the velocity being low or next to nothing where the bubbles can be distinguished.

Fig. 6 was taken at the same load but with low water level to show the effect of the circulation flue in the left hand boiler. The bottom tubes of this boiler are discharging water and steam up the flue into the drum, whereas no water is delivered to the drum from other sections of the header or from the header on the right hand side. Return circulation occurs through the upper tubes.

Fig. 7 shows the boilers steaming at approximately 275 per cent load and Fig. 8 about 450 per cent load. The upper tubes of the left hand boiler are now working more actively, but the relatively small amount of steam generated is indicated by the fact that about half the rows of tubes can be seen through water, especially in Fig. 7, the steam slipping through without causing a flow of water. The flow in the circulation flue is smooth and full bore. On the right there is violent commotion with whirls and swirls in all directions. The steam and water rise nearly to the top of the drum which indicates the head needed to make the turn and discharge the mixture into the drum.

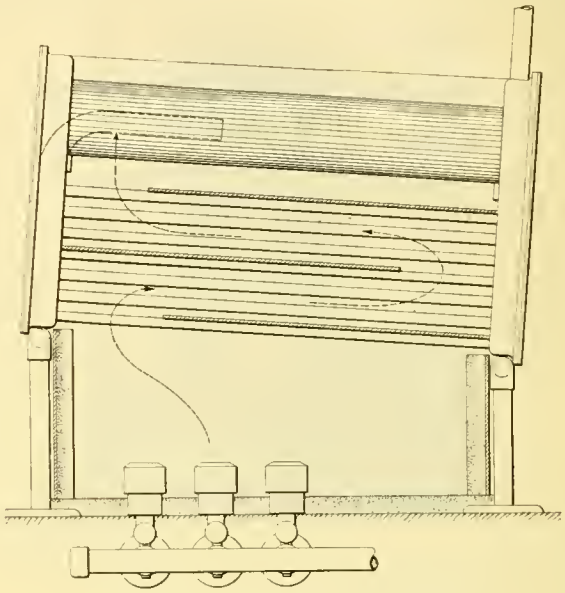

FIG. 3b MODEL WATER TUBE BOILER

Fig. 9 shows the lower right hand corner of the same type header to a larger scale, steaming at an equivalent load of 250 per cent. The circulation is upward on the left and downward on the right. The rush of circulation to the left of the header is presumably due to the fact that the heat is greatest in the center of the furnace, which corresponds to the left hand side of this header.

Fig. 10 shows Heine type headers in both parts of the boiler and double circulation flues on the left, these rising along the sides of the header in extensions which did not connect with any upper boiler tubes. No heavy mixtures were therefore discharged into the light steam water emulsion rising from the bottom tubes. The load was about 275 per cent. The discharge of the upper tubes of the left hand boiler slips through the water and the mixture in the center, near the top, is moving slowly, whirling in all directions. The right hand picture illustrates again the tendency for internal circulation in an open header; there is a marked rotary flow and downward

current on the right. A closer study of the figure will show what seem to be light shadows to the left of the tube ends in the bottom row. This is the discharge of steam slipping through the water. Fig. 11 shows the same boiler steaming at 500 per cent load.

Fig. 12 shows the Heine type header on the right and the single circulation flue on the left, at about 450 per cent load. The white streak across the right hand header is a cemented crack in the glass. Numerous small eddy currents or whirls can be distinguished. Bubbles that are nearly stationary are distinguishable all along the lower section, directly in the center and in the upper right hand corner—these forming the vortex of a whirl in a clockwise direction.

Fig. 13 shows a third arrangement of circulation baffle with three flues on the left, and a Babcock and Wilcox type header on the right; the load was about 450 per cent. Fig. 14, at no load, shows the construction of the header more clearly. The flow in the sections of the Babcock and Wilcox header was directly upwards, with no cross currents or whirls and only a slight sinuous movement, but was throttled by the nipples at the top of each section. Stationary bubbles can be distinguished in many of the headers. At low loads the slip through the headers was similar to that in the previous types, the

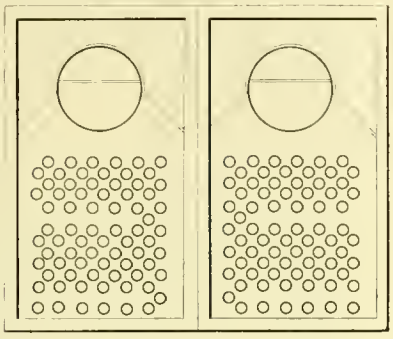

Fig. 3c Model Water Tube Boiler

bubbles rising through the water without causing discharge from the nipples.

Fig. 15 is a view of the rear headers when steaming at the same rate. The left hand header (corresponding to the Babcock and Wilcox type on the right in front) is boiling backward from the upper tubes, causing a fluctuating and higher water level. The white mark across the bottom of the right hand drum is caused by the splashing of the water against the glass.

Fig. 16 shows the rear headers at about 85 per cent load, a slight boiling back being noticeable here also. This figure shows another feature, however—the left hand drum is dry due to the poor circulation of the front headers into the drum, whereas the right hand drum is receiving water which can be seen emptying into the rear header. The steam slips through the water in the front headers on one side, without pumping water into the drum. The true water levels are equal, but about 3 in. low.

Reversal of boiling also occurred with other types of headers. Fig. 17 shows the boilers with front headers as in Fig. 10, steaming at 85 per cent. A number of tubes can be seen to be discharging steam. This occurred intermittently and would appear first at one tube and then another. Fig. 18 shows the rear of the boilers shown in front in Fig. 12 steaming at about 300 per cent load.

The back boiling was eliminated by reversing the boiler setting, that is, setting the boiler over the furnace so that the opening at the end of the lower horizontal baffling came at the front and higher end of the boiler, near the front header, as shown in Fig. 3b.

Fig. 19 shows the rear headers when the boiler was set in this manner, and the load was about 450 per cent. The rear headers were perfectly clear, and no discharge occurred from any of the tubes. The front headers were of the design shown in Figs. 5 to 9, which figures were also taken with the flow of hot gases entering the tube nest at the front.

Figs. 20 and 21 show the rear headers with the same setting, but with the Babcock & Wilcox type header at the front of the left hand boiler and the design of Fig. 4C at the front of the right hand boiler. The nipples of the sectional header were reduced one half in area by inserting sleeves. Fig. 20

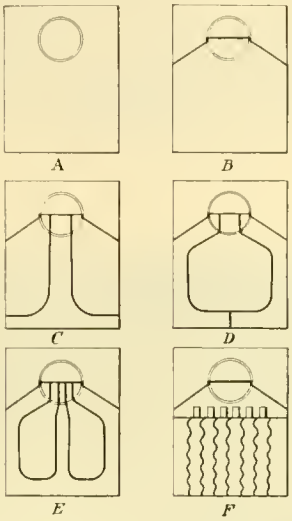

Fig. 4 Different Types of Headers Tested

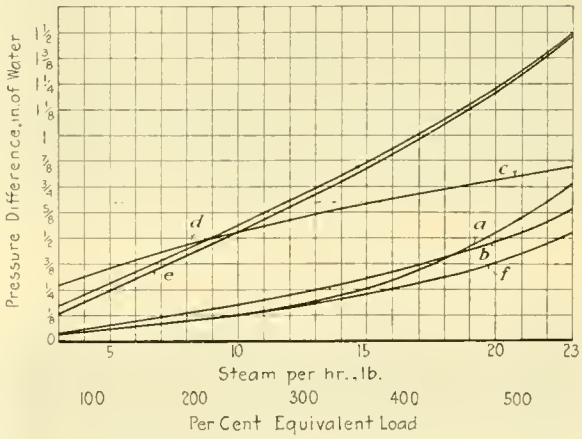

Fig. 22 Pressure Difference Tests, Headers 4A to 4F

shows a load of 300 per cent. While the true water levels were exactly the same, the left hand header shows a higher surface and also considerable commotion at the surface, due to reversal of circulation through the upper tubes. The water level fluctuated up and down with a swing of several inches. Fig. 21 shows the same boilers with 85 per cent load. The true water levels were equal but when steaming the level in the left hand unit fluctuated, rising and backing up the water in the drum and then falling.

In addition to the above tests on circulation, a series of tests was made in which the difference in pressure between the bottoms of the front and rear headers was measured. Curves in Fig. 22 show the results obtained. The letters in the figure correspond to the letters in Fig. 4. The circulation flues increase the pressure difference front and rear of the bottom

tubes and add to the circulation created in the tube itself due to the slope.

Boiling back, particularly from the upper tubes, takes place if the discharge area at the junction of header and drum is constricted.

CONCLUSIONS

Increased circulation in the lower rows of tubes of a horizontal boiler can be obtained by constructions which segregate the discharge from those tubes up through the front header into the drum, and by designing the circuit to prevent slip and to offer the least resistance, particularly at the entrance to the drum.

The velocity of circulation of a steam-water mixture increases about as the square root of the steam volume or load.

The volume of water circulated increases at first as the steam volume increases, reaches a maximum, and then decreases. The maximum load on a tube should not exceed that coincident with maximum water delivery.

The tendency for reversal of circulation is lessened by setting the boiler so that the gases strike the tube bank at its higher end.

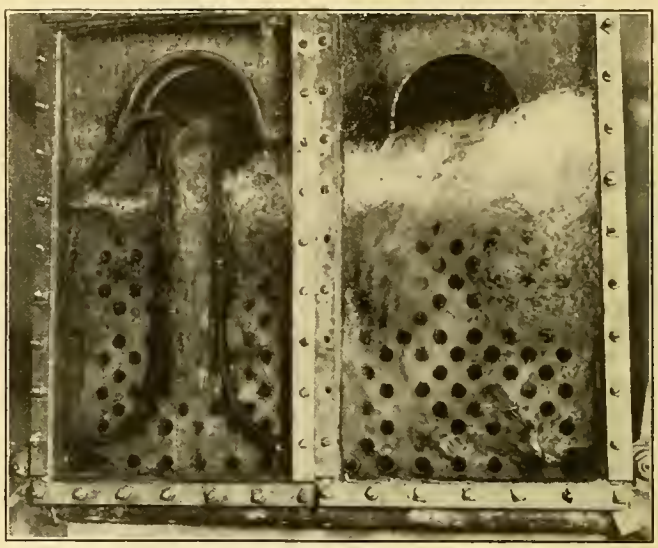

FIG. 5 FRONT HEADERS; LOAD 85 PER CENT; SETTING AS IN FIG. 3*b*

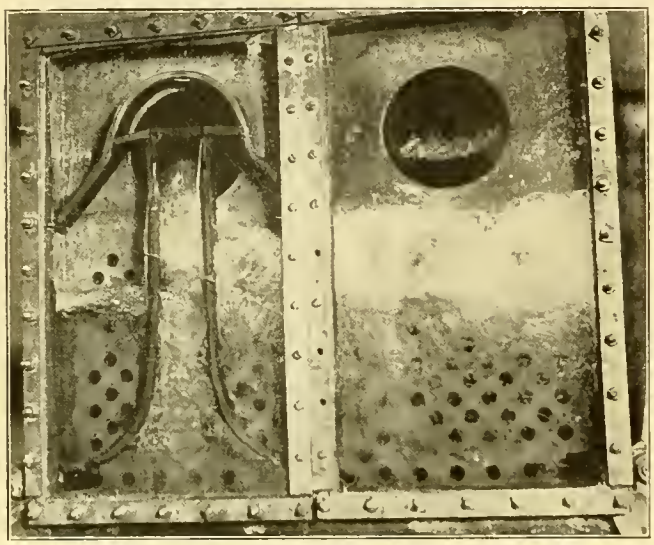

FIG. 6 FRONT HEADERS; LOAD 85 PER CENT; SETTING AS IN FIG. 3*b*; WATER LEVEL BELOW NORMAL

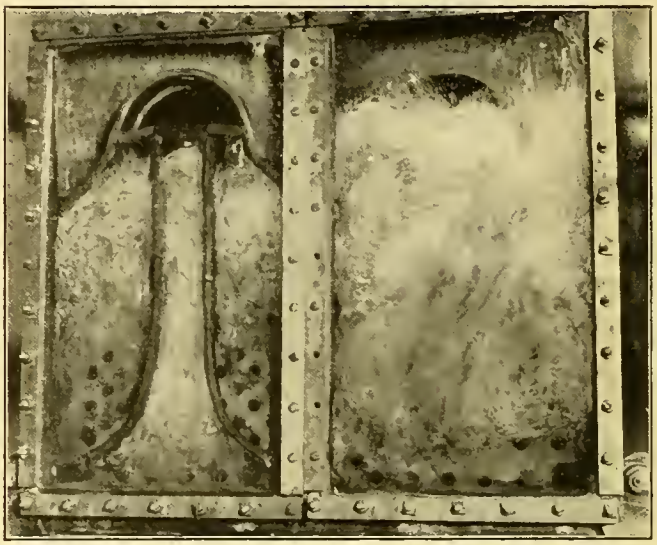

FIG. 7 FRONT HEADERS; LOAD 275 PER CENT; SETTING AS IN FIG. 3*b*

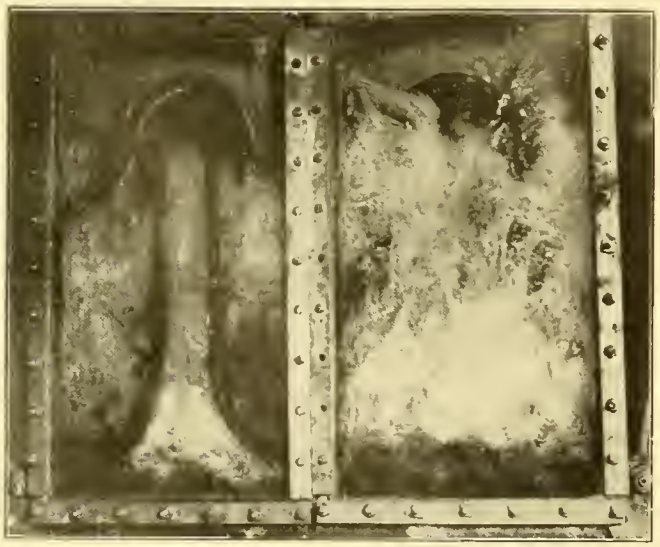

FIG. 8 FRONT HEADERS; LOAD 450 PER CENT; SETTING AS IN FIG. 3*b*

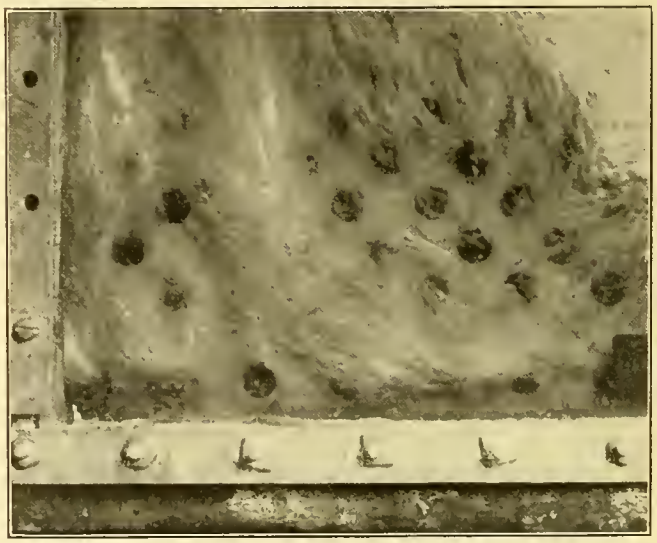

FIG. 9 LOWER SECTION OF SAME BOILER AS IN FIG. 8; LOAD 250 PER CENT; SETTING AS IN FIG. 3*b*

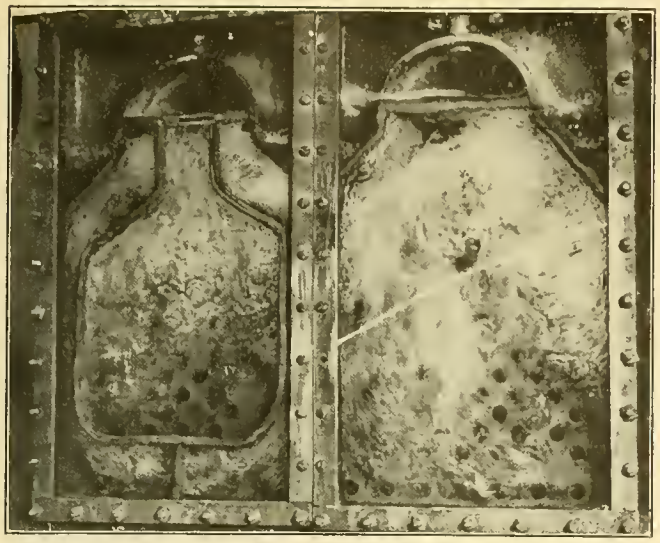

Fig. 10 Front Headers; Load 275 Per Cent; Setting as in Fig. 3a

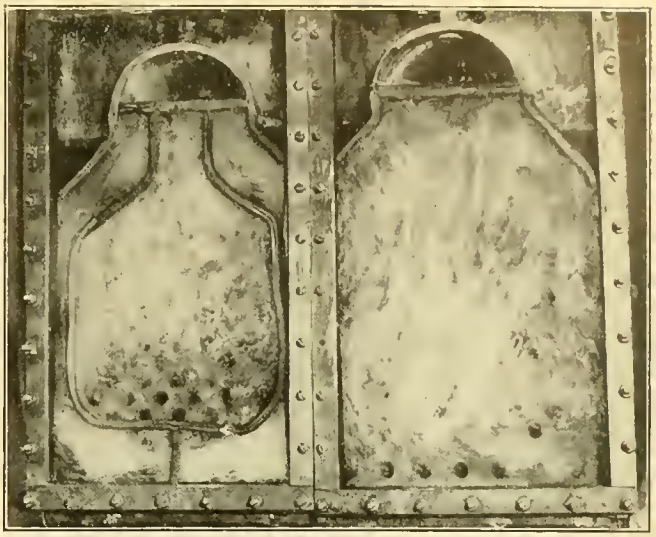

Fig. 11 Front Headers; Load 500 Per Cent; Setting as in Fig. 3a

Fig. 12 Front Headers; Load 450 Per Cent; Setting as in Fig. 3a

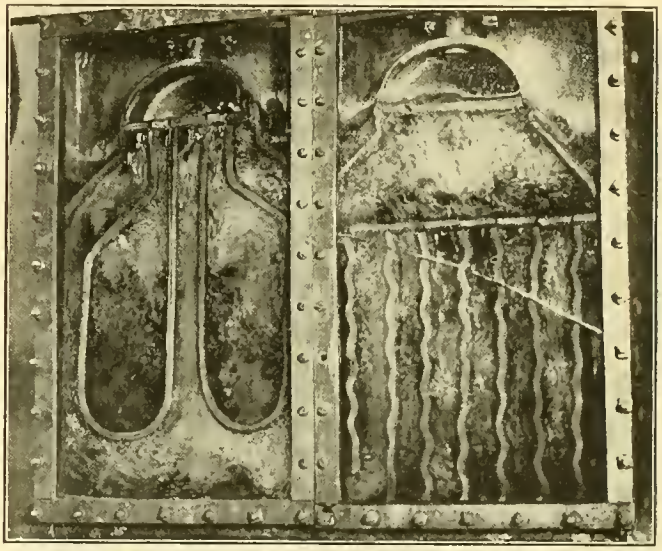

Fig. 13 Front Headers; Load 450 Per Cent; Setting as in Fig. 3a

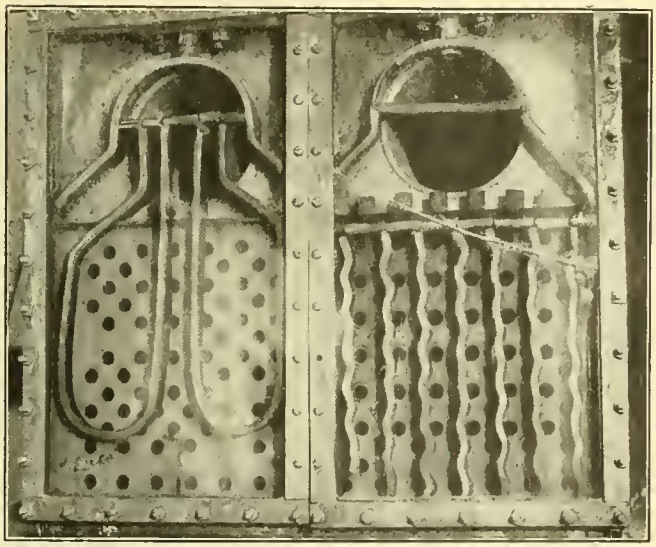

Fig. 14 Boilers without Load showing True Water Levels 1 in. below Bottom of Drum in Front Headers, and 1 in. above in Rear Headers

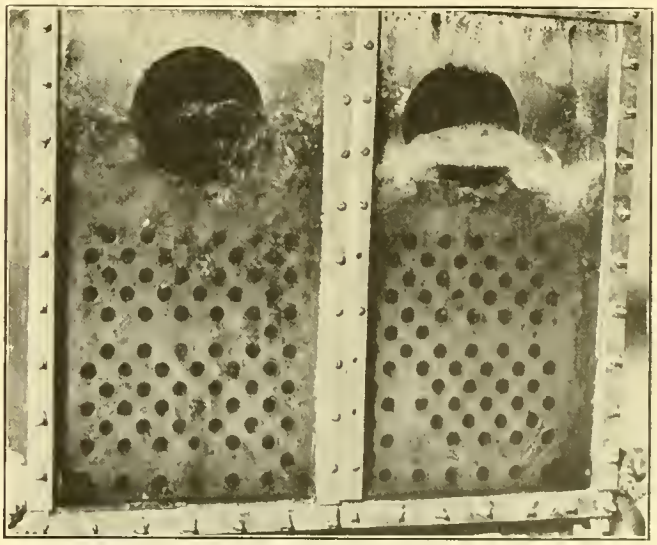

Fig. 15 Rear Headers Corresponding to Headers of Fig. 13 in Front; Load 450 Per Cent; Setting as in Fig. 3a

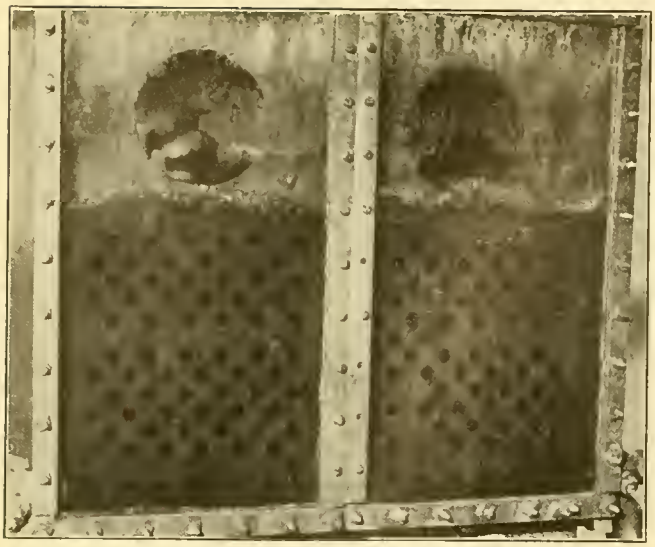

Fig. 16 Rear Headers Corresponding to Headers of Fig. 13 in Front; Load 85 Per Cent; Setting as in Fig. 3*a*

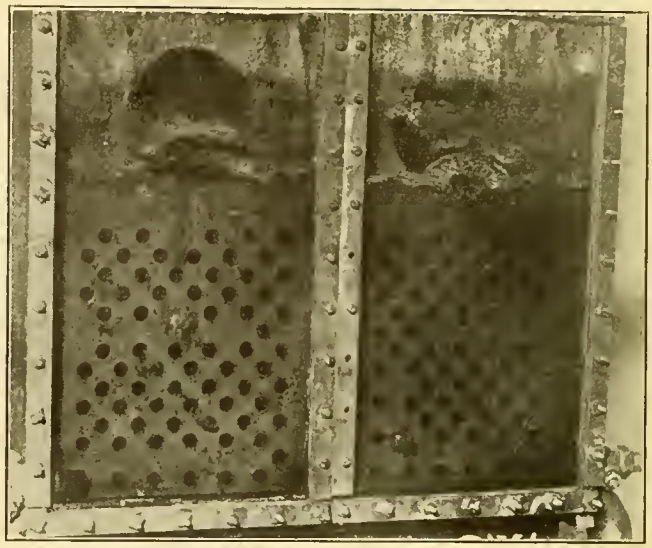

Fig. 17 Rear Headers Corresponding to Design of Fig. 10 in Front; Load 85 Per Cent; Setting as in Fig. 3*a*

Fig. 18 Rear Headers Corresponding to Design of Fig. 12 in Front; Load 300 Per Cent; Setting as in Fig. 3*a*

Fig. 19 Rear Headers Corresponding to Design of Fig. 5 in Front; Load 450 Per Cent; Setting as in Fig. 3*b*

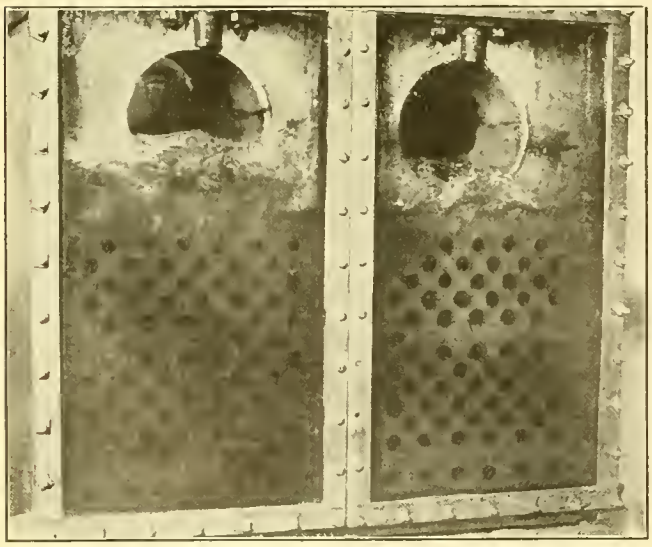

Fig. 20 Rear Headers Corresponding to Design of Fig. 4*F* and 4*C* in Front; Load 300 Per Cent; Setting as in Fig. 3*b*

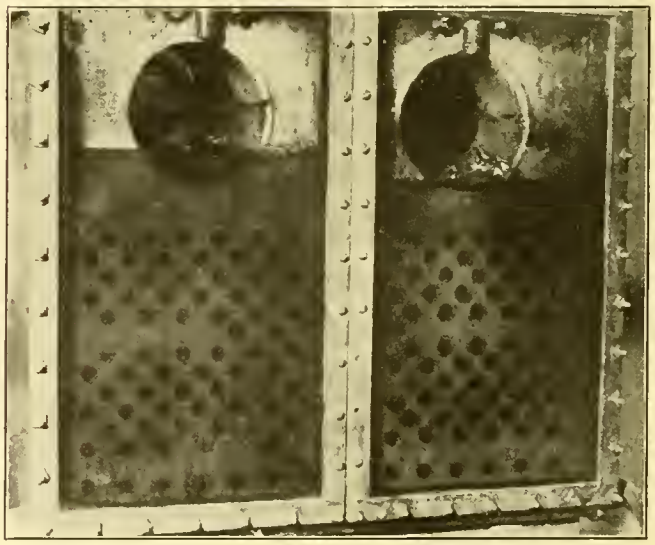

Fig. 21 Showing Rear Headers, same as in Fig. 20; Load 85 Per Cent; Setting as in Fig. 3*b*

PERFORMANCE AND DESIGN OF HIGH VACUUM SURFACE CONDENSERS

BY GEO. H. GIBSON, NEW YORK

Member of the Society

AND

PAUL A. BANCEL, NEW YORK

Junior Member of the Society

THE coefficient of heat transmission in an experimental condenser filled with pure steam appears from recent investigations to be a determinate quantity dependent upon steam temperature, water velocity, diameter of tube and mean water temperature and its value is of the order of 500 to 1500 B.t.u. per sq. ft. per hr. per deg. fahr. difference. In the commercial condenser the high rate of transmission undoubtedly existing for certain parts of the surface is masked by the large amount of relatively idle surface, so that the average coefficient for all the surface figures out much lower—sometimes as low as 50 B.t.u. The size and cost of a condenser to maintain a certain vacuum depend primarily on the extent of the zone of active condensation, that is, on how much of the surface does work and how much is idle. As will be shown, the problem is one of hydrodynamics as well as of heat transmission.

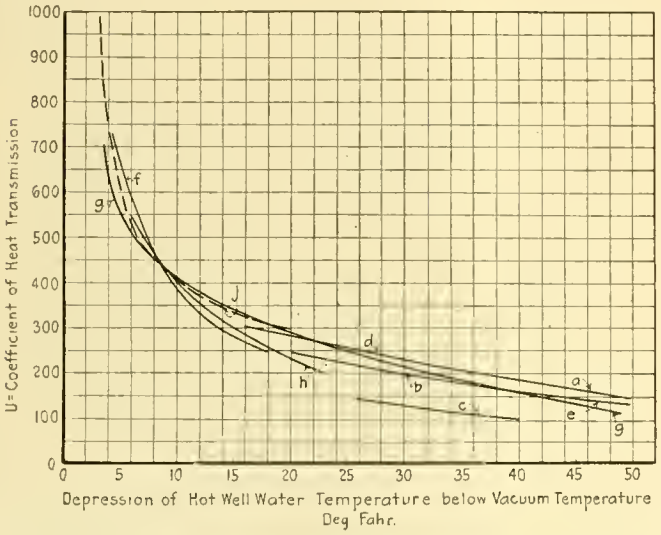

Fig. Relation Between Coefficient of Heat Transfer and Temperature Depression

These variations being commonly attributed to the presence of air and to imperfect stream distribution and penetration, modern high vacuum surface condensers are equipped with large capacity air pumps and are designed with liberal areas for the flow of steam through the tube bank, with the minimum depth of tube bank between inlet and outlet. When careful attention is also given to excluding air in leakage, high vacuums are successfully maintained. However, a condenser which will give a high coefficient of heat transfer when the test readings are taken under summer conditions with circulating water at temperatures of 70 to 80 deg. fahr., will also give relatively low values in winter with cold water; the warmer the water and the lower the vacuum, the smaller the mean temperature head required to transmit practically constant amount of heat through the surface.

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December, 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members, 20 cents to non-members.

DEPRESSION OF AIR PUMP SUCTION TEMPERATURE AS AN INDEX OF SURFACE EFFICIENCY

Examination of the results of a number of tests on commercial condensers, a vacuum evaporator, and a laboratory condenser indicates a definite relation between the coefficient of heat transfer and the difference between the steam temperature at the condenser inlet and the air temperature at the outlet.

The water velocity, mean water temperature and tube diameter affect the rate of transmission from the tube wall to the water, that is, the transmission on the *water side* of the tube, and their individual influences have been determined in experimental single tube condensers, so that corrections for these variables can be applied with a reasonable degree of certainty. Geo. A. Orrok's results have been used for the present purpose so far as possible.

The variables affecting heat transmission on the *steam side of the tube in an actual condenser* are complex and difficult of isolation; yet as an observed fact, their influence really dominates performance, since the coefficients of heat transfer still vary several hundred per cent after all variables affecting heat transfer on the water side have been allowed for.

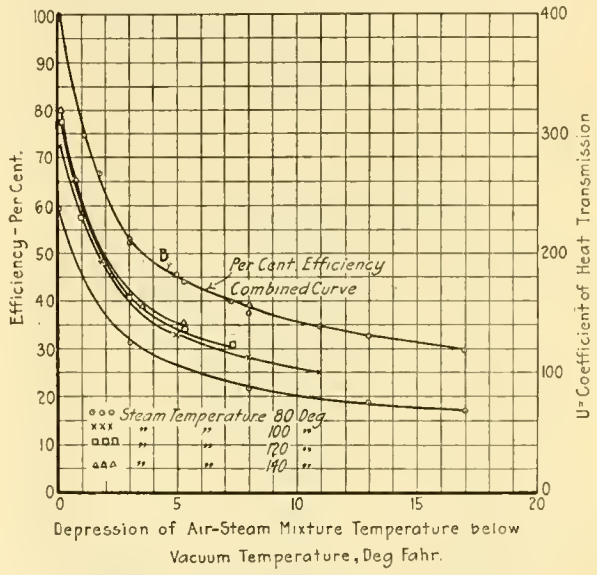

Fig. Relation Between Coefficient of Heat Transfer and Temperature Depression

In Fig. 1 the coefficient of heat transmission for a number of surface condensers is plotted against difference between steam and condensate temperatures. Graph *a* refers to a 24,000 sq. ft. condenser loaded to 5.9 lb. per sq. ft.; graph *b* to an 18,000 sq. ft. condenser loaded to 7.5 lb. per sq. ft.; graph *c* to an 18,000 sq. ft. condenser loaded to 4.07 lb. per sq. ft.; graph *d* to an 18,000 sq. ft. condenser loaded to 8.09 lb. per sq. ft., and graph *e* to a 21,000 sq. ft. condenser loaded to 5.95 lb. per sq. ft. Graphs *a* and *d* coincide. In graph *f*, for a 25,000 sq. ft. base condenser, the coefficient rises to a value of 850 B.t.u. for a single set of observations. Graph *g* refers to five condensers of different sizes, loads and vacuums, two with wet vacuum pumps and the others with hydraulic air pumps. Graph *h* shows the relation for a vacuum evaporator (in this case the actual air-steam mixture was observed, not the condensate).

Fig. 2 shows similar graphs based on results obtained by Prof. J. A. Smith with experimental laboratory apparatus. The four lower curves show the relations existing between the

coefficient of heat transmission and the number of degrees which the temperature of the air-steam mixture is below the steam temperature corresponding to the total pressure. Calling the heat transfer at zero air 100 per cent, all the results for different steam temperatures can be combined in a single percentage of efficiency curve, as shown by B, Fig. 2.

The maximum heat transmission, obtained by Smith with pure steam is low as compared with that obtained by Orrok and others.

Graph B is replotted as the dotted graph *j* in Fig. 1 by assuming the maximum coefficient to be 1000 at a condensate temperature 3 deg. below steam temperature, in order to bring

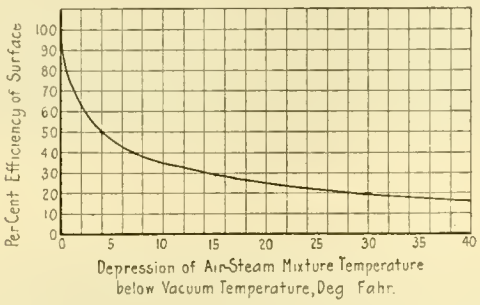

FIG. 3 EFFICIENCY OF SURFACE VS. TEMPERATURE DEPRESSION

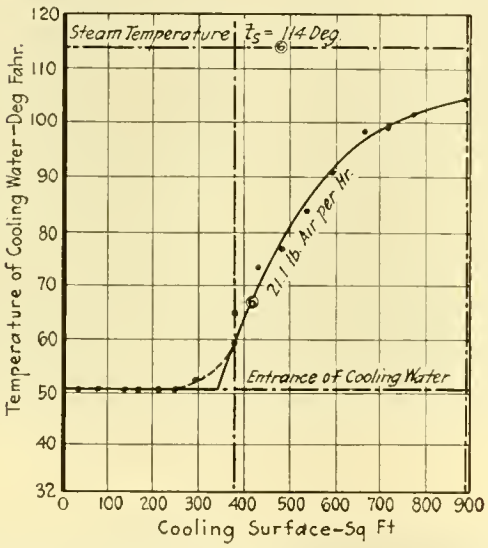

FIG. 4 RISE OF WATER TEMPERATURE IN PASSING THROUGH CONDENSER INDICATES ACTIVE AND INACTIVE ZONES

it into the region of the other graphs representing commercial condensers. Graph *j* is then seen to have the same trend as the others.

The graph of Fig. 3 was obtained by averaging the results represented in graphs *a, b, c, d, e, f, g,* and *h,* and expressing the heat transmission as a percentage of the maximum obtainable under the conditions of rate of heat transfer through the tubes and from tubes to water, prevailing in the condensers considered.

The performance of a condenser is usually dominated, to the exclusion of other factors, by the extent of the active and inactive zones of condensation. Thus tests show that the coefficient averaged for all the surface may *increase* as the water velocity *decreases.* The explanation is to be found in the lower vacuum and smaller specific volume of steam corresponding to the lower velocity, smaller quantity and higher final temperature of circulating water, under which conditions there is greater steam penetration and more surface is brought into action.

Other explanations of the variations in heat transmission coefficient have been founded principally on the variables affecting the water side of the tube or on the theory that a constant coefficient would be obtained by assuming the total heat transfer to vary as some fractional power of the instantaneous temperature difference instead of the first power.

We may assume for the present that the coefficient of heat transfer for a single tube immersed in steam depends on the water velocity (in an open tube or manner of agitation in other tubes), size of tube, material and cleanliness of tube and mean water temperature, but that all of these factors taken together do not explain the wide disparity of results obtained with actual condensers. We may also assume in the light of evidence that the total heat transfer is a function of the first power of the temperature difference and not of a fractional power as suggested by Loeb and Orrok.

Measurements of rise in temperature of circulating water in multiple pass condensers have shown that there are two

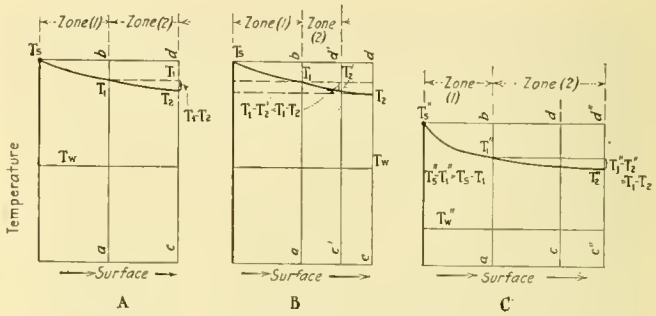

FIG. 5 VARIATION OF PROPORTION OF ACTIVE AND INACTIVE ZONES IN AN "ELASTIC" CONDENSER

COMBINED EFFECTS OF PRESSURE DROP AND AIR

fairly well defined zones in a surface condenser: one in which condensation takes place actively, the other wherein very little condensation takes place. Fig. 4 from a paper by Prof. Josse shows readings of water temperature and of heat absorbed in an actual condenser plotted against surface traversed. About 40 per cent of the surface is inactive.

Let us consider a condenser, Fig. 5A, in which steam condensation occurs up to line *a b* and air concentration during the flow over the remainder of the tube surface; i.e., nearly all the heat is transmitted to the water in that part of the surface preceding the line *a b*. The water temperature is assumed constant at T_w. In the first zone the temperature drop to T_1 is almost entirely due to the pressure drop required to overcome the pneumatic resistance offered by the condenser structure to the flow of a large volume of steam. From this region on, the temperature drop corresponds to the reduction in partial pressure of the water vapor, the drop in total pressure being negligible, due to the fact that the volume flowing in this zone of the condenser, where only 1 or 2 per cent of the steam remains, is very small. The partial pressure of the air at exit is represented by the difference of the vapor pressures corresponding to the temperatures T_1 and T_2, T_2 being the final air pump suction temperature.

Now assume that the air leakage is reduced, or the air pump capacity increased, so that the air withdrawal occurs at some lower partial air pressure represented by the smaller difference T_1—T_2' (Fig. 5B). A part of the zone (2) may then be

dispensed with and, as the same initial steam temperature T_s is maintained with less surface, the average coefficient of heat transfer will figure out higher.

Again, assume the case in Fig. 5C, wherein the water temperature is reduced and a higher vacuum maintained. If all of zone (1) up to *a b* is to remain active, the pressure drop expressed in head of steam must increase approximately in proportion to the square of the steam velocity and specific volume. Temperature T_1'', is therefore closer to the water temperature T_w'' than before. Furthermore, the difference between this temperature T_1'' and the air pump suction temperature T_2'' must increase in order to give the same partial air pressure with a lower total pressure. This is explained by Fig. 6. For a constant partial air pressure, which means constant air leakage with constant pump displacement, the temperature difference and the percentage of air richness must both increase rapidly as the vacuum increases. For these two reasons more surface will be required in zone (2) of Fig. 5C extending it to c''—d'' and the average coefficient of heat transfer will accordingly figure out lower. [The coefficient will also be further reduced because the average temperature of the steam is now lower through zone (1) on account of the greater pressure drop.]

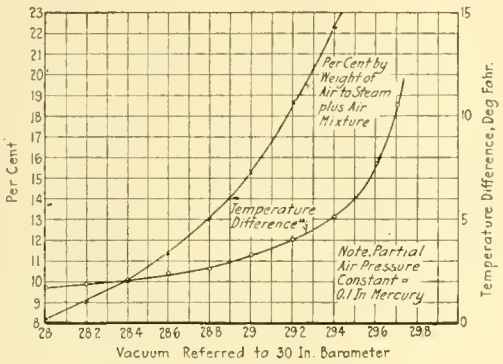

FIG. 6 PERCENTAGE AIR IN MIXTURE AND DIFFERENCE OF TEMPERATURES CORRESPONDING TO TOTAL PRESSURE AND THAT ACTUALLY EXISTING, FOR CONSTANT AIR PRESSURE OF 1/10 IN.

Many variables have to be taken into account to calculate the actual relative depths of these zones in a condenser. Among the independent variables which would need to be considered may be mentioned water velocity, initial water temperature, weight of water, tube diameter and cleanliness, arrangement of water passes, steam temperature, amount of air, air pump capacity, amount of surface and, perhaps most important of all, the arrangement or geometrical configuration of heat transmitting surface. However, we find that if the difference between vacuum temperature and air outlet temperature T_s—T_2 is increased by increasing pressure drop or by increasing the amount of air, there is a decrease in the average coefficient of transmission; and conversely if T_s—T_2 is decreased by decreasing pressure drop or decreasing the amount of air, there is an increase in the average coefficient. Empirical results showing the same relation have been given in Figs. 1, 2 and 3.

PRESSURE DROP

If the proportion of steam condensed per tube, the depth of penetration and the steam density were all constant, the loss of head through the first zone of the condenser would vary as the square of the velocity, or according to the well known relation for inelastic fluids $h=v^2/2g$. If the amount of steam condensed per tube and the steam density remained constant, but the penetration increased in proportion to the velocity of entrance, the pressure drop would vary as the cube of the entrance velocity.

Pressure drops actually observed usually fall between these limits. By dividing both the steam weight flowing and the pressure drop resulting by the mean specific weight of the steam, test readings can be expressed in terms of steam velocity and "head" of steam.

In Fig. 7 are plotted on logarithmic paper the heads and proportional velocities obtained in the experiments by Loeb on the Bureau feed water heater. The points agree very closely with a line of slope 2.5; that is, the head varies as $V^{2.5}$. The exponent of 2.5 can be explained on the basis that at increased loads the steam penetrates farther into the heater; it is like pumping water into a leaky distribution system. This is borne out by the quantities plotted in Fig. 8 for three condensers of large size. In these tests the increase in steam

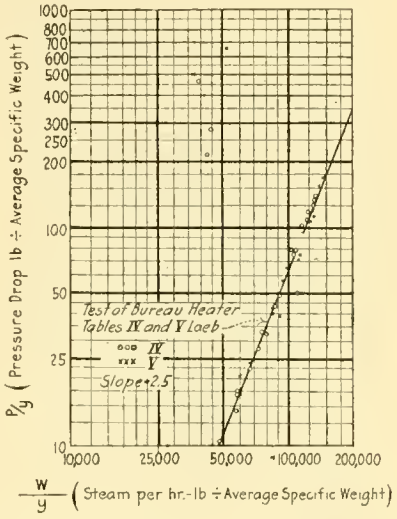

FIG. 7 RELATION BETWEEN PRESSURE DROP AND STEAM VELOCITY

velocity (weight per hour divided by specific weight) is due entirely to increase in vacuum and specific volume, the weight flowing actually decreasing at the higher velocities.

In some cases the increase in steam velocity is accompanied by decrease in active zone, and then it would be expected that the head of steam would vary as a function of the velocity less than the square. This occurs, for example, when the load is decreased, but the vacuum greatly increased, as by the use of very cold water. The decrease in load is accompanied by greater air leakage and this taken together with the fact that the air-steam mixture must be richer at high vacuum, as has been shown by Fig. 5, causes an increase in the inactive zone and shortening of the active zone. At the same time the velocity of the steam increases due to the higher vacuum.

If the depth of the active condensing zone is assumed to remain constant, however, we can assume that the head lost varies at least as the square of the velocity. In estimating performance, this is a provisional basis of calculation; for, as will now be evident, to calculate the pressure drop it is necessary to know the depth of penetration, which in turn depends on the average heat transfer which is the final result sought by calculation.

CALCULATION OF SURFACE EFFICIENCY

Assume that the several characteristics of a surface condenser are known for 28.5 in. vacuum, under which conditions

the pressure drop through the condenser is 1/10 in. of mercury column and the air pump capacity and air inleakage are such that the partial pressure of the air is 0.124 in. of mercury, so that the depression of the air pump suction temperature is 5 deg. below the steam temperature, corresponding to an efficiency, from Fig. 3, of 45 per cent.

We wish now to know the conditions at 29 in. vacuum. We have seen from Fig. 5 that additional cooling surface is required in zone (2) in order to reduce terminal pressure, so that the weight of steam at the greater volume corresponding to the higher vacuum can penetrate to the same depth in zone (1), wherein, in other words, greater pressure drop will occur. In the actual condenser, the surface remains constant, so that there must be a re-adjustment of working conditions, zone (1) becoming smaller because of resistance to the flow of the greater steam volume, also because more surface is required in zone (2) for air concentration.

[We must bear in mind that zone (1) is not only affected by

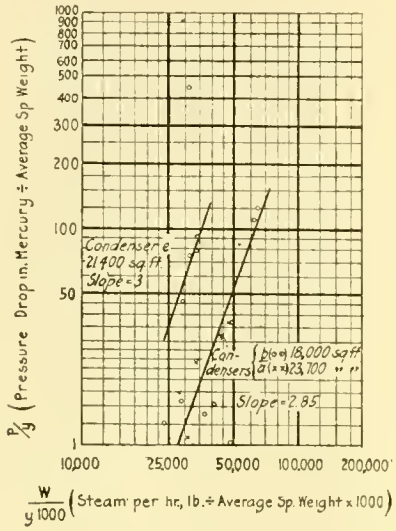

FIG. 8 RELATION BETWEEN PRESSURE DROP AND STEAM VELOCITY

pneumatic conditions but by the performance of zone (2) and of the air pump. Thus if we slow down the air pump, zone (1) will be shortened with consequent decrease in vacuum.]

We can calculate the pressure drop for the assumed elastic condenser of Fig. 5, wherein zone (1) always remains the same. This, in connection with the depression due to air pressure, leads to a temperature difference $T_s - T_2$ and a corresponding surface efficiency, which we will apply to the actual condenser.

Thus the pressure drop at 28.5 in. of 0.1 in. becomes 0.148 in. for the larger volume at 29 in. vacuum and the total pressure at the air suction is $(1-0.148)=0.852$.

Modern air pumps, particularly the hydraulic types, running at constant speed, remove practically a constant volume of air, that is, have constant displacement or equivalent displacement under wide conditions of operation. Therefore with constant air inleakage the partial pressure of the air in the air-steam mixture withdrawn from the condenser must also be a constant, neglecting the slight effect of temperature on air volume.

The partial air pressure thus remains equal to 0.124 and the partial vapor pressure is $0.852-0.124=0.728$ in. This pressure corresponds to a steam temperature of 69.5 deg., which is a depression of 9.5 deg. below the vacuum temperature, so that the efficiency of the condensing surface is now 36½ per cent, according to Fig. 3.

Similarly the depression for 29.2 in. vacuum is found to be 13.8 deg. and the efficiency 32 per cent, and so on for other vacuums, and a graph can be plotted as shown in Fig. 9, graph *A*.

Graphs *B*, *C* and *D* were obtained similarly, *B* being for a lower partial air pressure, due to less air leakage or a larger capacity pump, *C* for the same air conditions as *A*, but less pressure drop (as with better spacing of tubes), and *D* for both reduced air and less pressure drop.

Graph *B*: Reducing the air leakage (or increasing pump capacity) gives less temperature depression and hence raises the efficiency particularly at moderate vacuums.

Graph *C*: Reducing the pressure drop raises the high vacuum end of the efficiency curve and also extends it to higher vacuums. The efficiency of the surface at 29.4 in. vacuum is 36 per cent as against 25 per cent in graph *A*.

Graph *D*: Reducing both air leakage and pressure drop results in large increase in efficiency as shown by this graph.

ZONE CONDENSERS

We have been considering the conditions on the steam or steam-air side of the tubes, and the variations in the relative extension of the active zone of the condenser. The performance under any conditions will also be affected by the conductivity of the heating surface itself, dependent upon its

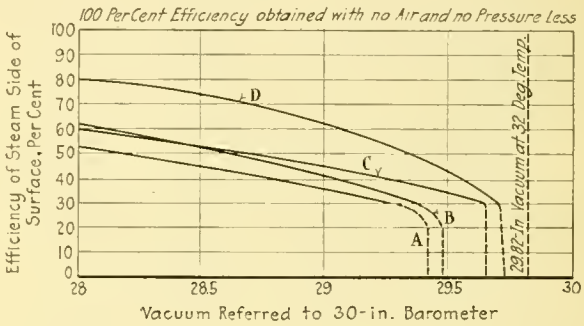

FIG. 9 EFFECT OF AIR AND PRESSURE LOSS ON EFFICIENCY

cleanliness and also upon the conductivity from the metal to the water within the tube. Fouling or scaling of condenser tubes will reduce heat transmission and can be corrected by cleaning only.

Assuming a clean condenser, the conductivity from the tube to the water becomes the controlling factor in the active zone, and therefore by increasing velocity, greater heat transmission and better vacuum can be obtained. In the inactive zone, however, any increase in velocity of the water is of little benefit. There is only a very small amount of heat being transmitted, so that the difference in temperature between the metal tube and the water is very small compared to the difference in temperature between the metal wall and the surrounding stagnant steam-air mixture. Hence any reduction in the already small temperature difference from metal to water gained by increase in water velocity has an imperceptible effect on the overall temperature difference between steam-air mixture and water and the corresponding rate of heat transfer, just as an increase in the size of the valve placed on the end of a long, small diameter pipe line, will not result in any appreciable increase in quantity of water discharged.

Thus whereas it is profitable to increase the water velocity through the tubes in the active zone of the condenser, any such increase is of no value commensurate with its cost in the inactive zone. A decrease of velocity in these tubes is even desirable, because by such decrease the power for pumping the circulating water can be decreased, or else for the same

power a higher velocity of water can be maintained through the tubes of the active zone where it will do some good. A large flow of water is not required for heat absorption in the inactive zone, as relatively little heat is transmitted here.

The application of this principle is shown by the sketches of Figs. 10, 11 and 12. In Fig. 10 a condenser is arranged with two passes, one containing three-fifths of the surface and the other two-fifths of the surface, the former being intended to comprise the active and the latter the inactive zone. All of the water is passed through the tubes of the active zone at high velocity. A part only of the water passes through the tubes of the inactive zone, the rest being short-circuited through the by-pass. If the velocity of the water through the inactive-zone tubes were one-fifth of that through the active-zone tubes, the head lost would only be 1/25 as great, with corresponding saving of power for pumping the circulating water. Thus, for the same circulating pump power as ordinarily required with a standard two-pass condenser, more water may be pumped and higher water velocity maintained through the active tubes of the condenser. Fig. 11 shows how the same conditions are obtained using two circulating pumps.

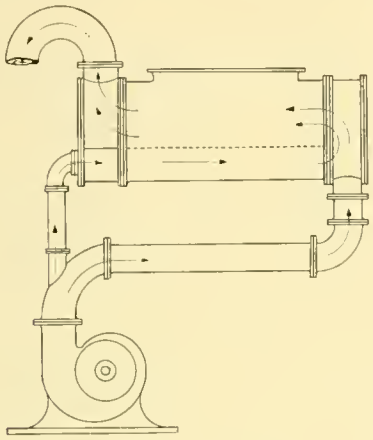

Fig. 10 Two-Pass Condenser with Active and Inactive Zones

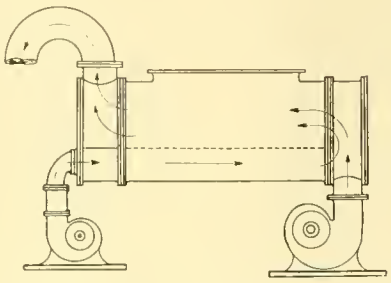

Fig. 11 Two-Pass Condenser with Active and Inactive Zones, Two Pumps

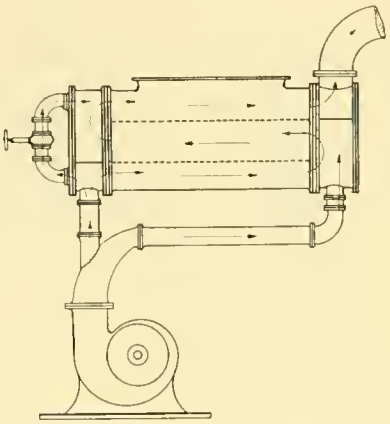

Fig. 12 Three-Pass Condenser with Three Zones of Different Activities

In Fig. 12 is shown a three-pass condenser in which the velocity in the lower zone is small, in the middle zone fairly high, and in the upper zone the maximum. All of the water goes through the upper zone, but only part of the total through the other zones. By manipulation of the valve, the quantity of water going through the zones is varied to take care of different conditions of operation in summer and winter, and of load, air leakage, air pump capacity and vacuum. A three-pass zone condenser may also be built with, say, half the tubes in the bottom or first pass and the other half of the tubes divided between the two upper passes. The objection to this design is that the inactive zone is too large (one-half the total) and the water velocity still too high.

CONCLUSIONS

The lower average heat transfer coefficient obtained with cold circulating water is due principally to a greater proportion of the surface being inactive, which in turn is due to greater pressure drop incidental to the flow of a larger volume of steam and to the greater proportion of air to vapor existing in the mixture stagnating in the outlet zone of the condenser.

Better efficiency of surface at high vacuum can be obtained by preventing air inleakage, increasing pump capacity and decreasing the pressure drop or pneumatic resistance of the condenser by proper arrangement of steam path and spacing of tubes, these being of great importance at very high vacuums.

The pressure drop through a condenser, expressed in terms of head of steam, varies as a function of the velocity of the steam, greater than the square if the increase in velocity is accompanied by an increase in average heat transmission coefficient and in depth of penetration, or smaller than the square if the increase in velocity is accompanied by a decrease in average heat transmission coefficient and in depth of penetration.

In purchasing high vacuum condensers, comparison should be made of the pneumatic resistance of the structures on the basis of velocity of flow at each row of tubes and the number of rows in series through which steam must flow. Attention should also be given to possibilities for the formation of air pockets out of the line of flow, considering both transverse and longitudinal sections.

The highest coefficients of heat transmission are obtainable in condensers of moderate size in which the smaller depth of tube bank lessens the pneumatic resistance.

The depression of the air suction temperature below the inlet vacuum temperature is an index of the surface efficiency, on the steam side.

By analyzing the temperature depression in a given condenser into that due to pressure drop and that due to partial air pressure, it is possible to determine whether flow conditions or air conditions offer the greater possibility for improving efficiency and vacuum.

By means of accurate electrical resistance thermometers temperatures can be taken at a multitude of points on both steam and water sides of the surface of a condenser undergoing changes in operating conditions, which would enable one to isolate the factors influencing the extent of the active and inactive zones.

A high velocity of circulating water, or the equivalent increase in water film agitation by the use of cores or spirals, is desirable in the tubes of the active zone of a condenser; and this can be obtained, without additional power consumption in pumping the circulating water, by reducing the velocity of the water through the tubes of the inactive zone.

APPENDICES

In two appendices to the paper are discussed at some length the effects of viscosity, velocity and temperature difference on coefficient of heat transfer in high vacuum surface condensers.

HIGHER STEAM PRESSURES

BY ROBERT CRAMER, CHICAGO, ILL.

Member of the Society

THE history of the development of the steam engine presents a gradual but continuous and persistent rise of steam pressures, so that it seems natural that engineers should ask the question: "How far can steam pressures be practically and profitably increased?" Pleas for higher steam pressures have several times resulted from investigations of this subject; one of the most remarkable of these was Prof. R. H. Thurston's paper on the "Promise and Potency" of High-Pressure Steam, before the Society in December, 1896.

Since the science of thermodynamics has been recognized by engineers as a sure guide to improvement of heat engine economy, there has existed a tendency to increase the temperature range of the working fluid, that is, to increase the temperature at which the working medium absorbs heat and to lower the temperature at which it rejects heat. In steam engine practice this has led to the recognition of well defined limits: a maximum steam temperature of about 600 deg. fahr., above which lubrication of piston engines and maintenance of valve parts and packings is difficult, and a minimum condenser temperature of about 80 deg. fahr., corresponding to 29 in. of vacuum or ½ lb. per sq. in. back pressure. This temperature is so near the usual cooling water temperature that a higher vacuum would require disproportionately large quantities of circulating water. The necessary size of the circulating pump and also the necessary increase in the size of the air pump render higher degrees of vacuum unprofitable.

In the best present day practice, except for slightly higher pressures in some few isolated cases, the maximum steam pressure is 200 lb. per. sq. in. abs., and the superheat is 200 deg. fahr. The corresponding temperature of evaporation is 382 deg. fahr. and the bulk of the heat is absorbed at a temperature 200 deg. fahr. below the maximum. It seems reasonable to expect that the approximation to the ideal Carnot cycle, and simultaneously the economy, would be improved by using higher pressure and less superheat, that is, by increasing the temperature at which the bulk of the heat is absorbed, without increasing the maximum temperature. Even a casual reference to steam tables and diagrams confirms this expectation and reveals the remarkable fact that the higher the steam pressure, the less the total heat in the steam if the final temperature be kept constant and correspondingly, the superheat is reduced with advancing pressures.

An examination of the Mollier total heat-entropy diagram shows that the amount of heat convertible into mechanical energy in adiabatic expansion to any given back pressure is considerably higher for high pressure and little superheat than for lower pressure and more superheat, if the maximum temperature of the steam is the same in both cases. We have thus two causes making for better thermal efficiency with increasing steam pressures at constant maximum temperature: the decreasing total heat of the steam and the increasing amount of that part of the heat which is convertible into mechanical energy in adiabatic expansion.

Fig. 1 illustrates the theoretical gains due to high steam pressures by means of the temperature-entropy diagram. This shows clearly how the relative amount of convertible heat increases with higher pressures, and the tabulations in Table 1 give exact numerical values.

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Tables 2 and 3 give the theoretical percentage of gain for certain comparisons, selected on account of their relation to conditions prevailing in present day practice. These tables show that, even in case of high vacuum in the condenser, the gains, while not overwhelmingly large, deserve careful consideration, and that in case of atmospheric exhaust, these gains are so large as to fully justify an endeavor to realize high steam pressures in practice. Theoretically, the efficiency of high pressure noncondensing engines should be as high as that of many condensing engines under present day conditions.

In all the comparisons the steam pressures are carried up to 1574 lb. per sq. in., which is the pressure at which saturated steam has a temperature of 600 deg. fahr. At the present time such high pressures should hardly be advocated, but the figures clearly indicate the gain which might be realized could designs of engines and turbines which are suitable for such steam pressures be successfully worked out.

TABLE 1 COMPARISON OF EFFICIENCY WITH DIFFERENT PRESSURES

Exhaust 29 In. Vacuum

Initial Condition of Steam			Heat Units In 1 Lb.		Ideal Efficiency	Ratio Compared with 1st Line	Cycle in Temp-entropy Diagram Fig. 1
Pressure Lb. per Sq. In. Abs.	Superheat Deg. Fahr.	Temperature of Steam, Deg. Fahr.	Total above Exhaust Temperature	Convertible in Adiabatic Expansion			
200	218	600	1267	417	0.3285	1.000	*a b c d e a*
600	113	600	1251	467	0.3730	1.135	*a f g h i* a_1
1574	0	600	1128	454	0.4025	1.226	*a k l m a*
Atmospheric Exhaust							
125	0	344	1010	157	0.1552	1.000	a_1 *n o p* a_1
600	113	600	1119	291	0.2600	1.675	a_1 *f g h q* a_1
1574	0	600	996	305	0.3062	1 972	a_1 *k l r* a_1

TABLE 2 RELATIVE GAIN IN THERMAL EFFICIENCY DUE TO INCREASING STEAM PRESSURE TO 600 LB. PER SQ. IN. ABS.

Final Condition of Steam	29 In. Vacuum		Atmospheric Exhaust	
Initial Condition of Steam	Constant Temperature 600 Deg. Fahr.	Constant Superheat 100 Deg.	Constant Temperature 600 Deg. Fahr.	Constant Superheat 100 deg.
As against 100 lb. initial pressure...	25 per cent	30 per cent	52 per cent	85 per cent
As against 200 lb. initial pressure...	13 per cent	15½ per cent	32 per cent	37½ per cent

The following considerations will show how far the benefits of high steam pressures may be realized under practical conditions, as far as our present knowledge and experience enable us to realize them.

The ideal Rankine cycle cannot be realized in practice. In steam turbines the expansion of the steam cannot be effected without friction losses which are converted into heat and to that extent make the expansion deviate from the adiabatic. It is also impossible to fully extract the mechanical energy which manifests itself in the velocity of the steam, the residual velocity representing a loss.

In piston engines of the double-flow type there are large losses due to initial condensation at the time of steam admission and to heat transfer between the steam and the cylinder walls. In the unaflow type of piston engine, properly designed, these losses can be almost entirely avoided. In this latter type of engine it is, however, impossible to carry the

expansion down to the condenser pressure, because if such were done the compression, which commences at the same point of the stroke where the expansion ends, would simply be an exact reversal of the expansion. Thus, the compression curve would retrace the expansion curve and no work would be done in the cylinder. In fact in this case no steam could enter the cylinder, because the clearance would contain as much steam of the same pressure and volume as that admitted for expansion.

These sources of loss, friction in the turbine, condensation in the double-flow piston engine and incomplete expansion in the unaflow engine, determine the practical limits of the possibility of realizing the Rankine cycle. In large steam turbines this approximation, or the Rankine cycle efficiency, has been carried to about 76 per cent, and it is a remarkable fact that an efficiency closely approximating this has been realized in unaflow engines, even in small sizes.

There is no reason why the same relative efficiency should not be realized with higher steam pressures. Such losses as are simply due to temperature differences must be the same if the initial and final temperatures of the steam remain the same, because the temperature changes through which the steam passes in performing the cycle are of the same magnitude in both cases.

TABLE 3 RELATIVE GAIN IN THERMAL EFFICIENCY DUE TO INCREASING STEAM PRESSURE TO 1574 LB. PER SQ. IN. ABS.

Final Condition of Steam	29-in. Vacuum	Atmospheric Exhaust
As against 100 lb. initial pressure, 100 deg. fahr. superheat	41½ per cent	187 per cent
As against 200 lb. initial pressure, 218 deg. fahr. superheat	22½ per cent	105 per cent

In a steam turbine higher steam pressures will mean either higher velocities or more stages, both introducing higher friction losses. It is, however, to be expected that by careful design the percentage of these friction losses as compared with the total amount of energy available in adiabatic expansion can be kept the same as in present day practice. In unaflow engines it is quite possible to keep the percentage of loss due to incomplete expansion as low as the corresponding percentage in present-day practice.

The foregoing seems to justify the employment of higher steam pressures. Standard boiler designs, however, do not permit the production of steam of a pressure higher than about 200 lb. per sq. in. without sacrificing safety and without calling for an investment in the boiler plant high enough to offset the gain in economy caused by higher steam pressures.

The solution of the problem of boiler safety under high steam pressures demands two fundamental changes in boiler design:

a The boiler must be constructed entirely of tubes of relatively small diameter. All drums and vessels of large diameter, as well as all flat surfaces (even if stayed) must be abandoned.

b Expanded, beaded or riveted joints exposed to the action of the fire must be avoided. That part of the boiler which receives the heat of the furnace must be practically a one-piece structure.

It is important that in meeting these requirements the essential characteristic of water circulation in the boiler be retained in order to make possible a control of the steam pressure and of the water content of the boiler by simple means. Flash boilers, while permitting high steam pressures, are not desirable because they require complicated automatic regulating devices necessary on account of the interdependence of feed and fire control.

In considering boilers for high steam pressures, it must not be overlooked that the mass of water in the boiler is at a higher temperature than that in a low-pressure boiler. This difference amounts to approximately 100 deg. for 600 lb. pressure as compared with 200 lb. Even if the heating surface is made very large, or, in other words, the evaporation per square foot is kept very low, the stack gases will leave the high-pressure boiler at a temperature 100 deg. higher than the corresponding gases of the low-pressure boiler. The boiler efficiency, other things being equal, is correspondingly reduced.

It is, of course, possible to meet this difficulty by making the heating surface of high-pressure boilers larger in proportion to what is current practice in boilers working under pressures used today. It is also possible to increase the effectiveness of the heating surface by proper design. Boiler designers are realizing the possibilities in this direction, even with steam pressures not higher than 200 lb. This is demonstrated by the fact that modern boilers show an evaporation per square foot of heating surface twice as high as was customary only a few years ago, at the same time realizing a better efficiency than formerly.

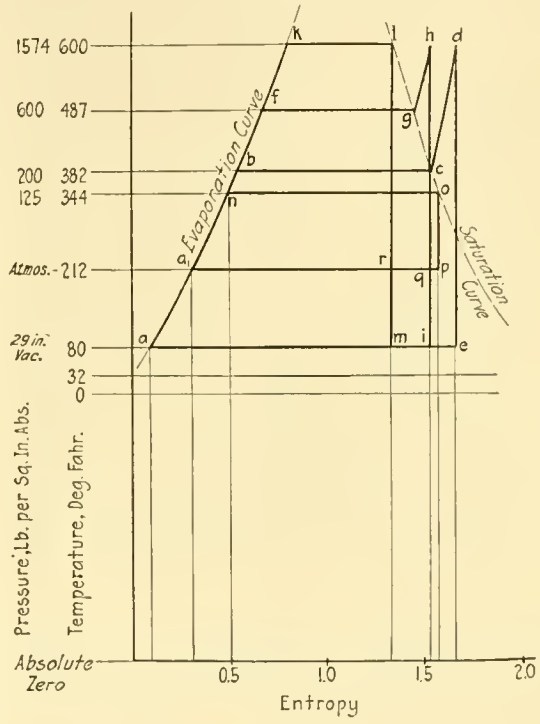

Fig. 1 Temperature-Entropy Diagram for Steam

It therefore seems reasonable that highly efficient high-pressure steam boilers can be made, even without resorting to special heat saving apparatus to offset the effect of the higher temperature of the water in the boiler. The possibilities of these extraneous heat saving devices should, however, not be overlooked. Even though the waste gases leaving the boiler have a temperature of 700 deg. fahr. or more, a properly installed economizer will reduce this temperature to any desired degree within the limits given by the temperature of the feed water. Even a very small economizer will save enough heat to offset the loss due to the higher temperature corresponding to higher pressure. In some instances, the waste gases might profitably be used to heat the air which supports combustion in the furnace.

The question of strength of constructional parts outside of the boiler to withstand high steam pressures is of great importance. In reciprocating engines this question can be answered from practice, because pressures far exceeding 600 lb. per sq. in. are used successfully in gas engines and Diesel engines, and therefore the design of cylinders for high steam pressures should not present any difficulties which have not already been overcome in other types of machines.

In steam turbines, especially in those of larger size, the casings of large diameter would need to have disproportionately heavy walls were they required to withstand pressures much higher than those employed today. The solution of the problem of adapting turbines to high pressures is found in the principle underlying most present designs of large steam turbine units. According to this principle, the pressure of the steam is greatly reduced in the first nozzle and the resulting high velocity is utilized in several rows of blades of the velocity stage type. Thus, it is possible to confine high pressures to the steam piping and to the "steam belt" carrying the steam to the first nozzles, but to have comparatively low pressure even in the first part of the casing. The lesser efficiency of the velocity staging is not so serious at the high-pressure end as it would be at the low-pressure end, because the loss manifests itself in a somewhat higher superheat of the steam entering the succeeding stages and is therefore partly recovered.

With high pressures, the difficulties with piping and fittings are greatly reduced on account of the reduced specific volume of the steam. Even if lower rates of flow than those customary in present practice are permitted in high-pressure steam lines (on account of the greater density of the steam), the fact that one pound of steam at 600 lb. pressure occupies approximately one-third of the space required by one pound at 200 lb. pressure reduces the required size of the piping and fittings to such an extent that both difficulties in design and cost for a given capacity are, if anything, less than for lower pressures.

In piston engines the question of cylinder lubrication is important. It is apparent that high steam pressures will permit neither slide nor Corliss valves. The advent of higher pressure will cause the poppet valve to come into its own in America, where it is now seldom used, in spite of the great success it has had in Europe for many years, lately the flexible seat type especially.

The largest part of the lubricating oil now used in piston engines is required for the steam distributing valves. That part required by the piston and piston rings is very small and the possibility of sufficient piston lubrication is not affected by higher initial steam pressures, because even in case of very high mean effective pressures in single-acting engines, where the piston serves as cross-head and therefore requires constant lubrication, the piston can be made long enough to keep the pressure per square inch within proper limits.

For a given output the cost of a unaflow engine suitable for high steam pressures should be less than that of double-flow engines, as soon as it can be manufactured under economical conditions of manufacture. Such an engine, if single-acting, has but one very simple organ of steam distribution and on account of its high mean effective pressure its weight per horsepower is low. Even in a single-acting engine of this type the mechanism is utilized twice as efficiently as in a four-stroke cycle Diesel engine.

Steam turbines for high steam pressures would probably cost a little more than those using lower pressures and giving the same power, on account of the extra stages required. This extra cost would be offset by a considerable saving in the required condenser cooling surface on account of the larger percentage of moisture in the steam entering the condenser and the reduced steam consumption due to better thermal efficiency. Table 4 will make this clear.

The question of stuffing boxes can be entirely eliminated in both turbines and piston engines—in turbines because high steam pressures need not be carried beyond the first nozzle, and in piston engines because the single-acting type of engine is from many points of view the logical design for high pressures. In such a piston engine the stem of the one valve can be provided with a "labyrinth" packing, as has been successfully done in practice.

TABLE 4 REDUCED STEAM CONSUMPTION DUE TO BETTER THERMAL EFFICIENCY

Initial Condition of Steam	200 lb. 600 Deg. Fahr.	600 lb. 600 Deg. Fahr.
Ideal efficiency with 29 in. vacuum	0.329	0.373
Percentage of steam in exhaust	0.814	0.749

Ratio of condenser cooling surface=0.329×0.749/0.373×0.814=0.812. Thus, a saving of about 19 per cent of the condenser cooling surface might be expected.

In the design of power houses the question of the proper arrangement of the auxiliary apparatus, such as feed pumps, air and circulating pumps, fans and stokers, would have to be considered from the point of view of high steam pressures. In very large plants all auxiliaries are often driven by electric power, and the current for them is furnished by a separate power unit. Inasmuch as these "house service units" in modern power plants have capacities of 2000 kw. and over, it is a simple matter to operate them directly with high-pressure steam.

Where it is desired that the auxiliaries be driven entirely independent, it should be possible to drive them with high-pressure steam turbines if the size of the auxiliary unit warrants this, or by high-pressure unaflow engines for the smaller sizes. In this latter case, the objection might be raised that the exhaust of the unaflow engine would introduce a certain amount of lubricating oil into the condenser. This question can be met in different ways. If the unaflow engine is of the vertical single-acting type, the lubrication can be reduced to a very small amount, and could possibly be accomplished with graphite only, so that the amount of lubricant introduced into the condenser would be insignificant and harmless.

Another way of meeting this question would be the noncondensing operation of the unaflow engines, using the heat of their exhaust in a feed water heater. This manner of operation appears to be very attractive, because the economy of noncondensing unaflow engines, as compared with noncondensing engines of other types, is extremely high. Where clean feed water is readily available, the method would be readily applicable, or the unaflow auxiliary units might be connected to an independent small jet condenser.

It seems clear that if steam pressures are increased to, say 600 lb. per sq. in. without using temperatures higher than those employed in modern practice, the difficulties encountered by the designer are not formidable and are more easily met than in the case of some types of explosion engines which have been successfully designed. The result to be attained by adopting such high steam pressures appears to be fully worth the effort, because thermal efficiencies closely approaching those of explosion engines can be realized with simpler apparatus and consequently better overall economy, at the same time retaining all the great practical advantages which steam utilization has over any other method of producing power.

PROPORTIONING CHIMNEYS ON A GAS BASIS

BY A. L. MENZIN, PHILADELPHIA, PA.

Associate-Member of the Society

THE first half of this paper is devoted to the mathematical development of the data required for calculating chimneys on a gas basis, taking into account the increasing tendency to operate boilers at higher overloads, the attention being given to baffling as a factor in improving boiler performance, and the efforts to improve the efficiency of combustion, resulting in a reduction of the volume of gases to be removed.

In the second half the applications of the formulae and data are exemplified by the consideration of the following problem: What sizes of chimneys will be suitable for two 500 h.p. boilers for continuous operation at not over 150 per cent of rating? The temperature of the air will not exceed 80 deg. fahr., and the breeching will be about 50 ft. long and have two right angle turns.

The following symbols are used in the equations given:

A = area of a circular conduit, sq. ft.
d = diameter in ft. corresponding to A
H = effective height of chimney, ft.
l = equivalent length of breeching, ft.
P = barometric pressure, in. of mercury
P_b = draft loss through the boiler, in. of water
P_e = total effective draft required at the entrance to the chimney, in. of water.
P_f = draft required in the furnace, in. of water
P_r = total draft loss in the breeching due to friction, in. of water
P_v = draft required to increase velocity, in. of water
P_v' = draft loss caused by sudden enlargement of the gas passage, in. of water.
P_c = draft loss in the chimney, in. of water
p_c = draft loss in the chimney per 100 ft., in. of water
P_z = maximum draft produced by the chimney, in. of water
p_z = maximum draft produced by the chimney per 100 ft., in. of water
P_d = damper friction, in. of water
q = volume of gases, cu. ft. per sec. per boiler h.p.
Q = total volume of gases, cu. ft. per sec.
t_a = temperature of the air, deg. fahr.
t_c = temperature of the flue gases, deg. fahr.
v = velocity of gases, ft. per sec.
γ = density of gases, lb. per cu. ft.

In general

$$P_f + P_b = (P_z - P_c) - P_r - P_d$$

In applications to the design of chimneys, $P_d = 0$, since the damper will be assumed to be wide open. Also since the maximum draft and the draft loss in the chimney are both proportional to its effective height, H, then $P_z - P_c$ may be replaced by

$$\frac{H}{100}(p_z - p_c)$$

and, in form for chimney calculations,

$$H = \frac{100\,P_e}{(p_z - p_c)}$$

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DETERMINING THE DRAFT REQUIRED AT THE BOILER DAMPER

This must be assumed from a knowledge of the equipment and conditions. Ordinarily, the draft required may be taken from characteristic curves, of which Fig. 1 is typical for boilers.

The draft required at the boiler damper is the sum of the draft assumed to be required in the furnace plus the assumed draft loss through the boiler.

The lower curve is based on observed draft losses during tests with coal fuel when the CO_2 in the gases was relatively high on correction of these losses to a standard of 13 per cent CO_2 and on the assumption that the draft loss varies as the square of the percentage of rating developed. This curve may be considered as applicable to boilers 15 tubes high without superheaters. The points circumscribed by circles are for a boiler 14 tubes high, but with a superheater over the first and second passes; the circumscribed crosses are for a boiler 13 tubes high also with superheater.

The upper curve was constructed from the lower by allowing for increased air, but at a decreasing rate for increasing overload. While it is not unusual for a boiler to develop its

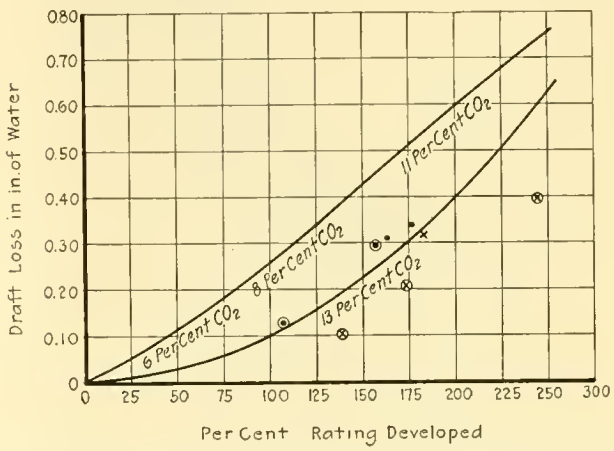

Fig. 1 Draft Loss from Furnace to Damper of a Cross-Baffled Three-Pass Edge Moor Water Tube Boiler with 18-ft. Tubes

For Efficient and Inefficient Firing

rated capacity with 8 per cent CO_2 in the escaping gases, it is hardly to be expected that a boiler should develop 175 per cent of rating with less than 11 per cent CO_2. Hence the variation in the percentages of CO_2 assumed.

In connection with the draft required in the furnace for natural draft and coal fuel, the following formula is useful:

$$C = \frac{(\text{h.p.}) \times 33480}{U\,E\,G}$$

where C is the maximum weight of coal to be burned in lb. per sq. ft. of grate surface per hr., (h.p.) is the maximum horsepower to be developed, U is the calorific value of the coal in B.t.u. per lb., E is the efficiency of the combined generator and G is the grate surface in sq. ft.

For the present problem, P_f will be taken as 0.25 in. and $P_b = 0.45$ in. The draft required at the boiler damper is then $0.25 + 0.45 = 0.70$ in.

DETERMINING THE QUANTITY OF GAS TO BE TRANSMITTED

Table 1 is for the general case. It is assumed that the true combustibles are practically total carbon, available hydrogen $(H - O/8)$ and sulphur. Sulphur occurs in small quantities, requires little air for combustion and has a low heat value; it may therefore be neglected in approximate calculations.

Hence coal may be considered as composed of carbon and available hydrogen.

The weight of gas per horsepower is approximately

$$W = \frac{33480w}{10{,}000\,(E + 0.02)}$$

where W is the weight of gas in lb. per hr. per boiler h.p., w is the weight of gas per 10,000 B.t.u., and E is the combined efficiency of the steam generator. w may be taken from Table 1. The quantity 0.02 added to E is an average allowance for carbon in the ash.

Example: At 9 per cent CO_2, $w = 15.7$. Let $E = 0.66$.

$$W = \frac{33480 \times 15.7}{10{,}000(0.66 + 0.02)} = 77.3 \text{ lb.}$$

The weight per sec. is $W/3600$, and γ by the formula $\gamma = \frac{41.3P}{30(t_c + 459.6)}$ where γ is the weight in lb. of 1 cu. ft. of gases, t_c is the temperature of the gases in deg. fahr., P is barometric pressure, in inches of mercury, is $(41.3P) \div \{30(t_c + 459.6)\}$. Hence the formula for the volume per sec. is

$$q = \frac{30W(t_c + 459.6)}{41.3P \times 3600} = \frac{6.73W(t_c + 459.6)}{1{,}000{,}000} \times \frac{30}{P}$$

where q is the volume of gas in cu. ft. per sec. per boiler h.p.

In ordinary problems, Table 2 may be used instead of calculating q by the formula above. A variation of 100 deg. either side of the standard of 540 deg. fahr. alters the volume by 10 per cent.

Returning to the problem, the volume of gases to be removed by the chimney may now be calculated. The maximum horsepower to be developed is $2 \times 500 \times 1.5 = 1500$ h.p.

$q = 0.52$ from Table 2 for 9 per cent CO_2 and 66 per cent efficiency. Then the total volume of gases per sec. is

$$Q = 1500 \times 0.52 = 780 \text{ cu. ft.}$$

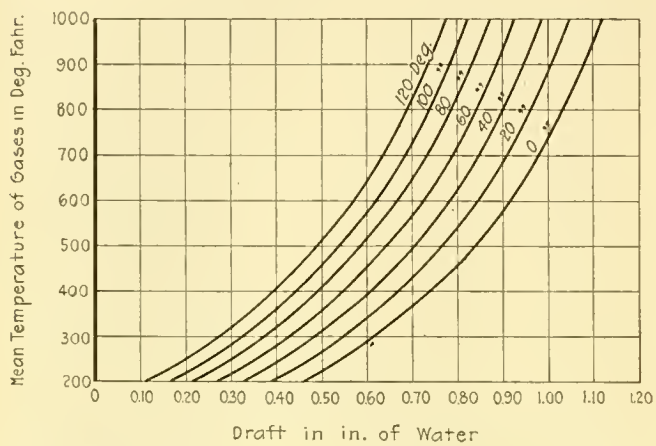

FIG. 2 MAXIMUM DRAFT AT SEA LEVEL PER 100 FT. OF CHIMNEY HEIGHT CORRESPONDING TO THE AIR TEMPERATURES NOTED ON THE CURVES

For any other height, H in ft. multiply by 0.01 H.
For any other altitude, multiply by the corresponding factor of correction from Fig. 3.

TABLE 1 WEIGHT OF GASES AND PERCENTAGE OF HEAT REJECTED TO THE CHIMNEY FOR DIFFERENT PERCENTAGES OF CO_2 WHEN CO = 0

Per Cent CO_2 in the Dry Gases by Volume	18.7	18.0	17.0	16.0	15.0	14.0	13.0	12.0
Excess air in per cent of the theoretical minimum	0	4	10	17	24	33	43	54
Weight of gases per 10,000 B.t.u. in the coal, lb.	7.8	8.1	8.6	9.1	9.6	10.3	11.0	11.9
Chimney loss per 100 deg. fahr. in per cent of the calorific value of the coal	1.85	1.92	2.04	2.16	2.28	2.44	2.61	2.82
Chimney loss per 500 deg. fahr.	9.25	9.60	10.20	10.80	11.40	12.20	13.05	14.10

Per cent CO_2 in the Dry Gases by Volume	11.0	10.0	9.0	8.0	7.0	6.0	5.0
Excess air in per cent of the theoretical minimum	68	85	105	130	162	206	267
Weight of gases per 10,000 B.t.u. in the coal, lb.	12.9	14.2	15.7	17.6	20.0	23.3	27.8
Chimney loss per 100 deg. fahr. in per cent of the calorific value of the coal	3.06	3.37	3.72	4.17	4.74	5.52	6.59
Chimney loss per 500 deg. fahr.	15.30	16.85	18.60	20.85	23.70	27.60	32.95

TABLE 2 WEIGHT AND VOLUME OF GAS PER BOILER HORSEPOWER AT SEA LEVEL

Assumed CO_2 per cent of dry gases by vol-volume	8	8	9	10	12	12	14	14
Assumed combined efficiency of boiler, furnace and grate	63	66	66	68	70	75	68	78
Weight of gases in lb. per hr. per boiler h.p.	91	87	77	68	55	52	40	43
Volume of gases in cu. cu. ft. per sec. per boiler h.p. for a temperature of 540 deg. fahr.	.61	.58	.52	.46	.37	.35	.33	.29
Suggested corresponding percentage of rated capacity of boiler to be used for proportioning chimneys	100	125	150	..	200	..	250	..

DETERMINING THE MAXIMUM DRAFT PRODUCED BY THE CHIMNEY

The general formula is

$$P_z = 0.255PH\left(\frac{1}{t_a + 459.6} - \frac{1.04}{t_c + 459.6}\right)$$

Values of P_z per 100 ft. of height and the factor of correction for different altitudes and pressures are given graphically in Figs. 2 and 3.

In the problem $t_a = 80$ deg. fahr. Let $t_c = 500$ deg. fahr. Then from Fig. 2 $p_z = 0.59$ in. If the altitude is 5900 ft. above sea level, then the factor of correction from Fig. 3 is 0.8. Hence $p_z = 0.8 \times 0.59 = 0.47$ in.

DETERMINING THE DRAFT LOSS IN THE CHIMNEY

The formula for this is

$$P_r = 0.008\,\frac{l}{d}\left(\frac{v^2}{t_c + 459.6}\right)$$

By means of this formula, the values shown graphically in Fig. 4 were obtained.

A variation of 100 deg. either side of the assumed standard of 540 deg. fahr. and a variation of 3 in. in barometric pressure, if uncorrected for, would each introduce an error of 10 per cent in the draft loss. Since the draft loss is usually small, it would seem that ordinarily only variations beyond these limits need be considered.

Before the curves in Fig. 4 may be used, it is necessary to assume a velocity. If v is assumed then A follows from the formula $A = Q/v$. For a first approximation, the velocity may be selected from Table 3.

In the present problem, the volume of gas to be removed is 780 cu. ft. per sec. Assuming a velocity of 25 ft. per sec., $A = 780/25 = 31.2$. The friction loss per 100 ft., by visual interpolation on Fig. 4, is $p_c = 0.08$ in. This is for a circular chimney at sea level.

TABLE 3 ASSUMED ECONOMICAL VELOCITIES FOR A FIRST APPROXIMATION

Volume of gas to be removed in cu. ft. per sec.	10	50	150	500	1200	2500	5000	8000
Economical velocity in ft. per sec.	10	15	20	25	30	35	40	45

For a square chimney of side equal to diameter of the circular chimney $p_c = 0.62 \times 0.08 = 0.05$ in. For a circular chimney and barometric pressure 24 in. of mercury, $p_c = (30/24)\ 0.08 = 0.10$ in. For a circular chimney at sea level but gas temperature equal to 650 deg., $p_c = \{(640 + 460) \div 1000\}\ 0.08 = 0.09$ in. For a square chimney, barometer at 24 in. and gases at 640 deg. fahr.,

$$p_c = 0.62\,\frac{30}{24}\,\frac{640 + 460}{1000}\,0.08 = 0.07 \text{ in.}$$

DETERMINING THE FRICTION LOSS IN THE BREECHING

The customary assumption is that one sharp right angle turn has the same friction as 50 ft. of length. In the problem the breeching is to be 50 ft. long and to have two turns. Hence $l = (2 \times 50) + 50 = 150$ ft. Assuming the breeching will be square, with side equal to the diameter of the circular chimney, then $P_r = 1.5 \times 0.05 = 0.08$ in. The quantity 0.05 is the loss per 100 ft. as computed above. For a circular breeching of the same size as the chimney $P_r = 1.5 \times 0.08 = 0.12$ in. This does not indicate that the total loss in the square breeching will be less than that in the circular one because of the draft losses due to changes of velocity, as discussed in the following section.

DRAFT REQUIRED TO INCREASE VELOCITY

The formula is

$$P_v = 0.123\,\frac{P(v_2^2 - v_1^2)}{30(t_c + 459.6)}$$

where v_1 is the initial velocity of the gases and v_2 is the final velocity.

The draft required to accelerate gases at sea level from zero velocity to velocities of 10, 20, 30 and 40 ft. per sec. for a temperature of 540 deg. fahr. is 0.012 in., 0.049 in., 0.111 in. and 0.197 in. respectively. The magnitude of this loss at the higher velocities explains the regulating effect produced by manipulating the damper.

The ratio of the area of a square to that of an inscribed circle is 1/0.7854. The velocity in the former will therefore be 0.7854 times the velocity in the latter. Table 4 shows the draft loss due to a velocity change based on this ratio for the case when gases pass from a square breeching into a circular chimney.

TABLE 4 DRAFT REQUIRED TO ACCELERATE GASES AT 540 DEG. FAHR., BAROMETER AT 30 IN.

Change of velocity in ft. per sec.	11.8 to 15	15.7 to 20	19.6 to 25	23.6 to 30	27.5 to 35	31.4 to 40	35.3 to 45	39.3 to 50
Draft required in in. of water	0.011	0.019	0.030	0.042	0.058	0.075	0.096	0.118

Except at the highest velocities, this draft is small enough to be neglected in the problem of calculating sizes of chimney; but as regards the design of the breeching this additional loss, for short breechings, may make the smaller circular breeching more desirable than the larger square breeching from an operating as well as a cost standpoint provided the gases leave the boilers at about the ultimate velocity.

Since the loss due to the velocity change will almost compensate for the decreased friction when the square breeching is used, if it is not long, then the friction loss per 100 ft. of breeching may be taken the same as in the circular chimney, whether the breeching will be square or circular.

LOSS OF DRAFT DUE TO SUDDEN ENLARGEMENT OF THE GAS PASSAGE

As stated in text books, eddies are set up when the velocity is decreased as a result of a sudden enlargement of the area. This is accompanied by a loss of pressure.

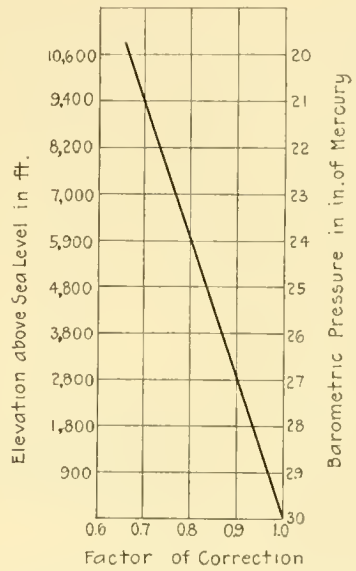

FIG. 3 FACTORS OF CORRECTION APPLICABLE TO FIG. 2

The formula is

$$P_v' = 0.123\,\frac{P(v_1 - v_2)^2}{30(t_c + 459.6)}$$

For a change of velocity from 30 to 10 ft. per sec., at sea level and temperature equal to 540 deg. fahr. this loss is 0.049 in. Where there are several sudden enlargements in a long flue, the aggregate loss may be considerable. Hence gradual changes of cross section are preferable where there is something to be gained by enlarging the breeching.

DETERMINING THE VALUE OF d IN INCHES

d is the diameter of a circular chimney or breeching, or the length of one side of a square chimney or breeching. The curves in Fig. 4 are based on circular conduits, hence d is always the diameter corresponding to the area A. Obviously, a quick way to determine d is to divide the area A by 0.7854 on the upper scale of a slide rule and read d in in. opposite 12 on the lower scale.

PRACTICAL METHOD FOR CALCULATING CHIMNEYS

Solutions of chimney problems are very simple if carried out in the following form:

Equipment and Location. Two 500 h.p. boilers to be oper-

ated up to 150 per cent of rating. Breeching to have two right angle turns and to be about 50 ft. long. Chimney to be circular. Plant to be at about sea level.

Assumptions. $t_a = 80$ deg. fahr., $t_g = 500$ deg. fahr., $q = 0.52$ cu. ft. (from Table 2), $P_f = 0.25$ in., $P_b = 0.45$ in., $P_f + P_b = 0.70$ in.

Calculations. Maximum h.p. $= 2 \times 500 \times 1.5 = 1500$.

$Q = 1500 \times 0.52 = 780$ cu. ft. Assume $v = 25$ ft. (from Table 3).

$A = Q/v = 780 \div 25 = 31.2$ sq. ft.

p_c from A and v on Fig. 4 $= 0.08$ in.

$l = (2 \times 50) + 50 = 150$ ft. $P_r = 1.5\ p_c = 1.5 \times 0.08 = 0.12$ in.

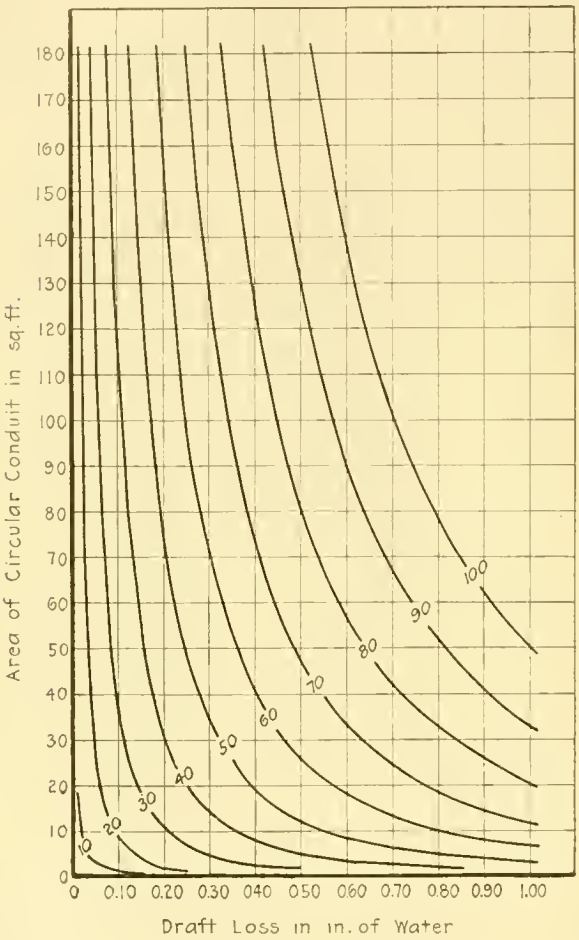

FIG. 4 DRAFT LOSS PER 100 FT. OF A CIRCULAR BRICK-LINED CONDUIT CORRESPONDING TO THE VELOCITIES IN FT. PER SEC. NOTED ON THE CURVES. FOR BAROMETER AT 30-IN. MERCURY, AND GASES AT 540 DEG. FAHR.

For any other height or length H in ft., multiply by 0.01 H
For a square conduit of side equal to the diameter of a circular conduit, multiply by 0.62
For any other barometric pressure P in in. of mercury, multiply by $30/P$
For any other gas temperature t in deg. fahr. multiply by 0.001 $(t + 460)$

$P_e = (P_f + P_b) + P_r + P_v + P_v' = 0.70 + 0.12 + 0 = 0.82$ in.

$p_z = 0.59$ in. from Fig. 3. $p_z - p_c = 0.59 - 0.08 = 0.51$ in.

$$H = \frac{100 P_e}{p_z - p_c}$$

$$= \frac{100 \times 0.82}{0.51} = 161 \text{ ft.}$$

By writing the above calculations in the following tabular form (Case 1*a*) and assuming other velocities then other sizes may be obtained quickly.

The value of P_v in Case 1*d* is based on the assumption that the gases leave the boiler at a velocity of 20 ft. per sec. In the other cases P_v was assumed to be negligible.

The best size of chimney will depend, of course, on relative cost, local and other conditions.

To illustrate further, assume that the plant will be at an elevation of 5900 ft. above sea level and that the chimney will be square. Then $P = 24$ in. The maximum draft, p_z', will be $0.8\ p_z$ and the friction loss in the breeching and chimney will be $0.62 \times 30/24\ p_c' = 0.78\ p_c$ where p_c is the loss at sea level. Hence

$$p_z' = 0.8 \times 0.59 = 0.47 \text{ in.} \quad P_r = 1.5\ p_c'$$

Case	v	A	p_c	P_f	P_v	P_e	$p_z - p_c$	H	d
1*a*	25	31.2	0.08	0.12	0.0	0.82	0.51	161 ft.	76 in.
1*b*	20	39.0	0.04	0.06	0.0	0.76	0.55	138 ft.	85 in.
1*c*	30	26.0	0.12	0.18	0.0	0.88	0.47	187 ft.	69 in.
1*d*	40	19.5	0.26	0.39	0.15	1.24	0.33	376 ft.	60 in.

Case	v	A	p_c	p_c'	P_r	P_v	P_e	$p_z' - p_c'$	H	d
2*a*	25	31.2	0.08	0.06	0.09	0	0.79	0.41	193 ft.	76 in.
2*b*	20	39.0	0.04	0.03	0.04	0	0.74	0.44	16 ft.	85 in.
2*c*	1	52.0	0.02	0.02	0.03	0	0.73	0.45	162 ft.	97 in.

Table 5 illustrates how the capacity of a chimney is affected by a variation of one or more of the governing conditions. The altered conditions are in italics. Since the quantity of gas per sec. per h.p. is dependent on both temperature of gases and combined efficiency, its value has been altered accordingly when these are involved.

TABLE 5 VARIABLE CAPACITY OF A CIRCULAR CHIMNEY 76 IN IN DIAMETER AND 160 FT. HIGH

Case	Temperature of Air, Deg. Fahr.	Temperature of Gases, Deg. Fahr.	Barometer, In.	Draft in Furnace, In.	Draft Loss in Boiler, In.	Draft Loss in Breeching, In.	Gas per Sec. per h.p. Cu. ft.	Capacity of the Chimney B.h.p
1*a*	80	500	30	0.25	0.45	0.12	0.52	1500
3	*100*	500	30	0.25	0.45	0.12	0.52	900
4	*20*	00	30	0.25	0.45	0.12	0.52	2700
5	80	*900*	30	0.25	0.45	0.12	*0.90*	2000
6	80	500	30	0.25	0.45	*0*	0.52	100
7	80	500	*27*	0.25	0.45	0.12	0.52	750
8	80	500	30	*0.20*	*0.22*	0.12	*0.35*	3900
9	80	500	30	*0.10*	*0.22*	0.12	*0.35*	4400
10	80	*600*	30	*0.10*	*0.60*	*0*	*0.33*	4200

Cases 1*a*, 3, 4, 6 and 7 are for a boiler in good condition but inefficiently fired. Cases 1*a*, 3, 4 and 7 are for different atmospheric conditions; Case 5 is representative of a boiler with baffles and heating surface in need of attention; Case 6 is for a chimney set directly over the boiler; Case 8 would apply to a natural draft installation efficiently operated; Case 9 is for an oil burning or forced draft installation efficiently operated; and Case 10 is for efficient operation at about 250 per cent of rating with forced draft and chimney set directly over the boiler.

UNIQUE HYDRAULIC POWER PLANT AT THE HENRY FORD FARMS

BY MARK A. REPLOGLE, AKRON, OHIO

Member of the Society

The hydraulic power plant at the Henry Ford Farms, Dearborn, Mich., contains two turbines designed to develop 85 h.p. each at 110 r.p.m. under 8-ft. head, together with electric generators. The plant supplies current for light, heat and power for Mr. Ford's residence, for the village pumping station, and for the miscellaneous requirements of the farms. It was built to operate under somewhat unusual conditions of head and contains features which the author believes to be novel and unique.

The plant is located on the River Rouge, near its junction with the Detroit River, which latter varies considerably with the levels of the Great Lakes. The Rouge River is subject to the widest extremes in flow. At the point of location of the plant is a dam over which the normal run-off is 100 sec-ft. There are short intervals, however, when the run-off is so great that it fills the valley with water so that no sign of the dam is apparent; at these times the head over the dam is completely destroyed, but the condition lasts only a few hours until the high water wave has passed. There are longer periods when the level is affected by the Great Lake conditions causing back water in the tail race and consequent lowering of the head for days at a time. Also, there may be weeks of surplus flow at semi-high head. In fact, the conditions may be summarized as

a Low water with normal head

b Low water with head lowered by Great Lake conditions

c Normal flow under variable heads

d High water with approximately half normal head, which is also variable and dependent upon Great Lake conditions

e Very high water, but with head almost destroyed

High water, with head varying from 2 to 5 ft., may persist for weeks at a time, so that provision to meet this condition was necessary. The condition of very high water but practically no head only obtains for a few hours at a time, and no adequate provision can be made for it, except the steam reserve.

The power house, an adjunct to Mr. Ford's private laboratory, is a concrete structure. The foundation consists of a monolith of reinforced concrete. Conditions made it necessary to floor the head race, power house site and tail race with concrete for several feet in thickness. The head race, 31 ft. wide and 10 ft. deep, was completely arched over for approximately 150 ft., and the tail race was similarly arched, both for architectural reasons.

The power house, Fig. 1, is a 3-story building, the lower floor containing the two turbines, the middle containing the auxiliary apparatus for controlling the turbines, and the upper the two dynamos, the governors, the switchboard and one steam reserve unit. The turbine floor is divided into three separate penstocks, connected by an overhead gallery.

Ordinary precaution led to the provision of two units, each having the capacity of the normal flow of the stream under 8-ft. head. The speed of 110 r.p.m. was established for full head conditions and this speed was maintained at all heads, varying from 1 ft. up to the full head of 8 ft. Herein lies the unique feature of this plant—the maintenance of full speeds and good power through a wide range of low heads and in the face of the condition that, under ordinary settings, the turbines employed require slightly over 4 ft. head to bring them to maximum speed at full gate and no load conditions.

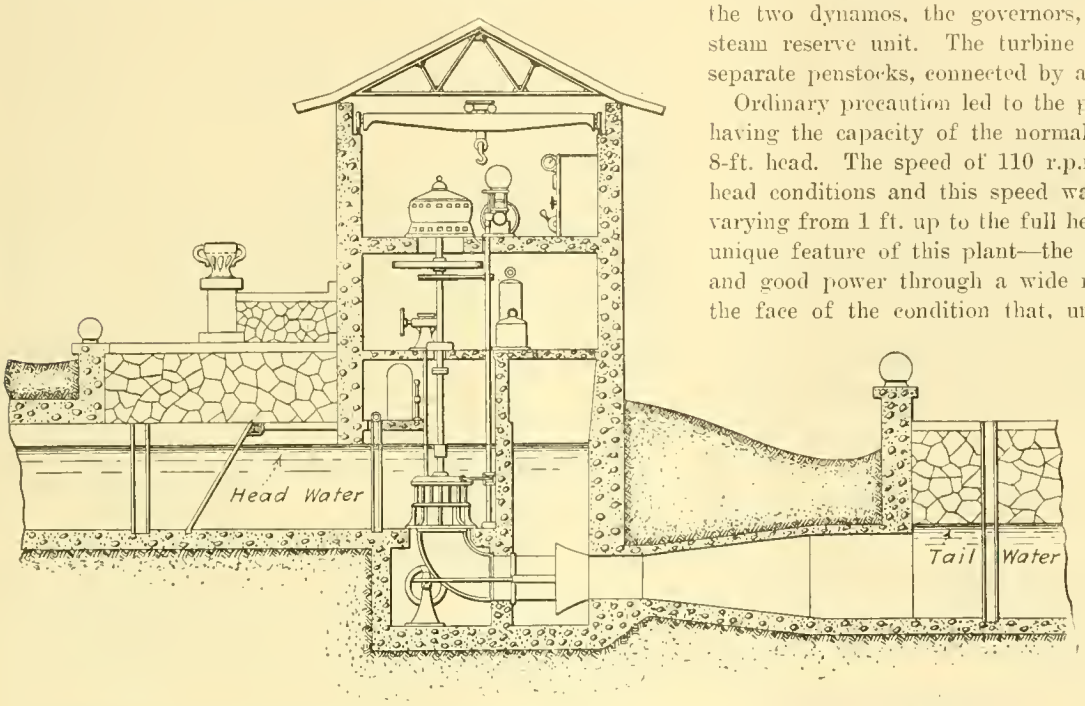

Fig. 1 Cross Section of Power House at the Henry Ford Farms

The turbines are of the vertical type, designed, as stated, to develop 85 h.p. each on the turbine shaft when operating under 8 ft. head at 110 r.p.m. They have wicket gates, operated by draw rods from a gate shaft reaching directly to the governor arm. The turbine chambers are scroll-shaped, arranged for their respective right and left hand turbines. The weight of the runners is sustained by roller bearings on top of the generators. All under water bearings are of bronze.

The two turbo-generators are of the vertical type, 55 kw. each, at 250 volts. They are direct current machines and have ample overload capacity. Each is self-contained, having a roller bearing on top which supports all the rotating parts, including the balance wheels and turbines. A third steam engine generator is provided. This is horizontal, and is of 35 kw. capacity at 250 volts.

The governors which are direct connected and vertically driven are of the open system, oil-pressure type. Full apparatus is provided in the top floor of the power house for recording test conditions.

The three penstocks on the lowest floor can be closed by folding head gates, manipulated by the overhead crane. Of these penstocks, the middle one is a common feeder for the others, each of which contains what has been termed a "turbine discharge accelerator." These accelerators are a form of

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draft tube, into which each turbine discharges and into which, also, water from the head race is discharged through a feeder. The head race water accentuates the turbine flow through the draft tube, having the same effect as an added head of head water.

The purpose of the discharge accelerators is to transfer energy from surplus water (otherwise running over the dam or wasting) to the turbines, augmenting their power under subnormal heads after they have reached their otherwise full power at those heads. In other words, their effort is to boost the power of the turbines, working under low head conditions, beyond that which the conditions would seem to warrant.

The principle of the accelerator may be followed by reference to Fig. 2. In this figure is also shown a common siphon

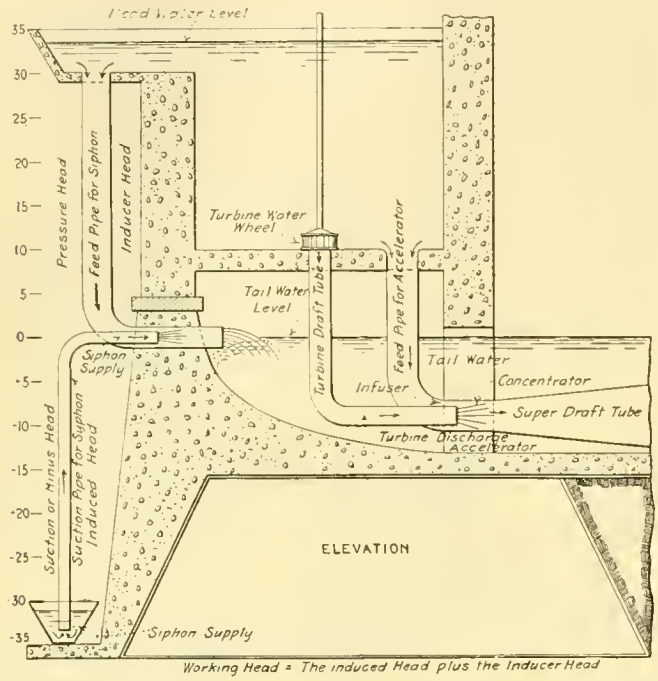

FIG. 2 COMPARISON OF SIPHON AND ACCELERATOR

for purposes of comparison. In the case of the siphon, the induced or suction head cannot be greater than the inducer, or pressure head. With the accelerator, the induced head may be greater than the inducer head. The accelerator is not an ejector.

The effect of the accelerator on the turbine is to partially remove the pressure at the discharge end without changing the pressure at the intake end. Under ordinary conditions, the pressure on both the head and tail water is 14.7 lb. per sq. in. alike. If the turbine were to discharge into tail water the pressure on which was, say, only 10 lb. per sq. in., the result would be the equivalent of adding slightly over 10 ft. head to the turbine, and as far as practical results were concerned, the turbine would now develop energy corresponding to the increased head. This is the effect of the discharge accelerator, which may therefore be likened in principle to a condenser of a steam engine.

Each accelerator consists of a super draft tube, a concentrator, and an infuser as shown in Fig. 3. The infuser is provided with a gate, by means of which the amount of accelerator water may be varied at will, or shut off entirely, in the latter case leaving only the turbine discharging into the super draft tube.

The area of cross section of the concentrator is less than that of the turbine draft tube. The effect of this narrowed section on the turbine's discharge during its ordinary operation was in doubt during the construction period, but when the installation was completed tests showed that the effect was negligible.

A series of tests were made on the accelerator of one unit on March 18, 1915, and the results are plotted in Fig. 4. In this figure, the scale of turbine horsepower is given on the left, kilowatts on the right and turbine gate opening in tenths below. A normal speed of 110 r.p.m. was maintained throughout the tests. The energy was absorbed by a water rheostat, and the power was measured by the switchboard instruments, which are new, therefore substantially correct.

The purpose of Series I was to show the maximum power of the turbine when the accelerator gates were closed. The curve shows approximately 90 turbine h.p. at between 9/10 and full gate, but the head was slightly over 8 ft.

Series II shows readings made at the same turbine gate openings, but the accelerator gate was open 20 per cent of its range throughout the series. Although the actual head is lowered, there is an actual increase in power.

Series III was made with the accelerator gate open about 40 per cent of its travel. This resulted in a still further increase of power.

Series IV was made with the accelerator gate open about 60 per cent of its travel. Throughout this series, the accelerator was sucking some air, but the power increased.

Series V was made with the accelerator gate open about 80 per cent of its travel. The accelerator sucked air violently during these last readings, but the power increased even though the head was less than 7 ft.

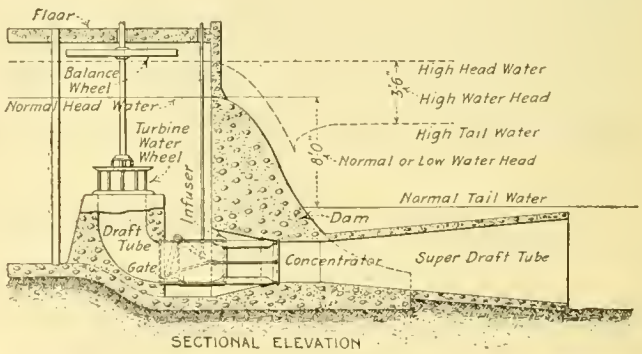

FIG. 3 85-H.P. TURBINE AND DISCHARGE ACCELERATOR

The excessive taking in of air prevented the further opening of the accelerator gate. Therefore its limit of action is unknown.

The curve in Series V shows 116 turbine h.p. at 6.94 ft. head. This curve, reduced by the well known formula, to an 8-ft. head shows that 143.5 h.p. can be obtained by the use of the accelerator from an 8-ft. head in connection with the identical turbine that had been guaranteed to develop 85 h.p. under 8-ft. head.

No attempt was made to measure the accelerator water used, as this test was made solely to demonstrate that a turbine can use waste water that would be detrimental to the power effects of the turbine if the accelerator were not used. The matter of measuring the water is a part of proposed further development, which will be continued until all the limitations are discovered.

The possibilities and limitations of the accelerator have not yet been fully determined, although several years of experi-

mentation have been spent in its development. In its operation, there seems to be some new and definite law, which has not yet been formulated. So far, indications are that low heads may be boosted as much as from 100 to 500 per cent, depending on the conditions. The extreme limit appears to be the atmospheric head.

The present instance is believed to be the first practical demonstration of the decided advantage to be secured by the application of the turbine discharge accelerator, and the design of the device is believed to be original.

There seems to be every reason to believe that full turbine power from a water turbine can be obtained from all the water used (when based on the actual or working head) even though only a portion of the water passes through the turbine proper. A water power equipped with an accelerator can be speeded for full head at low water condition, and the same

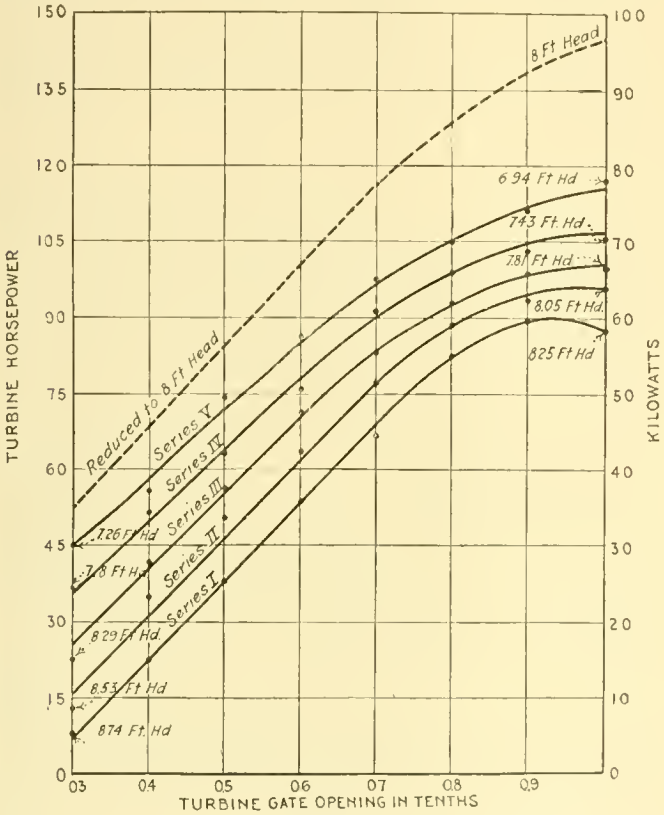

Fig. 4 Results of Tests on Accelerator

turbine can have its capacity practically doubled under the same head, if sufficient water is available. The power unit can develop its normal rated power at one-half head when sufficient water is available, and the turbine can furnish considerable power when the working head is less than 25 per cent of the normal head, and all this may be done at good efficiency.

A like reflection will show that with this system many water powers may become independent of steam or gas reserves, with the saving of the large expense these auxiliary power units now entail. With the accelerator, too, it is not necessary to provide so many power units in a given development, as the elasticity permits of good efficiency with fewer turbines.

There are very many cases in which low heads only are available and the water cannot be utilized practically and profitably. The accelerator can be used to boost the head in such cases to an amount at which development of the water power is possible. The accelerator can convert an actual head of 3 to 10 ft. into a working or effective head of 8 to 20 ft.

OIL ENGINE VAPORIZER PROPORTIONS

BY LOUIS ILLMER, READING, PA.

Member of the Society

This paper is a synopsis of a research study to determine the proper proportions of hot bulbs for oil engines. The study was begun by the author a number of years ago when he was called upon to fix vaporizor dimensions suitable for Hornsby-Akroyd oil engines of large capacity. A careful investigation of the underlying principles brought out the design data here presented and from these data hot-bulb oil engines in sizes up to 100 b.h.p. have been built and operated with satisfactory results. Recently this investigation has again been taken up and has been largely extended so as to include proportions for high compression oil engine vaporizers.

In the hot bulb oil engine, of which the well known Hornsby-Akroyd engine is the prototype, the vaporizer heated by the gases of combustion provides a hot surface for the double purpose of evaporating the heavy mineral oils in the fuel oil and of maintaining the confined mixture charge at a temperature high enough to enable self-ignition to be induced with moderate compression. Fig. 1 is a sectional view of the vaporizer generally applied to a single-acting 4-stroke cycle Hornsby-Akroyd stationary oil engine. The vaporizer is of cast iron and forms a chamber, the outermost end or cap of which is unjacketed and maintained at approximately incipient cherry-red heat, by the absorption of heat from the working charge. The spray nozzle is arranged to direct the oil against the hot surface of the vaporizer cap; the hot gases confined within the vaporizer from the previous charge evaporate the highly atomized particles of the injected oil, while the heavier particles impinge against the hot cap wall. Part of the heat required for evaporation of the oil is therefore supplied from the gases in the vaporizer and part from the vaporizer cap; the latter is the major part.

The essential principles of operation are: The oil is sprayed into the vaporizer chamber in the same period that a volume of air is sucked into the power cylinder. At the end of the suction stroke, the superheated oil vapor or gas in the vaporizer will have been mixed with approximately half of the hot products of combustion, while the body of air in the cylinder is confined there by the vaporizer neck. During the compression stroke, a certain portion of this air is forced through the neck at relatively high velocity, and is projected into the center of the highly heated oil-gas. This results at first in a supersaturated mixture of oil-gas and air being formed within the cap enclosure, the mixture being kept at a temperature considerably above ignition point by the heating effect of the products of combustion. Self-ignition will occur, therefore, at the instant the further addition of air makes this mixture of such proportions as to be explosive. Owing to this rather complicated action, the vaporizer dimensions must be exactly suited to the requirements, or the engine will not operate satisfactorily.

From the proportional analysis of some design data deduced from a fully developed line of horizontal 4-stroke Hornsby-Akroyd oil engines, it was found that the one simple relation suitable for design purposes was that of vaporizer volume to piston displacement. The other design factors depend upon more involved relations and center about the average tempera-

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ture attained by the unjacketed cap portion of the vaporizer wall.

The temperature relations existing in a hot vaporizer cap are best treated on the basis of a thin flat disc receiving a uniform heat input over one of its faces. Under conditions of equilibrium, the resulting heat flow will cause a temperature drop between the center and edge of the disc.

Let θ_1 = temperature of disc at center, deg. fahr.

θ_0 = temperature of disc at edge, deg. fahr.

$\theta = \theta_1 - \theta_0$ = temperature drop from center to edge of disc

r = radius of disc, in.

s = uniform thickness of disc, in.

H = uniformly distributed gross heat input in B.t.u. per hr. per sq. in. of area

k = specific thermal conductivity in B.t.u. per hr. per sq. in. of section at 1 deg. fahr. head

= about 3.82 for cast-iron.

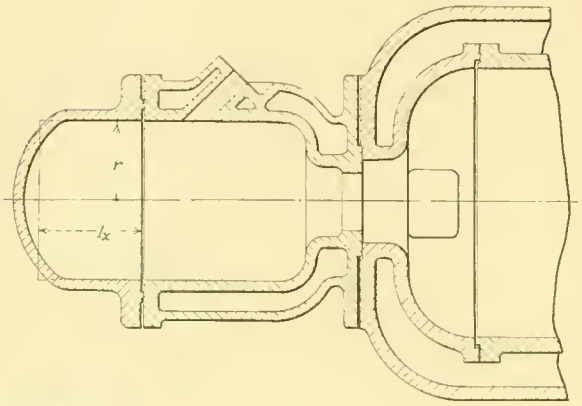

FIG. 1 VAPORIZER FOR SINGLE-ACTING 4-CYCLE OIL ENGINE

Since the temperature gradient, i.e., drop per inch of length, is proportional to the rate of heat flow, the gradient in the case of a cast-iron vaporizer cap will be equal to 1 deg. fahr. for each 3.82 B.t.u. flow per hr. per sq. in. of section. Applying this to a disc of radius r, the heat input will be measured by the area enclosed, multiplied by the uniform rate of input per sq. in. of surface. Assuming all of this heat is to be conducted to the edge of the disc, the rate of heat flow through the peripheral sectional area will be equal to

$$\pi r^2 H \div 2 \pi r s = \frac{H r}{2 s}$$

Dividing this equation by the constant k, the corresponding temperature gradient at the edge radius, r, will be equal to

$$\frac{H r}{2 k s}$$

This shows that the temperature drop per unit of length is directly proportional to the disc radius; and since the heat flow at the center of the disc is zero, the average temperature gradient will therefore be ½ that at the full radius, r.

The total temperature drop from center to edge of a thin disc will then be equal to the average drop per unit length multiplied by the disc radius, r, that is, for the disc

$$\theta = \theta_1 - \theta_0 = \frac{1}{4} \cdot \frac{H r^2}{k s} \quad \ldots\ldots\ldots\ldots\ldots [1]$$

Applying the same reasoning to the case of a relatively thin internally heated tube whose inner radius is r and length is l (both in inches), and in which all the heat is conducted away at one end, it will be found that the total temperature drop over the full length is equal to

$$\theta = \theta_1 - \theta_0 = \frac{1}{2} \frac{H l^2}{k s} \quad \ldots\ldots\ldots\ldots\ldots [2]$$

The temperature drop over a tube is dependent only upon the length of the tube, and for unit length the drop is twice that for a disc of unit radius.

The temperature distribution as determined by either of equations [1] or [2] is plotted in Fig. 2. The maximum temperature, θ_1, corresponds to that of the center of the disc or of the free hot end of the tube, while the disc edge or attached tube end assumes the temperature θ_0.

Numerical values for the counter-temperature, θ_0, vary with the size of the engine and the character of joint between the cap and jacket part of the vaporizer. In the case of the Hornsby-Akroyd vaporizer cap, a fair average value for θ_0 is 450 deg. fahr. under full load conditions.

If to the counter-temperature, θ_0, be added the average temperature ordinate under the curve, Fig. 2, then the average temperature, t_c, attained by the cap may be taken as approximately equal to

$$t_c = \frac{2}{3}(\theta_1 - \theta_0) + \theta_0 \quad \ldots\ldots\ldots\ldots\ldots [3]$$

In treating the case of a bumped head, such as is shown in Fig. 1, a simple and fairly reliable method is to resolve the cap volume into an equivalent cylindrical depth, l_x, enclosed by a flat plate end, as indicated by the dotted line in the figure. The corresponding contour length for heat travel, taken in terms of tube length, will then be equal to

$$\frac{r}{2} + l_x = l_e \quad \ldots\ldots\ldots\ldots\ldots [4]$$

where l_e = equivalent tube length in in. of the combined contour of tube and disc.

The input surface in this case will be the area of the disc plus the area of the cylindrical length, l_x, which is exactly equal to the interior surface of a cylinder having a length of l_e. Hence this factor may be inserted into equation [2] without further surface correction, thus

$$\theta = \theta_1 - \theta_0 = \frac{H l_e^2}{2 k s} \quad \ldots\ldots\ldots\ldots\ldots [2a]$$

The thickness, s, in the line of Hornsby-Akroyd engines referred to, is fairly well represented by the relation

$$s = 0.075\, l_e \quad \ldots\ldots\ldots\ldots\ldots [5]$$

When the cap is projected into the vaporizer and receives heat over a portion of its face in the manner indicated in Fig. 3, the counter-temperature, θ_0, is increased. The derived formulæ apply only to the disc portion of the surface which is directly exposed to the heating action of the hot gases, while the temperature drop over the length, d, of the protected tubular section of Fig. 3 should be taken proportional to the amount of heat conducted to the edge of the disc.

The case of an offset cylinder head, Fig. 4, receiving heat at a uniform rate of input over its entire surface is best treated by considering the shape as a whole and finding its equivalent tube length having an internal radius r_b. The equivalent tube length to be added to compensate for the flat closing head is given by the above formulæ; but in determining the equivalent length to be added for the annulus at the other end of the tube, due allowance must be made for difference of thickness, area and contour length as compared with that of a disc.

Before numerical results can be obtained by means of equation [2a], a value must be fixed for the heat input factor, H. Owing to the cyclic nature of the heat flow, the quantity of

heat that will pass into the vaporizer cap wall may be taken as proportional to the average temperature head maintained with respect to the hot cap multiplied by the square root of the rate of such temperature applications.

For the purpose of further simplification, it is assumed that the temperature of the exhaust gases is approximately equal to that of the cap, so that the interchange of heat to and from the cap during all but the power strokes may be regarded as negligible. This holds true of Hornsby-Akroyd engines, because the temperature of the hot exhaust gases enclosed by the cap is approximately 1300 deg. fahr. at full load.

Under the assumed conditions, fairly reliable values for the uniformly distributed heat input factor, H, may be based upon experimental determinations of gas engine jacket losses and may be taken as follows:

For 2-stroke cycle engines

$$H = \frac{t_h}{8}\sqrt{\frac{N}{100}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

and for 4-stroke cycle engines

$$H = \frac{t_h}{11}\sqrt{\frac{N}{200}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [7]$$

where N = engine speed in r.p.m.

t_h = effective temperature head in deg. fahr. as measured by the average temperature maintained during expansion with respect to the heat-absorbing jacket wall

H is in B.t.u. per sq. in. of cap surface per hr.

These formulae hold good only for relatively hot caps.

In case the vaporizer is subjected to external radiation, all of the heat absorbed by the vaporizer cap wall will not be conducted to the edge of the disc, as is assumed in the derivation of the above formulæ. The radiation loss of a vaporizer at red heat may be approximately compensated for on the basis of 10 B.t.u. per sq. in. per hr. uniformly distributed over the interior cap surface.

Another modifying factor of heat flow is the cooling action due to the evaporation of such portion of the injected fuel oil as may take heat out of the cap wall. This loss is likewise most conveniently allowed for by assuming it to be uniformly distributed over the entire surface of the cap.

As previously pointed out, the injection of fuel oil tends to cool the hot products of combustion confined within the vaporizer. The degree to which these hot gases contribute to the evaporation of the fuel oil depends in part upon the thoroughness of atomization. Without elaborating on this point, it might be said that in the Hornsby-Akroyd engine apparently about one-third of the full load oil is vaporized by the hot gases and the hot cap imparts the necessary heat of evaporation to the remaining two-thirds of the full load fuel oil and superheats this oil gas to a temperature of about 900 deg. fahr.

The quantity of oil required by an oil engine operating on the explosive cycle can be determined approximately from the following full load indicated efficiency formula:

$$E_i = 1 - \frac{1}{R^{n-1}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

where E_i = indicated efficiency

R = ratio of expansion (about 3⅓ for the Hornsby-Akroyd engine)

n = exponent in formula $P\,V^n = C$ as based upon the expansion line. For most explosive oil engines of the vaporizer type, n may be taken at about 6/5.

The total heat of evaporation for fuel oil remains fairly constant throughout a wide range of densities, and for the purpose of the present investigation it may be taken as approximately

$$q = 165 + \frac{t_f}{3} \quad \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

where q = total heat in B.t.u. required to evaporate 1 lb. of fuel oil from 70 deg. fahr.

t_f = deg. fahr. to which the oil-gas is heated.

An estimate can now be made of the total cooling action resulting from external radiation plus that due to the gasification of fuel oil by the cap. This heat taken on the basis of unit cap area, will be designated by h, and its numerical value varies from 10 to 25 per cent of the gross input heat, H.

Having thus fixed upon that portion of the input heat that is not conducted to the edge of the disc, a correction for the dissipated heat can be embodied in equation [2a] by taking the temperature drop from end to end of the tube proportional to the net or actual heat flow, thus

$$\theta = \theta_1 - \theta_0 = \left(\frac{H - h}{k}\right)\frac{l_e^2}{2\,s} \quad \ldots\ldots\ldots [10]$$

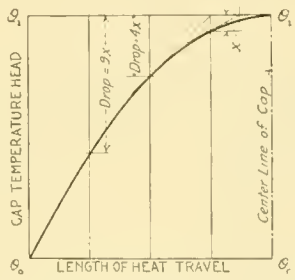

Fig. 2 Vaporizer Cap Temperature Head

where h = dissipated heat in B.t.u. per hr. per sq. in. of cap area, i.e., difference between the gross input heat and the net quantity actually conducted to the end of the tube.

The heat consumption of an engine per cubic foot of cylinder displacement can readily be shown to be equal to

$$0.185\frac{P_m}{E_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots [11]$$

where P_m = mean effective pressure in lb. per sq. in.

The maximum attainable mean effective pressure is dependent, in part, upon the amount of fresh air per cubic foot of displacement that is available for fuel combustion. In a 4-stroke cycle explosive oil engine in which the compression pressure crosses the atmospheric line at about 9/10 stroke the full-load mean effective pressure to be expected from a properly proportioned explosive mixture bears a constant relation to the indicated efficiency, and may be taken as approximately equal to

$$P_m = 200\,E_i \quad \ldots\ldots\ldots\ldots\ldots\ldots [12]$$

Combining [11] and [12], it will be seen that the full load heat consumption of a 4-stroke cycle oil engine is practically constant at 37 B.t.u. per cu. ft. displacement, and that this is independent of the compression pressure. This means that, in terms of fuel oil having a heating value of about 18,500 B.t.u. per lb., a 4-stroke cycle engine may be expected to burn about 0.002 lb. oil per cu. ft. of displacement at full load.

The maximum temperature of combustion may be approximately estimated on the basis of a full-load input of 37 B.t.u. per cu. ft. displacement, as found above. The air sucked into

a hot 4-stroke cycle cylinder may be taken at about 0.05 lb. per cu. ft. displacement, and allowing for the high temperatures prevailing in the cylinder after the instant of explosion, the specific heat at constant volume may be assumed at 0.25. The resulting theoretical temperature rise must be reduced to allow for the considerable cooling action of the cap wall; in the case of the Hornsby-Akroyd engine, the actual temperature rise does not exceed three-quarters that expected on the unjacketed basis.

The full-load temperature rise in the cap of the Hornsby-Akroyd vaporizer, resulting from the combustion of the oil-gas mixture, is probably not far from 2000 deg. fahr., and if this be added to the initial temperature, the maximum temperature of combustion may be fixed at about 2800 deg. fahr. At lighter loads the temperature rise will naturally be reduced in proportion to the oil requirements.

The temperature at point of release or end of expansion period is then equal to

$$T_4 = (1 - E_1)\,T_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots [13]$$

where T_4 = temperature of release, absolute

T_3 = temperature of combustion, absolute

and hence the desired net temperature head driving the heat into the cap wall is given by the equation

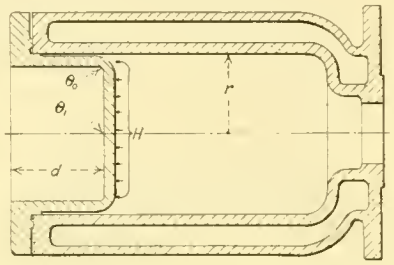

FIG. 3 VAPORIZER CAP PROJECTING INWARDS

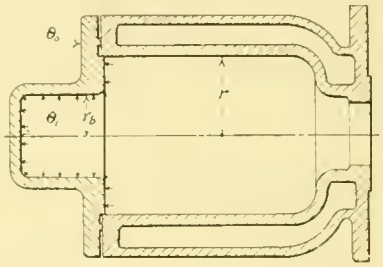

FIG. 4 VAPORIZER CAP PROJECTING OUTWARDS

$$t_h = t_a - t_c = \left(\frac{T_3 + T_4}{2} - 460\right) - t_c \quad \ldots\ldots\ldots\ldots [14]$$

where t_a = average temperature during expansion stroke, deg. fahr.

Numerical values for all the required factors having been finally fixed upon, the various equations may now be combined to find a value for the cap temperature, t_c. This must be taken with due allowance for the decreased heat input with rise of temperature in the cap wall. For a 4-stroke cycle engine, this condition is satisfied by substituting in equation [3] and transposing,

$$t_c = \frac{\left(t_a\sqrt{\frac{N}{200}} - 11h\right)\frac{l_c^2}{33\,k\,s} + \theta_0}{1 + \sqrt{\frac{N}{200}}\,.\,\frac{l_c^2}{33\,k\,s}} \quad \ldots\ldots\ldots\ldots [15]$$

Taking k for cast iron equal to 3.82 and confining the equation to the line of Hornsby-Akroyd oil engines, the above can be further simplified by substituting for the thickness, s, equation [5]. Accordingly at full load,

$$t_c = \frac{0.13\,l_c\left(t_a\sqrt{\frac{N}{200}} - 11h\right) + 450}{1 + 0.13\,l_c\sqrt{\frac{N}{200}}} \quad \ldots\ldots\ldots\ldots [16]$$

From these formulæ, the expected cap temperature for an oil engine vaporizer may readily be estimated. The equations also hold good for partial loads, provided the numerical values of t_a and θ_0 are suitably modified. A check shows the cap temperatures to vary approximately as the square root of the per cent of full-load oil used. It will be seen that since the cap temperature formulæ contain a speed factor, the cooling off of the cap under slow speed and light loads tends to limit the speed control of the engine.

The air sucked into the hot cylinder of a Hornsby-Akroyd engine may be assumed to have an initial temperature of about 250 deg. fahr. This air, taken at 0.05 lb. per cu. ft. piston displacement, when compressed to about 45 lb. per sq. in. gage, will be confined in a volume just about equal to that of the vaporizer. Since a portion of this air must remain in the clearance space behind the piston, only about one-half of the cylinder intake air will be forced into the vaporizer by the time the piston reaches its inner dead center. This amount of air weighs only about 12 times as much as the injected full-load oil and is insufficient for complete combustion. However, immediately after explosion of this charge, a portion of the ignited supersaturated mixture is sent forth through the contracted neck, when it is made to intermingle with the required amount of surplus air lying in the space behind the receding piston.

Oil-gas assumes explosive proportions when the air content of the mixture reaches about two-thirds of the air required for complete combustion, i.e., about 10 parts of air to one of oil by weight. Such a mixture will ignite of itself at a temperature of about 750 deg. fahr. Assuming that air in proportion of about 10 times the fuel weight to have been forced into the vaporizer at the end of the compression stroke, the hot products of combustion may be expected to raise the temperature of the entire vaporizer content of a Hornsby-Akroyd engine to 750 deg. fahr., ignition temperature when running on one-third to one-half of the oil used at full load. Below this critical point, the temperature head, t_h, is reduced to such an extent that the cap no longer keeps the enclosed gases sufficiently preheated to reach the ignition temperature at the end of the compression period.

A corresponding check made for full-load conditions shows that, due to the higher exhaust and cap temperatures, the average mixture temperature in the vaporizer will be raised to about 800 deg. fahr. This increase of temperature causes an advance in the ignition timing, and at heavy loads may lead to the characteristic pounding that accompanies serious preignition unless counteracted by water injection.

Here the author develops the following formula for the minimum allowable vaporizer volumes for high compression engines:

$$\frac{V_v}{V_0} = \frac{1 - \left(\frac{P_2}{400}\right)^{\frac{1}{n}}}{\left(\frac{P_3}{400}\right)^{\frac{1}{n}} - \left(\frac{P_2}{400}\right)^{\frac{1}{n}}} \quad \ldots\ldots\ldots\ldots [17]$$

where V_0 = total clearance volume of engine (including vaporizer)

V_v = required volume of vaporizer

V_c = clearance volume external to vaporizer

P_3 = maximum explosion pressure, absolute

P_2 = compression pressure, absolute

n = exponent in $P\ V^n = C$

Numerical results derived from equation [17] are shown plotted in Fig. 3, from which it is evident that equalization of pressure cannot occur in the sense assumed unless the compression pressure exceeds 135 lb. per sq. in. gage. Hence engines operating at less than this compression should have their vaporizer volume made equal to the entire clearance space. This requirement may be obviated, and the vaporizer volume reduced by about one-third, when working with a supersaturated mixture and projecting the ignited oil-gas into the surplus air lying outside the vaporizer, as practised in the Hornsby-Akroyd oil engine.

The moderate preheating requirements of a high compression oil engine allow self-ignition to be attained without maintaining the vaporizer cap at full red heat. This reduces internal strains and makes the cap better able to withstand fatigue without cracking. Furthermore, the increased ratio of expansion in the high compression engine lowers the exhaust temperature, and in case the vaporizer cap is to be maintained at an average temperature considerably higher than that of the exhaust gases, due allowance must be made in the given

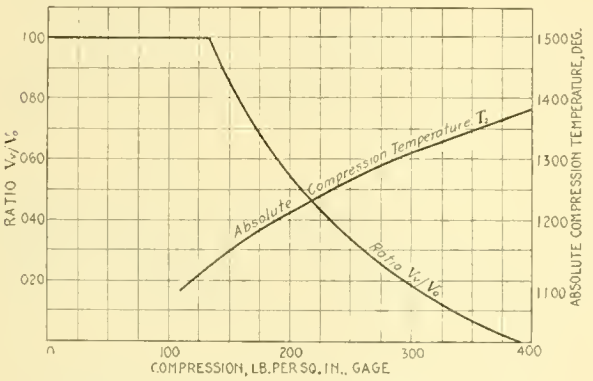

Fig. 3 Curve Giving Vaporizer Volume

formulæ for the cooling action occurring during the idle strokes.

The elimination of the idle suction and exhaust strokes, make the 2-stroke cycle especially applicable to hot-bulb oil engines; it not only improves the frequency of impulse, but also admits of wider speed variation without ignition failure. By carrying the compression in the vaporizer beyond the self-ignition limits, the engine can be proportioned to operate through a much greater speed range than is possible with the low compression Hornsby-Akroyd type of engine.

Comparing the high compression vaporizer type of oil engine with the Diesel engine, it may be pointed out that the former is lower in first cost and the net fuel economy is little, if at all, inferior when working with a compression pressure above 300 lb. per sq. in. gage. Among other advantages, the vaporizer engine embodies simplified construction, obviates extremely high pressures, increases mechanical efficiency, lowers the power loss required for air injection of the fuel oil, lessens operating skill required on the part of the attendant and to a considerable degree reduces the danger of destructive explosion.

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

Provisions have been made by the Publication Committee for Correspondence Departments in The Journal as follows:

A Department for contributed discussions on papers previously published, or new matter.

A Members' Correspondence Department including suggestions on Society affairs.

Contributions for these departments are earnestly solicited.

AN OPPORTUNITY FOR THE SOCIETY

To the Editor:

I wish to suggest an answer to one of the questions you ask on page 2 of the November, 1915, issue of The Journal as to how the work of the Society can be extended.

In my opinion, one way of doing this is to draw the attention of the membership to the desirability of inducing the Federal Government to bestow the same favor on engineering that has been accorded to agriculture, that is, to pass a law establishing Engineering Experiment or Research Stations at the Land Grant Colleges. The Society might well be given the privilege of supervising this work.

In order to satisfy the constantly increasing need and demand for engineering research work in this country, we should have an appropriation beginning the first year with $15,000 and an annual increase of $5,000 per year for two years, making a total annual sum of $25,000, to be paid each state and territory for maintaining a Research Station. This money should be used for no other purpose than research along engineering lines.

The staff at these stations should be composed, in the beginning, of three engineers, all of whom should be "thirty-two years of age, or over, and in actual practice of their profession for at least ten years and in responsible charge of important work for five years, and qualified to design as well as to direct engineering work." One of these should be designated Director.

As soon as the appropriation has increased to an amount permitting, one more engineer should be engaged, thus completing the staff of four engineers at each station.

The Federal Director of these stations should be first, an engineer and second, a good business man.

In the selection of these engineers it should be of the highest importance to choose men whose records show their ability to think scientifically, and in order to secure able engineers for these stations, I feel that one-half of the appropriation should be used for the salaries of these four engineers, the balance to be expended for apparatus, labor, etc., in connection with the experiments.

We need research on this scale in order to keep pace with the other world powers. We need it to improve the quality of our materials and to perfect our processes and methods.

In asking for this appropriation of one and a quarter millions dollars in round numbers annually, we cannot promise a regular return to the Government in the form of direct earnings, but we can promise an indirect return in course of time of many million of dollars in the form of increased wealth of manufacturing, increased tax returns on manufacturing property, also increased exports of improved machinery and merchandise.

Chas. Mills.

Riverside, Cal.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee of the Society, after completion of its report on Rules for the Construction of Stationary Boilers and Allowable Working Pressures, as announced in the March 1915 issue of The Journal, was continued by the Council as a Committee to make such revisions as may be found desirable in the Rules and to modify them as the state of the art advances.

A resolution was passed by the Council of the Society empowering the Committee to make rulings where inquiries are made respecting constructions not covered by the Code and to interpret any parts of the Code. The various inquiries have been given careful consideration by the Committee, each being given a case number under which it is filed in the records of the Committee, which are preserved at the office of the Society.

The procedure in the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed on at a regular meeting of the Committee. This interpretation is submitted to the Council for approval, after which, it is issued to the party making the inquiry and later published in The Journal, in order that any one interested may readily secure the latest information concerning the interpretations.

Since the first meeting for issuing interpretations which was held in Buffalo at the time of the Spring meeting of the Society, three additional meetings have been held by the Committee. Forty-six inquiries have been considered. Of these interpretations have been given for all but three, which are still in the hands of the Committee. Below are presented synopses of the forty-three cases for which interpretations have been issued. In general it has been thought advisable to refrain from the publication of the names of inquirers.

The Code was published in Volume 36 of the Transactions.

Case No. 1

Inquiry: Should the crown sheet of the vertical single flue boiler shown in Fig. 1 be stayed or braced as a flat surface?

Reply: The strains in a boiler of this design cannot be calculated, and it is the expressed desire of the Committee that such a boiler of the particular size and make be tested to destruction in the presence of the Ohio state inspector and the inspector of an authorized insurance company doing business in the State of Ohio.

Case No. 2

Inquiry: A ruling is desired relative to the method of supporting water tube boilers by head supports attached directly to the heads of steam drums, in order to enable the drums to be set close together.

Reply: Where forces other than than those provided for in the Code are applied to steam boilers or other pressure vessels, the strain imposed by such forces must be calculated and additional strength provided to withstand them, using a factor of safety not less than that prescribed for similar conditions in the Code.

Case No. 3

Inquiry: Can flange steel be used in the shells of locomotive, marine and vertical tubular boilers in construction under the A.S.M.E. Code? In other words, is it to be understood that fire-box steel will be required only where the plates are exposed to the fire or products of combustion?

Reply: In accordance with Pars. 2 and 3, flange steel may be used in shells of such boilers.

Case No. 4

Inquiry: Is there anything in the Boiler Code to prohibit a third return of the products of combustion in the setting of a horizontal tubular boiler, by turning arches over the same? It is also a common practice in heating installations where locomotive type boilers are used, to return the products of combustion around and over the top of such boilers by arching them in.

Reply: There is no mention of, nor provision for the passing of products of combustion over the tops of boilers and this arrangement is thus not prohibited by the Code. However, if such third-pass arrangement is used and the products of combustion come in contact with the shell or dome of a boiler, it would be necessary that the boiler be constructed entirely of fire-box steel to comply with Pars. 2 and 3 of the Code.

Case No. 5

Inquiry: Can the quadruple-riveted butt and double strap joint, illustrated in Fig. 2, be used under the rules of the A.S.M.E. Code? On quadruple-riveted joints, only a few rivet pitches can be put in a course of a shell, and it is often very difficult to get in a good spacing of rivets. This proposed spacing gives the designer more leeway. It is the same as the quintuple riveted joint shown on p. 102 of the Code.

Reply: There is nothing in the Code to prohibit the use of the proposed arrangement, providing the rules in the Code with respect to joints are complied with.

Case No. 6

Inquiry: The upper cut on p. 103 of the Code shows an impossible joint for boiler construction. The distance between the outer rows of rivets is too great and therefore the joint does not permit of calking tight.

Reply: The criticism is justified only when butt straps are thin. This type of joint is in common use in this country and abroad with heavy plates.

Case No. 7

Inquiry: Is the bushing specified in Pars. 307 and 315 considered necessary to more securely hold the pipe in the head? If this is the case, does not a lip pressed outwardly around the feed pipe perform the same function and could it not be included under the same specifications?

Reply: Much better construction would result by forming or pressing into the dished head a flat spot in which can be inserted a regular steel or brass bushing, as required by the Code. The intent of the brass or steel boiler bushing is to allow the pipe to be threaded in solid from each side; that is, from the inside or outside of the boiler.

Case No. 8

Inquiry: The title of the Code on the cover and page 1 reads, "Construction of Stationary Boilers," which is not correct. The Code does not cover stationary boilers only; it covers portable, semi-portable and traction boilers and the term is therefore misleading.

Reply: The interpretation given to the word "stationary" by the Committee is that stationary boilers in general are considered land boilers or non-marine boilers. Further, stationary boilers are construed in some interpretations to be applied to boilers in vessels where the vessels are not propelled by the steam generated in them, such as pile drivers and donkey boilers of steamships and barges. It was therefore decided unwise to amplify or describe the word "stationary" in detail.

Case No. 9

Inquiry: Is it allowable to publish extracts from the Code in a text book for students, where the quotations are not arranged in the same sequence as in the Code, but where all quotations are literally in the language of the Code, each paragraph being

preceded, as a distinguishing mark, by the paragraph number of the Code and by quotation marks?

Reply: The publication under the conditions outlined is allowable.

Case No. 10

Inquiry: Please advise as to where the boiler stamp specified in Par. 332 of the Boiler Code may be obtained?

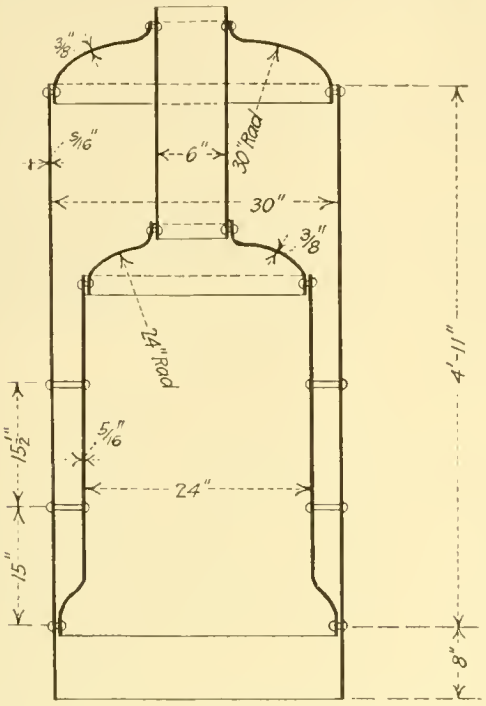

Fig. 1 A Design of Vertical Single Flue Boiler

and reaming of the tube holes is specifically provided for, apply to handhole openings as well?

Reply: Par. 248 applies only to tube holes and thus does not refer to handhole openings, and there is no provision in the present rules providing for the machining of handholes.

Case No. 12

Inquiry: Objections are raised to the action of the Ohio Board of Boiler Rules in rejecting a particular design of house heater safety valve as not conforming to the requirements of the A.S.M.E. Code, on the basis of the rules that prohibit adjustment for a higher pressure than 15 lb., and that prohibit location or piping so that there will be danger of scalding attendants.

Reply: It is the judgment of the Committee that the Ohio Board is entirely correct in its interpretation of the provisions of the Code.

Case No. 13

Inquiry: Please give an interpretation of the application

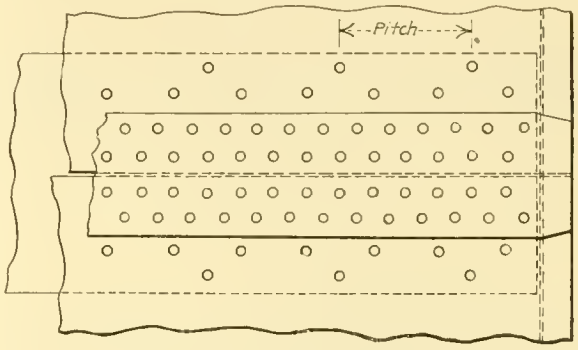

Fig. 2 A Design of Quadruple-Riveted Butt and Double Strap Joint

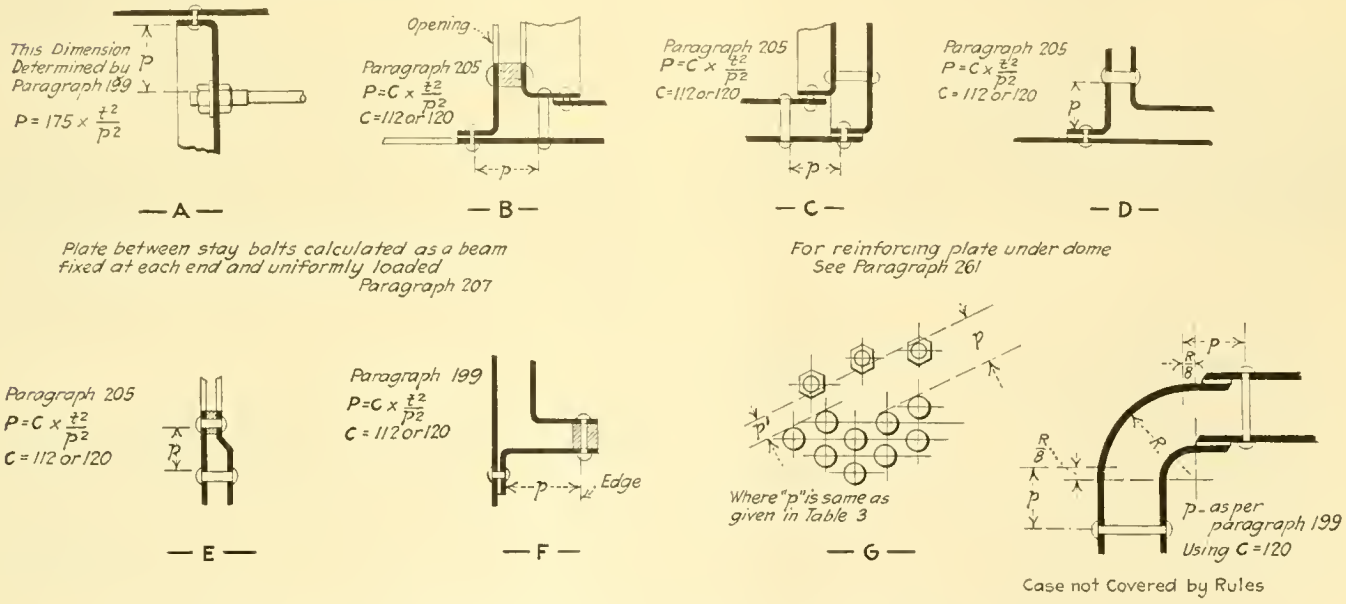

Fig. 3 Details showing Application of Pars. 205, 206 and 207 to the Staying of Wet-Bottom Boilers

Reply: At the meeting of the Boiler Code Committee of The American Society of Mechanical Engineers in Buffalo on June 24, 1915, the wish was officially expressed by the Committee that all A.S.M.E. boiler stamps be obtained through The American Society of Mechanical Engineers, 29 West 39th Street, New York. Stamps have been placed on sale by the Society, and may be obtained at the nominal price of $3.00 each.

Case No. 11

Inquiry: Does Par. 248, in which the drilling or punching

of Pars. 205, 206 and 207 to the staying of locomotive type wet bottom boilers, such as are used in portable or traction service, with particular reference to the details shown in Fig. 3.

Reply: Fig. 3 has been prepared to show the application of Pars. 205, 206 and 207 to eight possible cases where uncertainty may arise in the staying of boilers of this type, each of which is shown with a reference to a paragraph and a formula indicating the value of p together with the value of the constant.

An additional case not covered by the rules is also shown. The matter of reinforcing plate underneath the dome is answered by reference to Par. 261 of the Code.

Case No. 14

Inquiry: Is Par. 5 which apparently requires all manhole and handhole covers to be made of pressed steel, consistent with Par. 262?

Reply: It was found that the punctuation in Par. 5 in the first edition of the Code was incorrect and the paragraph has been repunctuated as follows: "5 Manhole and handhole covers and other parts subjected to pressure and braces and lugs, when made of steel plates, shall be—" etc.

Case No. 15

Inquiry: Is it allowable under Par. 195, to use the longer radius in calculating the thickness of a concave head having two different radii?

Reply: It is perfectly safe to use the longer radius in calculating the thickness of heads having two different radii.

Case No. 16

Inquiry: Is it possible to omit the constant in the formula in Par. 193, which handicaps the construction of drums with the tube spacings illustrated in Fig. 4? It is considered that the staggered relation of the tube design shown in Fig. 4 is equally as strong as if the tubes were put in parallel rows. Can this not be proved to the satisfaction of the Committee by a test to destruction of drums constructed in this manner?

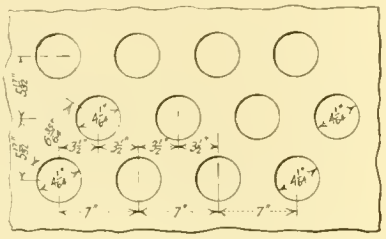

Fig. 4 Diagonal Spacing of Tube Holes in Steam Drum

Reply: The particular spacings of $5\frac{3}{4}$ in. and 7 in. for staggered 4 in. tubes, do not come within the range of the formula in the Code for diagonal ligaments, and as long as these particular spacings and size of tubes continue to be used, the efficiency of the tube sheet may be figured on the longitudinal ligament.

Case No. 17

Inquiry: *a.* Referring to the provision that all fire doors of water tube boilers are to be provided with latches, how can a fireman be expected to make use of such a device?

b. The specification, staybolt iron, is so drastic as to prohibit its use in the boiler business, which is a misfortune because staybolt iron is a better product for use in water tube boilers than staybolt steel.

c. Is not the thickness required by the formula for dished heads excessive. They are vastly beyond all previous practice.

d. Referring to Par. 191, how is it proposed to form the ends of a 72 in. shell by rolling? This involves so much extra labor when applied to shell plates that doubtful benefits are secured at much too high a cost.

Reply: *a.* The provision of latches on fire doors of water tube boilers was made in the interest of safety.

b. The requirements of the Code relative to staybolt iron are a direct copy from the American Society for Testing Materials specifications for that class of material.

c. This particular formula (Par. 191) in the Code, was determined after the most careful consideration and it will be inexpedient to consider any change.

d. In regard to the rolling of boiler shells, this is one of the most important features in the proper construction of boilers, and the Committee trusts that arrangements may be made in constructing boilers to meet the requirements of the Code.

Case No. 18

Inquiry: What is the purpose of Pars. 307 and 315, requiring boiler bushings? In locomotive type boilers it has been a practice to take the feed pipe through the fire door sheet, although in some cases, due to interference of external construction it has been necessary to have the firedoor in the side of the fire box instead of at the end. In these cases, it is also impracticable to introduce the feed water through the fire door head, and it is then introduced through the shell plate, using a reinforced plate riveted to the shell and threading both plates.

Reply: Par. 315 of the Code applies only to horizontal return tubular boilers. It was the intention of the Committee to make the use of a boiler bushing obligatory only when an internal pipe is used.

Case No. 19

Inquiry: Is it the intention of Par. 200 to allow the use of hollow staybolts in lieu of drilled staybolts,—at any rate for small bolts?

Reply: It was the intention of the Committee, as expressed in Par. 200, to permit the use of hollow staybolts, whether drilled, forged or made of tubing.

Case No. 20

(In the hands of the Committee)

Case No. 21

Inquiry: An explanation of the meaning of Par. 207 is desired. Apparently this matter is specifically covered in Par. 199.

Reply: This paragraph was arranged so that manufacturers could space stays wider than allowed by Table 3, providing stiffeners be used to keep the stress within prescribed limits; for illustration handholes where edges of plates are turned in.

Case No. 22

Inquiry: Is the term, "length of furnace" in Par. 239 intended to mean the length of the longest section or the length from end to end?

Reply: The length of furnace, referred to in Par. 239, is the total length and not the length of a section.

Case No. 23

Inquiry: Where a manhole is located in the head of a horizontal tubular boiler above the tubes, how should the arrangements of braces around the opening be provided for? It is possible that Par. 203 would cover in the case of handholes, but would not some additional provision for spacing be required in the case of manhole openings?

Reply: Par. 203 is not intended to be applied to the spacing of crowfeet or the spacing of through braces across any opening.

Case No. 24

Inquiry: Please state the correct procedure.

(*a*) to design an A.S.M.E. Code Boiler; it is understood that it is only necessary to follow the Code and that drawing need not be submitted for approval.

(*b*) to obtain authority to use the A.S.M.E. Code Boiler stamp; it is understood that this is supplied by the Society at a cost of $3.00 upon application in the form of an affidavit which prescribes its usage and is to be surrendered to the Society immediately at any time upon request.

(*c*) after obtaining the stamp to build the boiler; when an order for an A.S.M.E. boiler is received, it is understood that an insurance company is to be notified that an inspection is to be made of it.

(*d*) in handling inspections of boilers; it is understood that two inspections are made,—one before the riveting up and one as a final test:

(*e*) in the stamping of the boiler after completion; it is understood that the builder shall stamp the boiler in the presence of the inspector, with the A.S.M.E. Code stamp, the builder's name and the serial number of the boiler as well as the insurance company's or State stamp.

(*f*) in making report of inspector's data; it is understood that the inspector's data slip is turned in to the chief inspector and that a record must be made of all that is in same.

Reply: The understanding relative to Inquiries *a* and *b* as to the procedure necessary in commencing construction of an A.S.M.E. Code boiler, is correct. As to *c, d, e* and *f*, the matter of any insurance company certifying as to the correctness of the Code stamp is a question of contract between the manufacturer and the insurance company adding the stamp, and of the law in the case of a State stamp, over which the Committee has no jurisdiction.

Case No. 25

Inquiry: Referring to Pars. 268, 307 and 315, must the boiler feed and surface blow-off pipes be bushed in all types of boilers, including the locomotive type as well as the vertical submerged tube type?

Reply: Par. 315 of the Code applies only to horizontal return tubular boilers. It was the intention of the Committee to make use of a boiler bushing obligatory only when an internal pipe is used.

Case No. 26

Inquiry: Is it necessary to furnish mill test reports covering physical test and chemical analysis of material used in braces?

Reply: Attention is called to the specification for steel bars on p. 19 of the Boiler Code, which specification a builder will be called upon to follow for braces to be used in boilers constructed in strict accordance with the Code. Attention is also called to Par. 6 of the Code.

Case No. 27

Inquiry: An interpretation is requested on Par. 223, which does not state that the rivet holes must be drilled from the solid.

Reply: Any or all rivet holes in boiler construction may be punched ¼ in. small and drilled or reamed to full size thereafter.

Case No. 28

(In the hands of the Committee)

Case No. 29

Inquiry: Is the boiler brace shown in the accompanying sketch, where the end section left in the foot of the brace is smaller than called for by Par. 223, within the requirements of the Code?

Reply: It is the judgement of the Committee that all braces used in A.S.M.E. Code boilers should conform to the Code in every detail.

Case No. 30

Inquiry: Attention is called to the fact that the requirements of the Code for safety valves specifying a lifting device so attached that the valve disc can be lifted from its seat a distance of one-tenth the nominal diameter of the valve, requires an exceptionally strong lever, possibly of the cam type, and that the present types of levers are not satisfactory.

Reply: The requirements for safety valves were made after conference with the principal manufacturers of the country and it goes without saying that the Code requirements apply to all manufacturers and all designs.

Case No. 31

Inquiry: Is not a pressed steel flange for surface blow-off connection superior to an ordinary bushing screwed into the boiler shell, as provided for in Par. 307?

Reply: It is the intention of the Committee to make the use of a boiler bushing obligatory only when an internal pipe is used. The idea in specifying the boiler bushing is to have the internal pipe screwed in solid into a substantial fitting. Whether or not the plate should be reinforced where the bushing is screwed in depends on its thickness to give the required number of threads in accordance with Par. 268.

Case No. 32

Inquiry: The latter part of Par. 199 is understood by some to set a limit on the thickness of doubling plates; is this so?

Reply: It was not the intention of the Committee to limit the thickness of doubling plates that might be used on a boiler, but it was intended rather that the strength added by the application of a doubling plate should be limited to that which would be provided by a plate of equal thickness with the head to which it is applied; that is, for cases where doubling plates are thicker than the head of the boiler, the value of "*t*" shall be taken as ¾ of the double thickness of the head.

Case No. 33

Inquiry: Can safety valves of any size be connected to boilers by the use of nipples and threaded flanges? There appears to be a conflict between Pars. 268 and 286.

Reply: Par. 286 applies to the form of connection of a safety valve to a boiler. Par. 268 makes no reference to the form of connection.

Case No. 34

Inquiry: Does Par. 254 apply to the butt joints in the shell only, or to other riveted joints on boilers also?

Reply: Par. 254 refers specifically to plates and butt-straps collectively, whether reamed or drilled.

Case No. 35

Inquiry: Is it intended that Par. 292 apply to all designs of automatic water gages when there is one design in which an entire stoppage of either valve is impossible?

Reply: After careful consideration of this question, the Committee has decided to interpret Par. 292 as follows: No water glass connection shall be fitted with an automatic shut-off valve, except when the automatic shut-off valves are so constructed that the two connections to the water glass can be blown through separately and the steam connection cannot be entirely closed thereby.

Case No. 36

Inquiry: Does Par. 355 mean that a safety valve with a threaded side outlet must be used or can a valve with top outlet or one which exhausts directly into the atmosphere be used?

Reply: A safety, or water relief valve designed for a discharge pipe will comply with the requirements of Par. 355; safety or water relief valves without provision for a discharge pipe may comply with the requirements of Par. 355 provided the valve is so located that there is no danger of scalding the attendants.

Case No. 37

Inquiry: Can forged steel flanges of 4 in. pipe size, with a thickness of 1⅛ in. be used on boilers built to carry 175 lb. pressure? Table 16 requires a thickness of 1¼ in.

Reply: In regard to the thickness of flanges and bodies for nozzles and fittings, Tables 15 and 16 for the American Standard have been prepared for cast iron as a material, and until a flange committee prepares a table for steel, the Boiler Code will permit an allowable variation of 20 per cent from the thickness required by the above mentioned tables, leaving the drilling of bolt holes unchanged. Special forged fittings shall conform with respect to diameter of flanges and bolt circle, but otherwise need not conform.

Case No. 38

Inquiry: Is it required that every boiler stamped with the symbol illustrated in Fig. 19 of the Boiler Code, should also be stamped with the form shown in Fig. 20?

Reply: This inquiry is answered by the ruling given in Case No. 24 as follows: "Certifying to the correctness of the Code stamp is a question of contract between the manufacturer and the insurance company adding the stamp, and of the law, in the case of a State stamp, over which the Committee has no jurisdiction.

Case No. 39

Inquiry: Referring to Par. 299, which states: "Where the maximum allowable working pressure is less than 125 lb. per sq. in., Table 15 shall be used and where higher Table 16," a ruling is requested as to whether or not Table 15 is to be used for 125 lb.

Reply: The intention of Par. 299 is that Table 15 shall apply where the maximum allowable working pressure is 125 lb. per sq. in. or less.

Case No. 40

Inquiry: Referring to Par. 223 of the Code which calls for each branch of the crow-foot of boiler braces to carry two-thirds of the total load of the brace at the allowed stress, and for the net sectional areas to be at least equal to the required rivet section, exemption is asked for a special form of brace, as it is believed that this ruling applies to braces that are divided in the center of the crow-foot.

Reply: The design submitted is such that it does not come within the requirements of the Code. These rules have been formulated after thorough consideration of the stresses, and are in accord with sound practice.

Case No. 41

Inquiry: Referring to Par. 299 and Tables 15 and 16, it is understood that these requirements are based on flanges and fittings of cast iron; is it intended that these same tables shall apply to flanges of steel?

Reply: In regard to the thickness of flanges and bodies for nozzles and fittings, Tables 15 and 16 for the American Standard have been prepared for cast iron as a material, and until a flange committee prepares a table for steel, the Boiler Code will permit an allowable variation of 20 per cent from the thickness required by the above mentioned tables, leaving the drilling of bolt holes unchanged. Special forged fittings shall conform with respect to diameter of flanges and bolt circle, but otherwise need not conform.

Case No. 42

Inquiry: In Par. 323, the third sentence apparently applies only to boilers over 78 in. in diameter and specifically only to boilers suspended from over-head girders; has it any application to boilers provided with lugs resting on brackets?

Reply: Par. 323 applies only to boilers over 78 in. in diameter; such boilers must be suspended. Therefore, the paragraph relates only to lug supports of boilers over 78 in. in diameter.

Case No. 43

Inquiry: Par. 223 of the Code requires that: "The net sectional areas through the sides of crow-feet, T irons, or similar fastenings at the rivet holes, shall be at least equal to the required rivet section; does this refer to the blades of diagonal braces where attached to the shell of the boiler?

Reply: Par. 223 refers to blades of diagonal braces as they are similar fastenings to crow-feet or T irons. This means that the net section at the rivet holes of the brace should be at least 1¼ times the required cross sectional area of the body of the brace.

Case No. 44

Inquiry: A ruling is requested relative to a design of boiler in which cross drums are suspended below the shell of the boiler and exposed directly to the fire, so that they necessarily act as receptacles for mud and sediment and can only be classed as mud drums; as these are placed in direct contact with intense heat, they are considered contrary to modern practice and not of safe construction.

Reply: The Committee has decided that it will not express opinions on types of boilers, and it will therefore be impossible to comply with your request for an opinion.

Case No. 45

(In the hands of the Committee)

Case No. 46

Inquiry: With reference to the design of boilers for 500 to 600 lbs. pressure, the test pressure as specified in the Boiler Code would be prohibitive and give a larger factor of safety than could be expected with commercial construction. Can a modification be made that would permit the construction of such boilers at a commercial cost?

Reply: All requirements of the Code should be complied with irrespective of the working pressure. The Committee feels this is not an unreasonable requirement for commercial construction.

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SOCIETY AFFAIRS

THE Annual Meeting of the Society in New York, December 7-10, was a pronounced success socially as well as from a technical viewpoint. The registration exceeded all former records, and as a result the excursions and social affairs in connection with the Meeting were unusually well attended. The "Smoker," an innovation at this Meeting, met with the approval of the visiting members and its repetition at later meetings was strongly urged by all. An account of the social features of the Meeting follows.

THE ANNUAL MEETING

The Thirty-sixth Annual Meeting held in New York December 7-10 inclusive was a great success. There was a record attendance of 1437, of which 819 were members. Members were present from every section of the country, and fourteen Local Sections were represented by delegates, two of whom were from California. A feeling of enthusiasm was manifest, which found voice in various ways during the meeting. As reported elsewhere, there was a series of conferences of representatives of the Local Sections at which "Extend the Local Sections" was the watchword; and at these conferences the delegates proceeded to plan ways and means for accomplishing this end. At the Council meetings the sentiment expressed was equally prophetic. The spirit of democratization was in the air and action started toward a fuller control of the government of the Society by the membership at large.

It is probable that few members realize the great amount of work assumed by the Committee on Meetings in preparing the program for the Annual Meeting. The examination of the many papers submitted is itself an arduous task for busy men, besides the work of arranging an acceptable program and deciding the many questions which arise. The committee is always ably assisted by the New York Local Committee, who have charge of the social events, and this year unusually valuable contributions to the professional program were rendered by several of the local and professional committees. Seven papers were contributed by Local Sections and thirteen, including reports, by professional committees. By this means the papers are not only becoming more representative of the engineering work of the country as a whole, but are selected through intimate acquaintance with the subjects to be discussed and the mature judgment of the expert engineers who constitute the different committees.

PRESIDENT'S ADDRESS

Never, on a Tuesday evening of a convention of this Society, has there been so large an audience to listen to the presidential address as greeted Dr. John A. Brashear in the large auditorium of the Engineering Societies Building at the opening session. Dr. Brashear spoke in his always delightful manner on Science in its Relation to Engineering, and the manuscript of his address is appropriately given first place in this number of The Journal.

Following the address Calvin W. Rice, Secretary, reported for the Tellers of Election of Officers the election of the following:

For President:
D. S. Jacobus, New York.

For Vice-Presidents:
Wm. B. Jackson, Chicago, Ill.
J. Sellers Bancroft, Philadelphia, Pa.
Julian Kennedy, Pittsburgh, Pa.

For Managers:
John H. Barr, New York.
John A Stevens, Lowell, Mass.
H. de B. Parsons, New York.

For Treasurer:
Wm. H. Wiley, New York.

Past-Presidents Ambrose Swasey, S. T. Wellman, and W. F. M. Goss then escorted the President-Elect, Dr. D. S. Jacobus, to the platform, where Dr. Goss presented him as "one who had brought great honor to the profession and who for many years had unselfishly devoted himself to the work of the Society," and said that it was most fitting that he should now guide its destinies.

Dr. Brashear greeted Dr. Jacobus and said that he hoped the new President would have as good a time as he had had during his term of office and that he would have as cordial support as he had received from the membership. He referred to the Council meeting of that afternoon at which several resolutions were passed for the good of the Society at large, looking to the extension of its representative character, so that all its members "from Maine to California and from the Gulf to Canada" would have as great a voice as possible in the conduct of its affairs. Dr. Jacobus replied briefly, saying that this was the proudest moment of his life.

As is customary, the audience then adjourned to the rooms of the Society on the eleventh floor of the building where a reception was tendered to the President and President-elect and their friends.

ENTERTAINMENT FEATURES

It has become the custom for the ladies to hold a reception and serve tea in the rooms of the Society during one afternoon of the Annual Meeting, and as usual this event contributed much to the pleasure of those in attendance and gave the members an opportunity for a social hour at the end of a strenuous day of professional meetings.

On Thursday Mrs. Harrington Emerson entertained the ladies delightfully at luncheon at the Hotel Astor. About one hundred ladies enjoyed her hospitality on this memorable occasion.

In the matter of entertainment for the visiting members an innovation was introduced in the way of a smoker held in the rooms of the Society on Wednesday evening in place of the usual Wednesday evening lecture. To say that the rooms were not only crowded but were packed to their utmost capacity indicates the popularity of such a form of entertainment and the opportunity for members to get together for the renewal of acquaintanceship. It is safe to say that the membership will desire to have this feature of the Annual Meeting repeated another year and it is also evident that much larger quarters will have to be arranged for to accommodate those who desire to attend. Expressions of approval of this smoker, which was arranged by the New York Committee, were heard on every hand.

On Thursday evening as usual there was a dinner and dance in the Grand Ballroom of the Hotel Astor, which was attended by 300 members and guests. Last year this took the form of a combined dinner and dance, with dancing between the courses. This year the dinner took place before the dancing, so that groups who desired to dine together would not be broken up until the conclusion of the banquet. A reproduction of a photograph taken at the banquet is shown herewith.

Group of Members and Guests at the Dinner Held in the Hotel Astor, Thursday Evening, December 9, 1915

EXCURSIONS

On the third and fourth days of the Annual Meeting, six excursions were made to points of engineering interest. These were organized by the Excursion Committee, and each party was in charge of a competent guide.

The places visited were the Woolworth and Municipal Buildings, the studio of the Vitagraph Company of America, the aviation field at Garden City, the Brooklyn Navy Yard, the Interboro Rapid Transit Company's 74th Street Station, and the Harrolds Motor Car Company. The guides were Messrs. W. H. Greul, F. A. Scheffler, L. Goldmerstein, A. D. Blake, E. D. Herbert, and C. P. Bliss.

At the Woolworth and Municipal Buildings, members were afforded an excellent opportunity of inspecting particularly the power plants—that at the former building being privately owned and that at the latter being Edison service—and the elevator equipments.

At the Vitagraph studio, the practical details of making moving pictures were shown the party, and a very enjoyable time was spent.

Various types of flying machines, including Huntington, Schmitt, Buranelli-Carisi, Gallaudet, Curtiss, Bellanca, Young, driven by different motors, including Curtiss, Gyro and Gnome, were inspected at the Garden City aviation field. Flights were made by biplanes of the Max. Schmitt Company and by the Gallaudet machine of the New York National Guard.

At the Brooklyn Navy Yard, the Diesel engines for the fuel ship Maumee were run on the testing floor by special arrangement. These engines are the largest yet constructed in this country, 2600 h.p. A number of large battleships, including the Arizona, now being fitted out at the yard, were inspected.

The Seventy-fourth Street Station of the Interborough Rapid Transit Company, also visited, supplies the elevated railway system of New York City. The plant contains three 30,000 k.v.a. cross-compound turbines.

At the Harrolds Motor Car Company, the party was afforded the opportunity of seeing Pierce-Arrow motor car trucks and cars assembled.

COLLEGE REUNIONS

Friday night at the Annual Meeting has now come to be regarded as College Reunion night. This year ten such reunions were held and the members of the Society were invited to all.

These functions were the annual dinner and theater party of the Alumni of Stevens Institute of Technology, a smoker given by the Engineering Alumni of Brown University, the annual dinner of the Mechanical Engineers of Cornell University, a reunion dinner and smoker of the New York Lehigh Club, a reunion of members of the Technology Club at the Chemists' Club, a reunion of the Mechanical Engineering Alumni of the Polytechnic Institute of Brooklyn in the rooms of the Society, a reunion dinner and smoker of the Purdue Club of New York, a reunion dinner and smoker of the Alumni of the University of Illinois and the annual dinner of the New York Alumni of Worcester Polytechnic Institute.

BUSINESS SESSION

The business session on Wednesday morning opened with the presentation of the report of the Council and of the standing committees, which were approved by the meeting. Secretary Calvin W. Rice in offering the reports called attention to the salient features of the report of the Council, which is published elsewhere in this number.

Following the presentation of the reports of the Council and standing committees, E. S. Sanderson, *Chairman* of the Committee on Standardization of Special Threads for Fixtures and Fittings, presented a report of his committee on Straight Pipe Threads. This is the second report which the committee has submitted, the first having been given at the last Spring Meeting on the subject of Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases.

Mr. Sanderson said that while the subject of the report of his committee seems like rather a small matter, it probably affects as many manufacturers of small thread devices as could be conceived. The matter was first brought to the attention of the committee by manufacturers of automobile devices who, when the change was made from acetylene lighting to electric lighting for automobiles, found that the threads did not interchange and investigation showed that a similar condition existed with regard to threads on gas fixtures, electric sockets, etc. The report had been submitted to practically all the societies whose members might be users of such fixtures and it had their approval with but slight modifications which did not affect the usefulness of the report.

Dr. D. S. Jacobus announced the completion of the report of the Committee on Power Tests and said that a number of years ago the committee was appointed to bring out a report, considering, however, existing reports on this subject which the Society had issued, and which to a certain extent had become standard through long use.

A great deal of work had been done, especially by George H. Barrus, *Chairman* of the committee, William Kent and A. C. Wood, who formed a sub-committee of the main committee. From time to time there were meetings of the entire committee and every member of the committee had given his approval to the final report which had now been prepared.

The work was to be brought out first in a limited edition with the idea that some typographical errors might be found and the committee had suggested to the Council, who had approved, that a permanent committee be formed to interpret any portions of the report about which there might be doubt.

It was moved, and carried by the meeting, that the report be accepted, with the request to the Council that the standing committee mentioned be appointed.

The next business related to amendments to the Constitution, the first of which proposed to change the present provision for a special nominating committee for officers of 20 or more persons to a special nominating committee consisting of one per cent of the voting membership.

There was considerable discussion of this amendment, indicating a question in the minds of many as to whether one per cent of the present membership, which now constitutes 5000 voting members, would not make it too difficult for any member or group of members to organize a special nominating committee.

William T. Donnelly said that he had known of no abuse of the provision as it stood whereby only 20 persons were required to constitute such a committee. He considered the Constitution an instrument which should safeguard the membership, and that technically and ethically all amendments to the Constitution should arise from the membership rather than the Council; and unless there was some reason for the change in this section of the Constitution of which he was not advised, he was in favor of the old form.

Charles Whiting Baker considered the change not to be in the direction of democratization of the Society. While he believed that the nominating committees had done their work without favor or prejudice, still he would leave a door wide

open so that the ordinary man could come in and make his own ticket by choosing 20 men to nominate a candidate for any office in the Society.

Dr. Jacobus explained that in accordance with the requirements this amendment had its first presentation at the last Spring Meeting, otherwise he would have prepared another amendment in the same line to make the nominating committee more representative of the entire Society. He thought it would be a good plan to have the chairman of each Local Section a member of the nominating committee. At the Council meeting the day before it was voted to do everything possible to carry out the democratization of the Society and every member was to be given a chance, "from Maine to California and from the Gulf to Canada" (as expressed by Dr. Brashear at the opening session), to have a voice in the nomination of the officers and of the members of the Council.

James E. Sague, member of the Committee on Constitution and By-Laws, said there was no intent of the committee to move against a fair representation by the membership, but that it was considered that one member out of each 100 of the voting members would be a more business-like number than the limitation of 20 members.

A motion to lay the amendment on the table was duly seconded and carried by a preponderant vote in the affirmative.

At this point the business of the meeting was suspended to do honor to the memory of the late Frederick W. Taylor, Past-President, by brief memorial exercises, an account of which appears elsewhere in this number.

At the conclusion of these exercises the second amendment to the Constitution was considered, relating to copyrighting the Society's publications. At the present time the Society copyrights none of its publications except the annual volume of Transactions. The proposed amendment provided that "The Society shall claim the exclusive copyright to any reports of its duly appointed committees. The Council shall waive such copyright for specific reports. The Society shall copyright all papers read before the Society printing thereon in each instance that the paper may be reprinted by anyone after the same had been read before the Society, provided that due credit be acknowledged to the Society and the author."

Arthur M. Greene, Jr., explained that the purpose of the amendment was to enable the Council to secure a copyright in order to insure the proper publication of any report by those outside of the Society. The question arose in connection with the Boiler Code where certain people wished to publish parts of the Code, and the Council felt it necessary to protect the Code by insisting that they get permission whenever it is desired to publish. The purpose is merely to give the control of any publication to the Society rather than to leave it in the hands of one who would like to republish a paper or a report without securing permission.

Dr. Hollis Godfrey asked what was the relation of the author to a paper so copyrighted. There should be a provision which would enable the Society to release the copyright to an author of a paper when he desired to publish it in the form of a book. Authors have experienced difficulty in securing the consent necessary to publish matter of their own in book form when it has previously been copyrighted. The discussion by several others indicated that uncertainty existed as to whether this condition would obtain under the amendment as now provided, and it was finally moved and carried that the whole subject of copyrighting be laid on the table to give an opportunity for further consideration. The business meeting now adjourned and the first professional session began.

PROFESSIONAL SESSIONS

At this first session two papers were presented for discussion, on The Design of Fire Tube Boilers and Steam Drums, by F. W. Dean, and A Novel Method of Handling Boilers to Prevent Corrosion and Scale, by Allan H. Babcock. The latter paper was read by Mr. Babcock's assistant, Mr. Fred E. Geibel, who had come from San Francisco for this purpose. This paper provoked considerable discussion and it was a late hour when the meeting adjourned.

At this meeting also six papers were listed and distributed in pamphlet form for presentation by title only, and upon which written discussion was solicited for publication in The Journal. Five of these papers were contributed by Local Sections of the Society.

On Wednesday afternoon three simultaneous sessions were held respectively by the Sub-committees on Textiles, Machine Shop Practice, and Railroads. At the Textile Session the papers were on Higher Steam Pressures, Robert Cramer; Heating by Forced Circulation of Hot Water in Textile Mills, Albert G. Duncan; Relative Value of Private and Purchased Electric Power for Textile Mills, Frank W. Reynolds; and The Engineer and the Business of Fire Insurance, Joseph P. Gray.

At the Machine Shop Session there were two papers upon the Automatic Control of Machine Tools by L. D. Burlingame and L. C. Brooks, together with a Report of a Safety Code for the Use and Care of Abrasive Wheels, which had been put in the hands of the Sub-committee on Machine Shop Practice after consideration by a committee of the Machine Tool Builders Association and some other organiaztions.

A feature of the Railroad Session was a paper by a distinguished Honorary Member of the Society, Anatole Mallet of Paris, France, on the Operation of Parallel and Radial Axles of a Locomotive by a Single Set of Cylinders. A paper was also given on Four-Wheel Trucks for Passenger Cars by Roy V. Wright.

On Thursday morning there were two simultaneous sessions, one on Power Plants and one with Miscellaneous Papers. Those relating to Power Plants were The Heat Insulating Properties of Commerical Steam Pipe Coverings, L. B. McMillan; Performance and Design of High Vacuum Surface Condensers, Geo. H. Gibson and Paul A. Bancel; Circulation in Horizontal Water Tube Boilers, Paul A. Bancel; and Unique Hydraulic Power Plant at the Henry Ford Farms, Mark A. Replogle.

The papers of the Miscellaneous Session were headed by the Junior Prize paper for 1915 on The Flow of Air Through Thin-Plate Orifices, by Ernest O. Hickstein. This is the first paper to receive a prize from The American Society of Mechanical Engineers. The donation of the prize was made possible by a fund for Student and Junior Prizes recently established by a member of the Society. The other papers at this session were Elasticity and Strength of Stoneware and Porcelain, by James E. Boyd; Foundations, by Charles T. Main; and Oil Engine Vaporizer Proportions, by Louis Illmer.

The last session was a session of general interest and of a semi-technical nature under the direction of the Sub-committee on Protection of Industrial Workers with the following papers which drew out a considerable amount of discussion: Standardization of Safety Principles, Carl M. Hansen; Modern Movement for Safety from Standpoint of Manufacturer, Melville W. Mix; The Attitude of the Employer towards Accident Prevention and Workmen's Compensation, W. H. Cameron; and Industrial Safety and Principles of Management, W. P.

Barba. This was the last session with Dr. Brashear in the chair as President of the Society, and he closed the meeting with a few remarks expressing his thanks to every member of the Society. He explained how when the nomination had been offered him he felt that his other duties would prevent his serving the Society, but he finally agreed to accept if he could be relieved of minor duties. As had proved he found the major duties quite sufficient, for he had traveled 12,500 miles since the first of September, to say nothing of his earlier trips, for the purpose of meeting members and friends of the Society in different parts of the country and for delivering lectures before different sections and other associations in the country.

TRIBUTE TO F. W. TAYLOR AT ANNUAL MEETING

As a tribute to the late Dr. Frederick Winslow Taylor, Past-President of the Society, who died on March 21, 1915, the regular business of the Wednesday morning session of the Annual Meeting was suspended at 11 o'clock a.m. for a period of an hour, during which was held a memorial meeting to Dr. Taylor.

It was the desire of the Society, after the distressing news of Dr. Taylor's early death, to show honor to his memory in some fitting way, and in May last, the Council appointed a committee consisting of Henry R. Towne, *Chairman*, John R. Freeman, Prof. Frederick R. Hutton and Oberlin Smith, for the purpose of preparing a memorial.

This committee learned later of the service in memory of Dr. Taylor to be held in Philadelphia in October by the Society to Promote the Science of Management. An account of this remarkable service, which was conducted on Friday, October 22, in Houston Hall, University of Pennsylvania, and at which many leaders in management and personal friends of Dr. Taylor were present, was given in the November issue of The Journal.

At the Annual Meeting, Mr. Towne said it was the intention of his Committee to include in its report an account of the proceedings of the Philadelphia service, and that it would ask leave from the Society to print the full report of the Committee in Volume 37 of Transactions as a lasting tribute to Dr. Taylor's memory.

Brief addresses were then given by Mr. Towne, Mr. H. L. Gantt and Rear-Admiral Casper F. Goodrich, all intimate friends of Dr. Taylor, referring to various phases of his life and work, accounts of which follow.

Henry R. Towne. Science is defined as "knowledge gained by systematic observation, experiment and reasoning." That is the Baconian system, and this was followed by Mr. Taylor throughout his whole professional career. He not only aimed to acquire knowledge, but did acquire it, and out of the knowledge so acquired he created a new science, and, emphatically, he is entitled to be classed as a scientist as well as an engineer. Mr. Taylor's achievements were not the result of sudden impulse or inspiration,—they were the fruition of years of patient investigation, study, toil, experimentation and intense application of his admirable reasoning faculties. One of the most notable of his traits to all who have followed his career and to those of us who knew him was the endless pertinacity with which he pursued an object to which he had once turned his serious attention, and the work which he did was ever pursued in the true spirit of research.

"Facts, not opinions," is a motto which peculiarly applies to the life and methods of Mr. Taylor. He was ever seeking to get *facts*, to understand those facts correctly, to analyze them, and to apply them to useful ends. That is true throughout the whole of his wide range of work, but above all to his study of facts concerning human nature and their application to industrial work and management.

True to the spirit of the scientist, Mr. Taylor never rushed into print. Like Charles Darwin, before giving the world the results of his studies and discoveries he waited long years to assure himself of the facts and that his deductions from them were sound. He began his career at Midvale in 1878. His first public utterance on the subject of industrial management was in 1886, and then only as a discussion of a paper presented by Metcalf. His first paper on the piece-work system was not presented until 1895, after fifteen years of investigation and study, and his classic paper "The Art of Cutitng Metals," presented in 1906, came out only after twenty years of research. He spoke only when he had a message, and then always with absolute modesty. One could always feel that the man was not presenting himself, but his topic, and that that possessed him, that he was trying to present what he believed to be a new and interesting truth for the world to consider.

Mr. Taylor's major publications constitute a remarkable list. His first was in 1886 on "The Relative Value of Water Gas and Producer Gas for Open Hearth Furnaces," a short publication of only eight pages. In 1893 came his "Notes on Belting," the most comprehensive address on the subject the world had ever had up to that date, which was accepted as the basis for all further studies and investigations, and is practically the authority to-day on all the phases of the subject to which it relates. In 1895 was issued his "Piece-work System," the first paper on the subject. In 1899 he and Mr. White wrote a short paper of great interest and importance on "Colors of Heated Steel." In 1903, he brought out his first elaborate paper on the subject of "Shop Management," and for the first time presented to the world what we now call commonly the "Taylor System." In 1905 was issued his book on "Concrete," of which a third edition is in press to-day, and in 1906 came his paper on "The Art of Cutting Metals," 246 pages, which was epochal in its significance and importance, and finally in 1911 his complete gathering together of his "Facts and Arguments on the Subject of the Principles of Scientific Management," a book of 144 pages. What a record for twenty-five years! How wide the range of subjects, how long and thorough the study, and how complete his summing up of them!

Mr. Taylor was born in Philadelphia, in 1856, and attended the Germantown Academy as his early school. Then he was sent to school in France and Germany, and afterward spent a year and a half in an enjoyable trip to nearly all of continental Europe, and then two years at Exeter Academy preparing for Harvard University.

His eyes failed under the strain of his work and he had to give up the intention of entering Harvard. He entered a machine shop in Philadelphia in 1875, and for three years served his apprenticeship as a pattern maker and machinist, and there laid the foundation for the practical work which he took up later on. In 1878 he entered the Midvale Steel Works as a laborer and rose, in the short period of six years, to become chief engineer of the plant. One of his notable achievements while still a young man at Midvale was the successful design of a 20-ton steam hammer, which was novel in principle and daring in its features.

In 1883, while at Midvale, realizing his need for more thorough technical engineering education, he entered as a correspondence student of Stevens Institute, and by diligent and

earnest study secured his degree of Mechanical Engineer at the end of three years.

In 1890 he left Midvale and entered the employ of the Manufacturing and Investment Co., and for three years devoted himself to the reorganization of their large interests in Maine and Wisconsin, including in his work the design of two large pulp mills, and contributing many improvements to the processes and machines used in that special industry.

From 1893 to 1898 he worked out plans in five or six different establishments in Philadelphia and elsewhere, for remodelling their systems of shop management, and introduced many features of what afterward became known to all of us as the "Taylor System."

To whatever he turned his thoughts and his hands he gave concentrated attention, and in all cases he improved where he did not wholly originate. His range of work covered many fields and is an interesting chapter of human experience.

In 1901 he withdrew from salaried positions of all kinds. He had won a competence and was satisfied with it. His ambition lay not in that direction but in the carrying forward and upward of the work in which he had been so deeply interested and with which he was so closely identified, and he devoted himself from that time to the end of his life, without compensation, indeed even at the expenditure of much of his private means, to spreading the gospel of better industrial management.

In 1907 he was consulted by the United States Government in regard to the introduction of modern methods of management in its work-shops, arsenals and navy yards. In 1909 and afterward he frequently lectured on the subject of management and on kindred topics.

In 1906 the University of Pennsylvania conferred on him the honorary degree of Sc. D. and Hobart College that of LL.D. He was President of this Society in 1906, as well as being a member of many engineering and scientific organizations.

Mr. Taylor's was an abounding life. From youth to manhood and maturity it was brimming over with mental activity, an activity that flowed into many channels, but in each of them concentrated sooner or later upon some definite, specific object. He followed each object until a solution of the problem it presented had been worked out, and worked out so completely as to satisfy him, to make him willing to present the solution to the world.

In 1901 he said to one of his intimate friends: "I cannot afford any longer to work for money." That statement was typical of the man. Money was not an end with him but only a means, and having acquired the means to satisfy his reasonable desires his whole heart went into the furtherance of the work with which he had been identified through all his career.

His achievements were based primarily on his work at Midvale, and there he laid the foundations of nearly all the improvements with which he was afterwards identified, especially in regard to the cutting of metals, piece-work methods, the study of belting and shop management.

His books have been translated into many languages. His system has won world-wide recognition and increasing acceptance, and the tributes which were paid to him at the Taylor Memorial Services in Philadelphia, on October 21 and 22, 1915, were significant of the exceptional character of the man and his achievements.

As to the "Taylor System," the achievement with which his name is chiefly identified, there are many misconceptions. Most truly it is a science, and a new science. It is perfect in its simplicity and completeness. It is not piece-work, it is not differential rates, nor improved tools, nor time studies, nor routing plans, nor functional management, but it is all of these coördinated and combined, and above all, it aims to effect the uplift of the worker. Mr. Taylor aimed to show the workingman how to apply his time and efforts to better advantage and to accomplish more work than before in shorter time with less effort.

Sooner or later this fundamental fact in Mr. Taylor's work will be appreciated, and then the leaders of organized labor who, unwittingly, I like to think, thus far are opposing the introduction of the Taylor System, not only into Government plants but into private plants as well, will see their error and will lend their influence to promoting the introduction of a system which will do more than anything else that has been proposed in our day and generation for the uplift of labor.

Mr. Taylor saw the inequity of the old system of piece-work compensation, under which increased efficiency and output, instead of being rewarded, were punished by a reduction of the piece-rate. I partly grasped that fact, and proposed in 1899 a method which would supply a partial remedy. Mr. Taylor grasped the full fact and furnished a remedy which completely solved the problem. His best monument is the Science which he created, and that will endure forever.

H. L. Gantt. It was my good fortune to be associated with Frederick Winslow Taylor, when, as a young man, he was developing those characteristics that were to make him famous.

His reputation does not depend upon the fact that he designed and built the most successful big steam hammer in the world, or that he developed a method of treating tool steel that trebled its cutting power, or that he determined the laws of cutting metals, or even that he was the father of scientific management. These were incidents in his career, and only the logical results of his methods. At an early date he realized how much of the world's work was based on precedent, or opinion, and undertook to base all his actions on knowledge and fact.

Endowed naturally with untiring energy and a wonderfully analytical mind, he concentrated all the power of that combination on the problem of determining the facts he needed. He was interested in what had been done, mainly for the indication it gave of what could be done. His mind was continually on the future, and to him the great value of knowledge was that it enabled him to anticipate that future. Accurate in his calculations and logical in his conclusions, he never failed to put his trust in the results of his investigations, and often accomplished what was considered by others to be impossible.

Balked at the outset of his career in 1880 by the lack of knowledge of cutting steel, which then existed, he set himself the task of supplying that lack. Three years were spent in finding out how to study the problem; and, although the work was not completed for over twenty years, it is a fact that when I entered his employ in 1887, the fundamental laws had already been approximately determined. Subsequent investigations served only to confirm what had been done, and to correct minor inaccuracies.

At Bethlehem he became so interested in determining these laws exactly, that it is doubtful if he ever realized how wonderfully accurate his earlier results really were. To be sure, much more ground was covered in the subsequent work, but as an investigation into the laws of cutting metals, his work as a young man at the Midvale Steel Works stands out, to my mind, as far the more remarkable achievement.

One of the by-products of this investigation was the dis-

covery of the Taylor-White process of treating high speed steel, the far-reaching effect of which has not only not yet been fully realized, but cannot be until all the other problems entering into machine shop management have been given the same kind of study as has been given the cutting of metals.

The least heard of, but, to my mind, his most daring feat, was the design of the great hammer of the Midvale Steel Co. This hammer was kept in alignment by the elasticity of its parts, which yielded to the force of a foul blow and returned exactly to their former position. Dependence upon the principle of elasticity enabled him to build a hammer which, for its weight, had far greater power than any other hammer that had ever been built.

Moreover, Mr. Taylor repudiated the theory that large bodies must move slowly, which had apparently been accepted by previous designers of large steam hammers, for few, if any had been supplied with top steam. He recognized the fact that large bodies could be made to move as rapidly as small ones, if only sufficient power were applied to them. Accordingly he supplemented a falling weight of 25 tons by 50 tons of top steam, and designed a hammer whose rate of action was nearly three times that of other hammers of the same class.

The fact that he became a pioneer in another field is not surprising, for he was destined to be a leader in whatever field his activities took him. It seems quite likely that if he had adhered to what was then known as strictly engineering, he would have made even a greater reputation than he achieved in the field of management.

The work by which he is best known, however, is not what was then regarded as strictly engineering. Strange as it may seem, although much knowledge and thought had been devoted to the design of machinery and apparatus, but little study had been given to the possibilities of the men who were to operate that machinery. Even to this day many engineers consider their work done when they have designed and built, and demonstrated the possibilities of a piece of apparatus. They seem to feel that the efficient operation of it is not in their province. Mr. Taylor felt otherwise. To him, perfection in design was worthless without efficiency in operation, and at an early date he turned his attention to the efficient utilization of human effort.

In this work he used the same methods that had already brought him success, namely, to disregard opinions, from whatever source, unless substantiated by facts. Where facts were not available, and they seldom were, he used the scientific method for their determination.

When I went to the Midvale Steel Works in 1887, he had already made considerable progress in this work, and had fully developed the methods of detail analysis and study, which later became the origin of scientific management.

He recognized as an economic as well as an ethical fact, that the employer should always consider the interests of the employee.

Endowed with vast energy and great ability to work, he recognized the advantage such qualities would be to others, and offered high wages to those who would develop them. That he was correct is shown by the remarkable success which has been attained by all who profited by his training.

Having determined on a course of action he pursued it regardless of consequences; and inasmuch as such courses were planned by a clear head and followed with an iron will, he often accomplished results far in excess of what even his most earnest supporters thought possible.

To end here would not complete our picture. He was not the steam roller that some people like to represent him, but he did believe that a strenuous life was the life worth while, and that it not only brought more financial compensation, but that it added to the usefulness and happiness of men.

He had still another side: People said he made work of his play. True, work was his joy. Not the routine that would be done by anybody, but the work that others had been unable to do. An unsolved problem was a constant challenge to him, and he attacked it with a thoroughness and an eagerness that it is hard to comprehend.

Rear-Admiral Casper F. Goodrich. It is always a great pleasure for me to speak of Dr. Frederick Winslow Taylor, and I thank you for the opportunity of again bearing witness, such as it is, to the man's remarkable character and his genius. I am familiar with a certain chapter in the life of Dr. Taylor which I think is unknown to the majority of you, and until very recently was not known to more than a mere handful of people.

I first met Mr. Taylor in 1885, when he was chief engineer of the Midvale Steel Works. I took a great fancy to him then, and I recommended him to the then Secretary of the Navy, Mr. Whitney, for the position of Superintendent of our great gun works at the Washington Navy Yard. I do not think that Mr. Taylor felt himself free at that time to accept the position, but at all events this recommendation brought him into relation with Mr. Whitney, and later when the latter started a certain line of manufacturing, he asked Mr. Taylor to take the position of general manager of the works. In that way I was associated with Mr. Taylor for a couple of years, very intimately, and I have maintained the friendship based upon that association up to his death.

I am indebted to him for a great many very valuable services. In 1907 I was sent as Commandant of the New York Navy Yard, where I found five separate industrial establishments within the yard, each one, in so far as it could be, complete in itself. Each one of these plants had been erected by one of the bureaus of the Navy Department,—there were buildings devoted to construction and repairs, ordnance, equipment, yards and docks, etc. This multiplication of plants was not conducive to economy, and I immediately saw the need for reform.

Mr. Truman H. Newbury, who was then Assistant Secretary of the Navy, and who later became Secretary, had charge of the navy yards at that time, and I went to him with the facts and I said: "Mr. Secretary, I will present to you no scheme, no proposition, that I have not already threshed out with the ablest engineer in this country. I do not pretend myself to be a mechanical engineer, but I do, fortunately, possess the friendship and the confidence of Mr. Frederick W. Taylor, and I will go over all these propositions with him and I will bring nothing before you that does not meet with his approval." Mr. Newbury, of course, knew all about Mr. Taylor and he liked to feel that any matter in the way of reform would be based upon the broadest and the wisest of grounds. He promised me the backing of the Navy Department. I consulted Mr. Taylor and we drew up a scheme and carried it out, and suffice it to say that with Mr. Newbury's authority and Mr. Taylor's advice we succeeded in concentrating the work of the Yard into fewer shops and in enormously decreasing the appropriation necessary.

I will only give one other illustration of what he did. There came over to my desk on one occasion a statement or schedule, as it is called, of the tool steel required at the different navy yards in only one of the departments. I was amazed at the

vast number of varieties of tool steel that were demanded by name, by brand, and in every case there was a certificate that none other would serve. I consulted Mr. Taylor who advised me to buy steel according to specifications and not by brand. I asked him if he would help me prepare specifications and he very quickly offered me all the assistance I required. So we prepared the specifications, which were later adopted by the Tool Steel Board appointed by Mr. Newbury to take up the question of the varieties of tool steel required, and their composition.

The first high speed steel that was bought under Mr. Taylor's specifications, as adopted and promulgated by the Navy Department, was for the gun works at Washington, and Admiral Leutzed, who was then in command, told me he had been previously paying $1.25 a pound for the steel required and he was now getting tool steel for from 32c to 36c a pound, and the new steel was doing about 33 1/3 per cent more work.

I thank you for this opportunity of claiming what I consider to be one of the greatest privileges of a long life, that of speaking of my former intimate and dear friend, Frederick Winslow Taylor.

Henry H. Suplee. A little story about Mr. Taylor which I do not think has been told anywhere might be of interest.

Mr. Taylor had some knowledge of the German language, and wished to perfect himself in it. Instead of hiring a teacher and studying a grammar, he set about to organize his own method of studying German. He got several of his friends together—there were about a dozen of us—and we were to meet once a week in his father's house in Germantown. He employed a teacher, not to teach him, but to do what he told the teacher to do. Then he devised a method of studying German, so that we could all learn to speak it fluently. It was his idea that if we attempted to play the game known as "Twenty Questions,"—a game in which twenty questions are asked in regard to various subjects, and those present gave the answers—and if we were obliged to answer the question in German, we would soon learn the language. If we made mistakes, it was to be the duty of the teacher to correct us. The teacher was not to instruct us in German, but to hold us down to the ordinary rules of good speaking, and to correct us if we made mistakes in our conversation with one another. We held meetings once a week for one winter and played this game and we were all fluent speakers in German at the end of that time.

ANNUAL REPORT OF THE COUNCIL

The Council herewith presents in brief the important phases of the Society activities during the year 1915, under the presidency of Dr. John A. Brashear. In reports published in the December Journal, the Standing Committees have given accounts of their work in detail. This year in the appointments by the President the plan was carried out so far as possible of having a member of the Council on every Standing Committee. The appointments on Standing Committees for the year were: Finance Committee, A. E. Forstall; Committee on Meetings, L. P. Alford; Publication, Henry Hess; Library, Jesse M. Smith; Membership, George A. Orrok and later Charles E. Lucke; House, O. P. Cummings; Research, R. J. S. Pigott, A. M. Greene, Jr.; Public Relations, Spencer Miller; Constitution and By-Laws, James E. Sague. H. A. Hey, Chairman, Robert H. Kirk, W. P. Hayes, and E. S. Cooley were appointed as Tellers of Election.

Membership. Under the guidance of I. E. Moultrop, Chairman of the Increase of Membership Committee, coöperating with the Membership Committee in keeping to high ideals of membership, there has been a steady increase in enrollment of the most representative men of the profession. Fig. 1 gives comparative data on the membership of the four national societies.

On account of the unusual conditions prevailing abroad and the inability of communicating with members there, foreign members of the Society have been continued on the rolls until further action of the Council.

The Society has lost by death during the past year, B. F. Isherwood, Honorary Member and two Past-Presidents, Fred W. Taylor and James M. Dodge.

The Council elected to Honorary Membership E. D. Leavitt, the second President of the Society, who served during one of the most difficult periods of its history. Mr. Leavitt is best known for his notable successes in the design of high-duty, compound pumping engines for city waterworks service and of engines and other machinery for some of the great mining operations of the country.

Local Sections. The Council at its January meeting appointed a Committee on Local Sections, the personnel of which is E. H. Whitlock, *Chairman*, Cleveland, Ohio; W. F. M. Goss, Urbana, Ill.; L. C. Marburg, New York; Walter Rautenstrauch, New York, and D. Robert Yarnall, Philadelphia. It is hoped by this means to develop and put on an efficient basis this important phase of the Society's work.

One of the first plans carried out by the Committee was a conference of section representatives held at the Spring Meeting in Buffalo. Delegates attended from Atlanta, San Francisco, Milwaukee, Chicago, New York, Providence, Philadelphia, Cleveland, Worcester and Birmingham, and so much of interest was developed that the Committee arranged for a second conference at the Annual Meeting. It is planned to make these conferences of local section chairmen a feature of either the Annual or Spring Meetings.

Local meetings have been held under the auspices of the several local sections committees in Atlanta, Boston, Buffalo, Chicago, Cincinnati, Los Angeles, Milwaukee, Minnesota, New Haven, New York, Philadelphia, St. Louis, San Francisco, and Worcester.

Coöperation of any local section of the Society with existing engineering organizations in the same city has been enthusiastically supported by the Council in the endeavor to promote general concurrence of all engineering societies in technical meetings. St. Louis has formed such an affiliation with the Engineers' Club of that city and the Philadelphia Local Sections' Committee with the Engineers' Club of Philadelphia.

New sections were established this year at Los Angeles, Cal., Worcester, Mass., and Birmingham, Ala.

Student Branches are established in 38 universities, representing a total enrollment of nearly 1,000. Branches have been added this year at Virginia Polytechnic Institute, and Georgia School of Technology.

Finances. The annual report of the Finance Committee, together with the auditors' report, covers fully the financial

status of the Society. In this connection the Council wishes to call attention to the fact that our life membership fund ($44,120.11), representing all that has been paid in for life memberships, is maintained as a separate fund and is invested. Similarly all the other trust funds and for quite a number of years all the initiation fees have been put into a fund and invested. From this latter fund, at a rate of $6,000 per year, we are retiring the certificates of indebtedness for the land on which the headquarters is built. We have thus accumulated $40,268.90 to offset the $54,100 of certificates of indebtedness. We have also $40,000 cash on hand, so, if we wished to, we could pay off all these certificates and be free and clear, but to do so, would leave little working capital. As we are doing a business of $150,000 a year, and discount all bills, it is economy to carry this extra cash, particularly as all our funds are invested at the same rate of interest as we are paying on the certificates.

Financially, we are one of the strongest engineering societies in the world, although we have secured far less by gift than many similar organizations.

Employment Work. There has been marked activity in the employment work this year. We have registered over 400 positions with firms who have asked our coöperation in securing men; this does not include recommendations of experts in consulting work of which we do not keep record but for whom we have many inquiries. We have definite record of over 100 men who have been placed in positions through the Society, and we are confident that this cannot represent the entire list as firms and individuals in many cases fail to advise the Secretary's office.

It may be of interest to note that the other national societies have now adopted this policy of assisting members to secure positions by bringing firms and men together.

Prizes for Technical Papers. The Society has received by bequest from the late Rear-Admiral George W. Melville $1,000, the income of which is to provide a gold medal to be awarded annually to such competing member of the Society who presents the best original paper or thesis. As an adequate die for a medal cannot be purchased out of the above fund, upon application to the Court the Society has been authorized to allow the fund to accumulate until sufficient to defray the cost of a suitable set of dies.

There was reported last year the receipt of $2,000, through the generosity of a member of the Council, from which fund there are to be awarded annually three prizes, one of $50, to a Junior and two of $25 each to student members who contribute the best original papers. It is felt that such awards will influence the young engineer to undertake original work. The committees in charge of awards are: For Juniors, R. H. Fernald, *Chairman;* Fred E. Rogers, George B. Brand. For students, Frederick R. Hutton, *Chairman;* R. H. Fernald, D. S. Kimball. One award was made this year for the paper, "Flow of Air Through Thin Plate Orifices," by Ernest O. Hickstein, Junior Member. As the papers submitted by students did not meet the requirements as to standard, no awards were made this year.

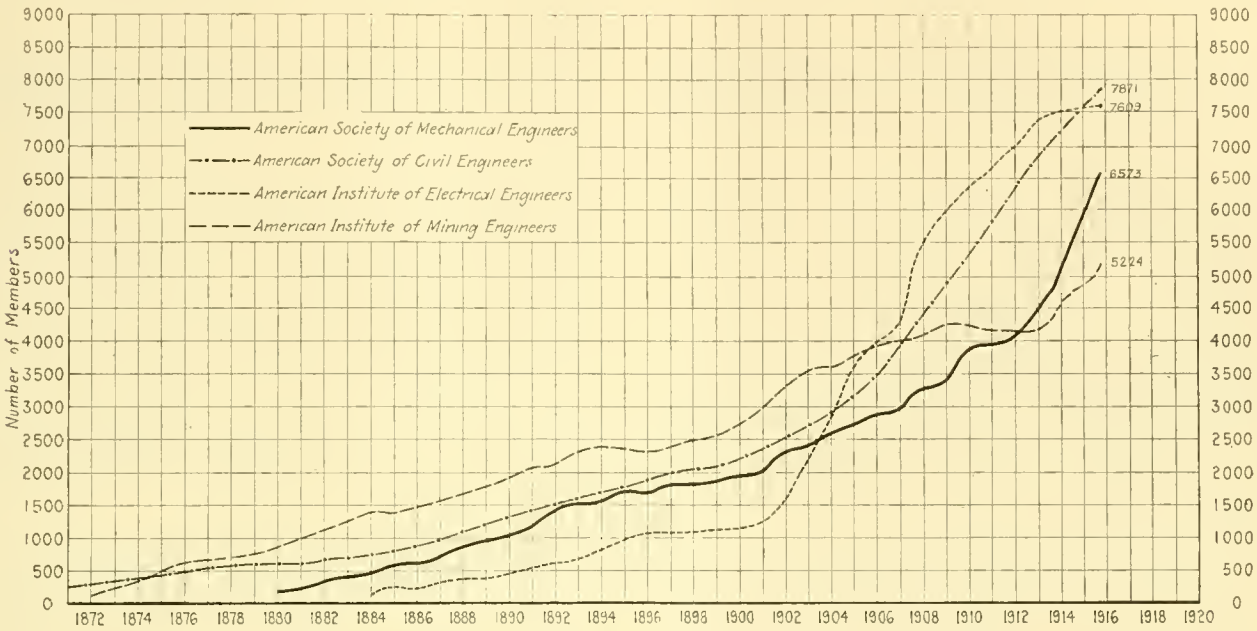

Fig. 1. Comparative Growths of Membership in the Four National Societies

MEMBERSHIP FOR YEAR 1914-15

Grade	Oct. 1, 1914	Losses				Additions		Net Increase	Oct. 1, 1915.
		Transfer	Resign	Lapsed	Death	Transfer	Election		
Hon. Mem.....	14				1	1			14
Member.....	4077	1	29	36	38	33	328	257	4334
Assoc.....	380	12	6	9	4	1	38	8	388
Assoc. Mem....	245				1	20	184	203	448
Junior.....	1274	42	25	24	2		212	119	1393
Total.....	5990	55	60	69	46	55	762	587	6577

Note—Affiliates, students' sections 955, a decrease of 36 since 1914.

Publications. The history of the Society from the time of its formation in 1880 through the year 1915, has been completed and issued uniform in size and binding with Transactions, with the exception of color which is dark green used to designate extra publications of the Society.

The Council has approved the plans of the Publication Committee as given in their report, which outlines a broad and progressive policy for the several publications of the Society.

COMMITTEE REPORTS

The Council has ruled that the signatures of members of the committee grouped as assenting or dissenting must accompany all reports. This ruling is covered in the following by-law:

"B-47. All written reports of all committees shall be presented to the Council. Each written report of every committee must be approved in writing by at least a majority of the members of that committee, before it is presented to the Council. A member of a committee who disagrees with the action of a majority of that committee may express his disagreement over his signature, either on the report of the committee or in a minority report. The minority report of any member of a committee if offered, shall be presented at the same time that the report of that committee is presented to the Council. All reports of committees must be first received by the Council who shall prescribe the manner in which they shall be presented to the membership of the Society and be made public and printed."

Boiler Code. On the completion of the report of the committee having in hand the preparation of a code for steam boilers, the original committee and its advisory committee were reappointed as one committee to be known as the Boiler Code Committee and asked to continue and extend its work to cover any structures and their operation that are connected with and serve purposes similar to boilers. The amount of time and work which the various members of this entire committee have given to the preparation of this report is so great that the Council wishes to record here its sincere appreciation.

Threads for Fixtures and Fittings. As the result of careful consideration of this subject and the coöperation by detailed correspondence with a selected list of thirty-eight of the largest manufacturers, the Committee on Threads for Fixtures and Fittings has completed its work on Rolled Threads. The report on Straight Threads will be presented at the Annual Meeting, 1915.

Tolerances for Screw Threads is a subject which is receiving the attention of a special committee and with the ready coöperation of manufacturers of taps and dies, the committee is now at work on tolerances for taps and screw threads.

The Power Test Report resulting in a complete standard for power tests is completed and presented for record in the Transactions for 1915. This is another example of years of self-sacrifice.

A permanent committee will be appointed to interpret the rules of the report when called upon to do so, to make such revisions as may be found desirable, and to modify the rules to meet new conditions as they may arise in the future. This new committee will hold meetings from time to time at which all interested will have opportunity to present suggestions.

RELATIONS WITH OTHER SOCIETIES

The American Institute of Electrical Engineers, the American Institute of Mining Engineers and The American Society of Mechanical Engineers, representing the Founder Societies of the United Engineering Society have coöperated by joint agreement in maintaining and financing the libraries of the Founder Societies under the direction of a Library Board. The same arrangement has also been provided in the matter of insurance and the establishment and maintenance of the Library Service Bureau. The representative appointed this year on the Board of Trustees is John R. Freeman, succeeding Fred J. Miller, whose term of office expired and who, under the by-laws, was not eligible for re-election; Jesse M. Smith and Alex. C. Humphreys, Past-Presidents are the other appointees.

The Engineering Foundation. A noteworthy incident in the history of the profession of engineering was the inauguration in January 1915 of The Engineering Foundation, a fund to be administered "for the advancement of arts and sciences connected with engineering and the benefit of mankind." The basis of this fund is the gift of $200,000 by Ambrose Swasey of Cleveland, Ohio, Past-President of this Society. The American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers and The American Society of Mechanical Engineers are equally represented in the administrative board of The Foundation. The United Engineering Society has been made custodian of the funds. The representatives of this Society on the Board are Jesse M. Smith and Alex. C. Humphreys; Frederick R. Hutton is Secretary of the Board.

Conference Committee. By the death of Alfred Noble a vacancy was caused in the Society's representation on the Joint Conference Committee of the national engineering societies and Arthur M. Greene, Jr., member of the Council, was appointed to fill the place. The Conference Committee is composed of two representatives each from the American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, The American Society of Mechanical Engineers and Society of Naval Architects and Marine Engineers.

John Fritz Medal Award. F. R. Hutton was reappointed for a term of four years on the John Fritz Medal Board of Award. The other representatives of the Society are Ambrose Swasey, J. A. Brashear and John R. Freeman.

Honorary Vice-Presidents. Frank B. Gilbreth represented the Society on the occasion of the opening of the new house of the Verein deutscher Ingenieure in Berlin. Major Wm. H. Wiley, Treasurer of the Society and member of the Council, was appointed the official representative of the Society at the convention of the Atlantic Deeper Waterways Association in Savannah, Georgia, F. F. Gaines acting as alternate.

As has been their practice for several years the Austrian Society of Engineers on the occasion of their annual meeting sent a letter of greeting to the Council.

The Engineers' Club of Kansas City, has been added to the list of those with whom we have arranged an exchange of courtesies in the use of the rooms and library privileges.

Graphics. As the result of invitations extended by The American Society of Mechanical Engineers a number of associations of national scope have appointed representatives on a committee to make a study of the methods used in the different fields of endeavor for presenting statistics and quantitative data in graphic form. Their preliminary report has been published for the purpose of inviting suggestions.

Classification of Literature of Applied Science. Delegates from about twenty national technical societies have conferred

with a view to perfecting a permanent organization for the purpose of preparing a classification of the literature of applied science which may be generally acceptable and adopted.

The name of this organization is Committee on Classification of Technical Literature. This Society is represented on the committee by F. R. Low, who is chairman of the committee of the whole, L. P. Breckenridge, W. W. Bird, A. E. Forstall, E. J. Prindle. The Committee from this Society will also take under consideration a proposed digest of material which has appeared in the publications of the Society, as the result of a suggestion from the New York Section on the occasion of a paper by E. J. Prindle on "A Proposed System of Classifying and Digesting the Records of the Society to render immediately available all information on each branch of every subject."

Expert Testimony. On request from and coöperating with the American Association for the Advancement of Science, the Council appointed F. H. Richards, W. H. Boehm, and H. deB. Parsons, with authority to add two members to their number, on a committee having for its object better practice in the use of expert testimony of engineers.

The American Society for Testing Materials have invited the Society to a proposed conference to consider the desirability and feasibility of coöperation in important matters of mutual interest and advantage to the various technical societies.

Flanges. A committee composed of H. G. Stott, *Chairman,* A. R. Baylis, A. M. Houser, Julian Kennedy, E. A. Stillman and W. M. White has been appointed to coöperate with the standardization committee of the Manufacturers' Association, in the recommendation of Flange Standards for Hydraulic Work.

The Committee on Flanges has been specifically requested to extend its work to include recommendations for ammonia apparatus and for steel fittings.

International Engineering Congress. The International Engineering Congress which was held in connection with the Panama-Pacific International Exposition in San Francisco was conducted under the auspices of the five national engineering societies, the American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, The American Society of Mechanical Engineers, the Society of Naval Architects and Marine Engineers, and was placed in the hands of a committee of management consisting of the presidents and secretaries of these five societies, and eighteen other members representative of them and resident in or near San Francisco.

Professor Durand and E. C. Jones later resigned from the Am.Soc.M.E. committee, and their places were filled by C. T. Hutchinson and E. C. Jones.

For the convenience of the members and their guests of the national engineering societies, an "Engineers' Special" was provided, leaving New York September 9, and arriving in San Francisco September 15.

Two hundred and forty-one papers were presented at the 52 sessions of the Congress, and although the existing international conditions made impossible a representative delegation from abroad, 66 of the papers contributed to the Congress were by authors outside of the United States. It is interesting to note that 48 authors of papers coming from the United States were members of this Society.

The return trip of a large number of the engineers was made along the line of the Southern Pacific and Canadian Pacific through Portland to Seattle, Victoria, Vancouver, Glacier, Lake Louise, Banff, Calgary and Moose Jaw, giving the party opportunity to inspect the engineering works along the line, the last objective being the big dam at Bassano.

MEETINGS

The Society has held its general meetings during the year, the Annual Meeting in New York and the Spring Meeting in Buffalo, N. Y.

An additional general meeting was held in San Francisco, September 16 and 17. The headquarters of the Society was the Clift Hotel and the local arrangements were in the hands of the local committee of the Society, F. W. Gay, *Chairman,* F. H. Varney, *Vice-Chairman,* C. F. Braun, *Secretary,* H. L. Terwilliger and J. T. Whittlesey. Five professional papers were presented. This meeting preceded the general sessions of the International Engineering Congress.

PUBLIC RELATIONS

The Council received an invitation from Worcester Polytechnic Institute to be represented at the fiftieth anniversary of the granting of the charter to Worcester Polytechnic Institute. Dr. Brashear, President, and Calvin W. Rice, Secretary, attended.

On invitation of the Governor of Massachusetts, E. F. Miller, I. E. Moultrop and John A. Stevens were appointed to represent the Society at the hearing on boiler legislation on December 17, 1915.

Park A. Dallis was appointed to represent the Society at the inauguration of Edward Kidder Graham as President of the University of North Carolina, and W. R. Dunn at the inauguration of John Henry MacCracken as President of Lafayette College.

Dr. Brashear and E. M. Herr were the representatives at the celebration of "Carnegie Day" at the Carnegie Institute of Technology.

Fire Hose Specifications. The Society coöperated with the Chamber of Commerce in the joint appointment of H. deB. Parsons as the representative of both organizations on a special committee created by the Fire Department of the City of New York to revise the specifications for fire hose. The work has been performed and the report placed in the files of the Society.

Sir William H. White Memorial. The movement recently started by the engineering societies of England to erect a memorial to the late Sir William H. White was responded to by the appointment of a memorial fund committee of this Society composed of Jesse M. Smith, *Chairman,* Alex. C. Humphreys and Frederick R. Hutton. The contribution from the members and friends of this Society was 63 guineas.

Constitutional Conventions. The Committee of Engineers representing national and local engineering societies was organized to present recommendations to the New York Constitutional Convention, and was composed of representatives of the American Society of Civil Engineers, American Institute of Electrical Engineers, The American Society of Mechanical Engineers, American Institute of Consulting Engineers, New York Section of the American Institute of Mining Engineers, Municipal Engineers of the City of New York, and the Brooklyn Engineers' Club. The Committee's recommendations were for continuity of control in the conduct of

the State's public works and by persons appointed by virtue of special fitness for these offices. In the report made by the joint committee the opinion is expressed that considerable success was secured by the engineers' efforts.

The general committee has presented its report and on recommendation of this committee and the representatives of this Society, Charles Whiting Baker, *Chairman,* A. M. Greene, Jr., E. G. Spilsbury, the committee is continued with those of the other societies represented for such assistance as it may render in other states where similar matters may be under consideration.

Naval Consulting Board. The Society was honored by an invitation from the Secretary of the Navy, Hon. Josephus Daniels, to participate in the work of the Naval Consulting Board, by the appointment of two representatives. By letter ballot W. L. R. Emmet and Spencer Miller were elected by the Council as the appointees of this Society. The Board is composed of two representatives each from twenty-two societies, including the Chairman, Thomas A. Edison, Honorary Member of this Society.

Engineer Reserve Corps. The suggestion was made in the spring of 1915 that the national engineering societies offer to assist the United States War Department in the formation of an Engineer Reserve Corps in the United States Army. Acting on this, the American Society of Civil Engineers, American Institute of Electrical Engineers, American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the American Institute of Consulting Engineers appointed committees authorized and directed to take such steps for the organization of such a reserve corps as might be advisable. In order to simplify future conferences a single committee has been formed to represent jointly the five societies—or the engineering profession as a whole. This general committee consists of Wm. Barclay Parsons, *Chairman,* Committee American Society of Civil Engineers; Henry S. Drinker, *Chairman,* Committee American Institute of Mining Engineers; B. J. Arnold, *Chairman,* Committee American Institute of Electrical Engineers; Wm. H. Wiley, *Chairman,* Committee The American Society of Mechanical Engineers; R. D. Mershon, *Chairman,* Committee American Institute of Consulting Engineers. The special committee in this Society is composed of Wm. H. Wiley, *Chairman,* John A. Hill, *Vice-Chairman,* W. F. M. Goss, H. A. Gillis and James M. Dodge. The separate committee in each society will take care of the work of its society as soon as the decision of the War Department can be given and a general scheme of organization adopted.

Pan-American Scientific Congress. In response to an invitation from the Department of State a committee of this Society is coöperating in the plans for a second Pan-American Scientific Congress to be held in Washington, D. C., December 27, 1915, to January 8, 1916. The Committee of this Society consists of General W. H. Bixby, *Chairman,* also Chairman in charge of Section V Engineering, Carl C. Thomas, Charles T. Plunkett, S. W. Stratton and Calvin W. Rice. Upon invitation from the Department of State, Ambrose Swasey, Past-President, and W. H. Marshall have been appointed as representatives of the Society to the Congress. Dr. John A. Brashear, President, has been selected by the Secretary of the Department of State of the United States as the representative of the engineering profession in America.

COUNCIL NOTES

DECEMBER 7, 1915

At the meeting of the Council on December 7, 1915, the following members were present: John A. Brashear, *President,* M. L. Cooke, R. M. Dixon, *Chairman Finance Committee,* H. L. Gantt, W. F. M. Goss, A. M. Greene, Jr., James Hartness, Alex. C. Humphreys, E. E. Keller, Spencer Miller, H. G. Reist, J. E. Sague, Ambrose Swasey, Max Toltz, S. T. Wellman, E. H. Whitlock, Wm. H. Wiley, *Treasurer,* Calvin W. Rice, *Secretary,* and by invitation, Dr. D. S. Jacobus, *President-elect.*

The report of the Power Test Committee was received and ordered printed. It was voted to appoint a permanent committee to interpret, revise and modify the rules to meet new conditions as they arise.

It was voted to invite the Committee on Standardization of Flanges to extend the Flange Report to include flanged fittings for ammonia work.

It was voted unanimously to favor an amendment to the Constitution that will make the election of the Nominating Committee more democratic. Dr. Jacobus announced his intention to ask the Chairman of the Local Sections to assist him in the selection of the Nominating Committee.

The Administration Committee had reported at the previous meeting that the growth of the Society and the enlarged opportunities for the accomplishment of work of national importance presented new problems.

The Committee recommended the further development of the Sections and of The Journal as means for immediately strengthening the work of the Society and maintaining the organization in the influential position it should occupy in the world.

In order that the Secretary be free to devote himself to the larger features pertaining to the accomplishment of the Society's greater activities, and that the editors be released from attending to the manufacturing features of the Society's publications, the Committee recommended that they be relieved of the details of the business management of the Society, and these matters placed in the hands of a new department in charge of a business manager to be responsible for their execution.

The report of the Administration Committee was approved in principle and was referred to the Executive Committee with instructions to proceed with the development of its recommendations and from time to time recommend to the Council such action as it should take with reference thereto.

It was voted to approve a Local Section of the Society at Birmingham, Ala., and R. E. Brakeman was appointed Chairman, and Paul Wright, Secretary and Treasurer.

The report of the joint committee in connection with the drafting of amendments to the Constitution of the State of New York was received, and the Committee of the Society was ordered continued with similar committees of other societies to render assistance in other States where similar matters may be under consideration.

DECEMBER 10, 1915

At the meeting of the Council on December 10, 1915, the new officers were formally introduced. The following members were present: John A. Brashear, *President,* J. H. Barr, R. M. Dixon, *Chairman Finance Committee,* W. F. M. Goss, Henry Hess, Alex. C. Humphreys, F. R. Hutton, D. S. Jacobus, *President-elect,* C. T. Main, Spencer Miller, H. de B

Parsons, J. E. Sague, J. A. Stevens, E. H. Whitlock, Wm. H. Wiley, *Treasurer,* and Calvin W. Rice, *Secretary.*

H. G. Stott was elected a member of the Board of Trustees of the United Engineering Society to succeed Jesse M. Smith, whose term of office had expired and who was not eligible for reëlection.

Prof. Frederick R. Hutton was reappointed to succeed himself as a representative of the Society on the John Fritz Medal Board of Award, to serve for a term of four years.

W. F. M. Goss was nominated as the representative of the Society to the Board of the Engineering Foundation.

P. N. Engel, Fred Dorner and Wynn Meredith were approved as Chairmen of the Chicago, Milwaukee and San Francisco Sub-committees on Increase of Membership, respectively.

Interpretations of the Boiler Code were on motion received and ordered issued. These are published elsewhere in this issue of The Journal.

It was voted that the request to the Committee on Standardization of Flanges to extend their work to flanged fittings for ammonia apparatus include a further request to consider steel fittings.

It was voted that the Committee on Constitution and By-laws be requested to report the phraseology of suitable By-laws to cover the duties, manner of appointment as to terms of office, etc., of all the Standing Committees of the Society for which instructions have not already been provided.

Calvin W. Rice, *Secretary.*

NEW OFFICERS OF THE SOCIETY

DAVID SCHENCK JACOBUS

President for 1916

David Schenck Jacobus, distinguished as one of the foremost American mechanical engineers and educators, was born in Ridgefield, N. J., in 1862. He was educated in a private school, then in Stevens High School, Hoboken, N. J., where he won by competitive examination a free scholarship in the Stevens Institute of Technology. He was graduated from the Institute with the degree of Mechanical Engineer in 1884.

Upon his graduation he was appointed instructor, then assistant professor of experimental mechanics, being closely associated with Prof. J. E. Denton. In 1897, he was called to the chair of experimental mechanics and engineering physics, in which he continued until 1906. From 1900 to 1906 he was also in charge of the Carnegie Laboratory of Engineering, built and equipped with funds donated by Andrew Carnegie for carrying out a course of instruction to supplement class room work by practical experiments made by the students.

At the Stevens Institute, Dr. Jacobus devised original apparatus for illustrating physical laws, and for testing various mechanical devices, and developed a course of experimental mechanics especially fitted for a mechanical engineering school.

While at the Institute, too, Dr. Jacobus performed a large amount of expert work, involving investigations and reports upon mechanical devices and processes for the production of power, and efficiency tests on steam motors, turbines and other power plant apparatus. He was early in the field of refrigeration, making tests of machines and writing articles on the subject. He also made early experiments on acetylene gas generators and on fire sprinkler systems.

Since 1906, he has been actively associated with the Babcock & Wilcox Company at the head of its engineering department in the position of advisory engineer. This made it necessary for him to give up practically all his work at Stevens Institute, although it was arranged that he should continue on the faculty under the title of special lecturer in experimental engineering and should deliver lectures on steam engineering subjects. At the same time, as an evidence of esteem, the Institute conferred upon him the honorary degree of Doctor of Engineering and he was made a trustee.

Dr. Jacobus is an authority on steam engineering, and he has written numerous scientific papers on steam engineering subjects, many of which have been included in the transactions of the engineering societies and many published in engineering periodicals.

He was elected to membership in The American Society of Mechanical Engineers in 1889; he was a Manager of the Society from 1900 to 1903 and was Vice-President from 1903 to 1905. He has served on a number of committees of the Society, among which was the committee which framed the present constitution. He was chairman of the committee appointed to standardize a system for testing steam engines which presented its final report in December, 1902. In 1903, he was appointed chairman of a committee to suggest a standard tonnage basis for refrigeration; this committee reported in 1904, and was re-appointed. He has served on the Committee on Power Tests which originally organized by electing him as chairman; owing to pressure of business duties he resigned the chairmanship, but he has nevertheless taken an active part in the preparation of the report. In 1914, he was appointed a member of an advisory committee which was formed to assist the Boiler Code Committee, and on the combining of the Boiler Code Committee and advisory committee into a single Boiler Code Committee he was made one of the members. He was elected President of the Society in December, 1915.

He is a member of the American Institute of Mining Engineers, American Institute of Electrical Engineers and the Society of Naval Architects and Marine Engineers, and a fellow of the American Association for the Advancement of Science. He was President of the American Society of Refrigerating Engineers in 1906-1907. He is a member of the American Mathematical Society, the Society for the Promotion of Engineering Education, the American Society for Testing Materials, and The Franklin Institute of the State of Pennsylvania.

J. SELLERS BANCROFT

J. Sellers Bancroft was born in Providence, R. I., in 1843. He was educated in Philadelphia, and was graduated from the Public High School there in 1861. On February 1 of the same year, he began an apprenticeship with the successors of Bancroft and Sellers, William Sellers & Co., whose work has contributed so much to the American machine tool industry. The firm of Bancroft & Sellers was founded by his father and Coleman Sellers in 1848. Mr. Bancroft became gang foreman in 1863, shop foreman in 1866, and was admitted to the firm in 1873. Finally, when the business was incorporated in 1887, he was appointed general manager.

He remained with this concern until January 31, 1902, when his prior successful activities in directing the development of the manufacture of the Lanston type-setting machine induced him to take the position of general manager and mechanical engineer of the Lanston Monotype Machine Company, of Philadelphia. He still holds this position, and, in addition, those of treasurer, director and vice-president of the company.

Mr. Bancroft has been a prolific inventor, as is attested by the large number of patents—more than one hundred—which have been granted him. These cover improvements in machine tools, injectors, shafting appliances, power cranes, and the interlocking electric devices for their control; and type-casting and composing machines.

Since 1897, he has been engaged in the improvement of the monotype casting and composing machine, which he has brought into practical working shape, and which is now being introduced all over the world. The gradual development by him of this machine can be traced in the improvements of it he has from time to time patented.

Mr. Bancroft's membership in the Society dates back to practically the time of its organization, and his name appears in the second year book issued in January 1881. He has been a member of The Franklin Institute of the State of Pennsylvania since the early 60's. He is a member of the Society of Naval Architects and Marine Engineers.

JULIAN KENNEDY

Julian Kennedy, expert in iron and steel manufacture, was born in Poland, Ohio, in 1852. He began his education in the public school and in the Poland Union Seminary. He left this institution in 1869 to become a draftsman, under his father's supervision, on the construction of the Struthers Iron Company's blast furnace, at Struthers, Ohio, and then a machinery attendant.

In 1872, he entered the Sheffield Scientific School of Yale College, and was graduated three years later. He took a course in civil engineering until the end of the junior year and then continued in the course in chemistry. After graduation, he was appointed instructor in physics, and remained at the School in this capacity for one year, taking at the same time a post-graduate course in the chemistry of iron and steel, and also a special course in higher mathematics and astronomy. During this time, he had charge of the physical laboratory, gave a course of illustrated lectures on physics to the students of several seminaries in New Haven, and also lectured in the mechanics course of the School.

In 1876 Mr. Kennedy was appointed superintendent of blast furnaces of the Brier Hill Company, Youngstown, Ohio. The next year, he became superintendent of the blast furnace of the Struthers Iron Company, and in the following years he served successively as superintendent of the Morse Bridge Works, Youngstown, Ohio; superintendent of blast furnaces at the Edgar Thompson Steel Works, Braddock, Pa.; superintendent of the Lucy Furnaces, Pittsburgh, Pa.; and general superintendent for Messrs. Carnegie, Phipps and Co., with headquarters at Homestead, Pa. In all these works, he was responsible for both construction and operation.

In 1888, he was appointed chief engineer of the Latrobe Steel Works, Latrobe, Pa. He had charge of the construction of this works, and in 1890, while continuing as chief engineer of the plant, opened an office for private practice in Pittsburgh. Since that time, he has been engaged in general consulting and contracting engineering business and has been retained as consulting engineer by practically every important steel works in the United States. He has also performed a great deal of engineering work in several European countries.

Mr. Kennedy has taken out a large number of patents in connection with the manufacture of iron and steel, and has also acted as expert in a large number of patent suits. Among his own inventions, most of which are in successful use, are improvements in blowing engines, reversing engines, blooming mills, hot blast stoves, blast furnace filling devices and other steel works equipment.

Mr. Kennedy is a member of the Engineers Society of Pennsylvania, the American Institute of Mining Engineers, the British Iron and Steel Institute, the New York Chamber of Commerce, and the Pittsburgh Chamber of Commerce.

He received the honorary degree of Master of Arts from the Sheffield Scientific School in 1900, and in 1909, Stevens Institute of Technology conferred on him the honorary degree of Doctor of Engineering.

He was elected to membership in the Society in 1912 and was appointed on its sub-committee on Iron and Steel in 1913.

JOHN H. BARR

John Henry Barr, mechanical engineer, was born at Terre Haute, Ind., in 1861. He was educated at the University of Minnesota, receiving the degrees of Bachelor of Mechanical Engineering in 1883 and Master of Science five years later. From Cornell University, he obtained the degree of Master of Mechanical Engineering in 1889.

Mr. Barr began his professional training in 1883, when he was appointed assistant to the resident mechanical engineer of the Calumet and Hecla Mining Company. The following year, he was appointed mechanical engineer of the Lake Superior Iron Works. In 1885, he began his work as a teacher, being appointed instructor in mechanical engineering at the University of Minnesota; four years later he was made assistant professor and in 1890 full professor. From 1891, for four years, he was assistant professor of mechanical engineering at Sibley College, Cornell University. Here also he rose to be associate professor of machine design and later full professor of machine design, which chair he occupied from 1898 to 1903. In 1900 he was mechanical engineer to the Anaconda Copper Mining Co. From 1903 to 1908 he was director and factory manager of the Smith Premier Typewriter Co. From 1909 to 1913 he was consulting engineer of the Union Typewriter Co., and in 1913 he was appointed chief engineer of the Remington Typewriter Co.

Mr. Barr was elected to membership in the Society in 1889. He was appointed on the Committee on Meetings in 1913 and served as chairman in 1915. He acted on the Nominating Committee in 1914, and is chairman of the Sub-Committee on Protection of Industrial Workers.

He is a fellow of the American Association for the Advancement of Science and a member of The Franklin Institute. He was a trustee of Cornell University for ten years. He was president of the Syracuse Chamber of Commerce, 1910-11, and was a member of the Syracuse Intercepting Sewerage Board till after his removal from Syracuse. He was a member of the Syracuse Lighting Commission (1907). He was a member of the New York State Commission on Voting Machines from 1903 to 1915 (chairman 1907-1915).

He is the author of a number of textbooks and articles on machine design. His textbooks include Kinematics of Machinery, Notes on Machine Design, and (with D. S. Kimball) Elements of Machine Design. He was the author of reports on Machine Tools at the Paris Exposition, 1899.

JOHN A. STEVENS

John A. Stevens, consulting mechanical engineer, was born at Galva, Illinois, in 1868. He was graduated from the East Saginaw High School and studied one year at the University of Michigan. He served a three years' apprenticeship to the machinists' trade with Mitts and Merrill, Saginaw, Mich., after which he was engineer on the lake steamers Sappho, Byron Whitaker, W. H. Stevens, Roman and Cambria. At the age of twenty-seven he was granted an unlimited engineer's license for ocean steamships.

In 1893 he came East to enter the employ of the International Navigation Company of New York, and he served as engineer on board their ships Indiana, Illinois, New York, St. Louis and St. Paul. On the last of these he was first assistant engineer, having been given eight promotions in two years and eight months.

He resigned from the company's service in 1896 to take up the position of chief engineer with the Merrimack Manufacturing Company, Lowell, Mass. While with this company, he practically rebuilt its entire steam plant and also superintended the power work of the company's southern mills. He made numerous complete tests of steam plants and boiler trials of engines and auxiliaries. Since the date of his severing his connection with this company, he has made all its power plant layouts and estimates.

He resigned his position as chief engineer at the Merrimack Manufacturing Company early in 1909, and in May of the same year he went into private general consulting engineering practice. Since that time he has superintended the construction of a great many power plants, made complete analyses of many large properties, and dealt with various engineering problems.

Mr. Stevens has been granted a number of patents for water tube steam boilers, and is also the patentee of the American steam superheater.

He was elected to membership in The American Society of Mechanical Engineers in 1902, and in the Society of Naval Architects and Marine Engineers in the same year. In 1907 he was elected a member of the National Association of Cotton Manufacturers.

He was appointed by Governor Guild in 1907 to represent the boiler using interests of Massachusetts on the Massachusetts Board of Boiler Rules. He served on the Board for three years, at the expiration of which time he was appointed by Governor Draper to serve another similar term. The first three years of his service on this Board were spent in formulating the Massachusetts Rules, which were later used in many other states and cities.

Mr. Stevens was one of the seven members originally selected to serve on the Society's committee "to formulate standard specifications for the construction of steam boilers and other pressure vessels and for the care of same in service," now known as the Boiler Code Committee, and he has served actively on this committee continuously since its organization in 1911.

H. deB. PARSONS

Harry de Berkeley Parsons, consulting engineer, was born in New York City in 1862. He was educated at Columbia College, from which he was graduated as Bachelor of Science in 1882, and at Stevens Institute of Technology, from which he received the degree of Mechanical Engineer, two years later. From 1892 to 1907 he was professor of steam engineering at Rensselaer Polytechnic Institute, and in 1908 he was appointed professor emeritus of practical engineering.

Mr. Parsons has been practicing his profession as consulting engineer in New York since 1885. He was a member of the New York State Voting Machine Commission from 1898 until 1915, and of the Metropolitan Sewerage Commission of New York from 1908 until 1914, when the work of designing a main drainage system for all the boroughs of the City was completed, together with a report showing the need for such system. He has served as consulting engineer for many of the city departments and for the Board of Estimate and Apportionment, as well as for many private firms, banks and corporations, and has been retained for making numerous appraisals of industrial establishments.

He is the author of "Steam Boilers, Their Theory and Design" and of "Disposal of Municipal Refuse."

Mr. Parsons was elected to membership in The American Society of Mechanical Engineers in 1885. He served on the Publication Committee from 1890 to 1902. He was elected on the Meetings Committee in 1903, and also served on this Committee from 1909 to 1914. He acted as chairman of the representatives of the Society on the Joint Committee on Fire Proofing Tests, whose report was published in Volume 18 of The Transactions. He was chairman of the Committee on Standard Cross-Sections and Symbols, whose report was published in Volume 36 of The Transactions.

He is a member of the American Society of Civil Engineers, the Society of Naval Architects and Marine Engineers, the Chamber of Commerce and the Merchants Association of New York.

FELLOWSHIPS AT ILLINOIS

The University of Illinois announces fourteen research fellowships in the Engineering Experiment Station, open to graduates of American and foreign universities and technical schools. Appointments are made for two years and lead to a Master's degree. Nominations to fellowships are made from applications received by the Director of the Engineering Experiment Station; they are based on character, scholastic attainments and promise of success.

The fellowships afford an excellent opportunity for the carrying on of investigations in the various branches of engineering and for the study of problems of importance to engineers and to manufacturing and industrial interests.

Those desiring additional information should address the Director of the Station at the University.

CRIPPLED SOLDIERS PROBLEM

Frank B. Gilbreth, Mem.Am.Soc.M.E., the author of the paper on Motion Study for the Crippled Soldier, published in the December, 1915, issue of The Journal, writes that he is still open to receive information regarding cases in this country in which maimed or otherwise disabled men have been educated and assisted to perform work successfully. Mr. Gilbreth's address is 77 Brown St., Providence, R. I.

Mr. Gilbreth himself has been taking active steps to obtain such information for the purpose of applying it to the problem of disabled soldiers, and his efforts have met with success, but he still needs more data on account of the complexity of the problem.

He reports valuable assistance from Prof. L. M. Wallace of Purdue University, who sent out the following questionnaire to members of the University staff, with good results: Would you kindly indicate the occupations in which you have known disabled men to have found successful employment, and the special devices they may have used to aid them in their work?

CONFERENCE OF LOCAL SECTIONS

The Conference of delegates from the Local Sections of the Society held at the Annual Meeting proved a great success and the results thereof promise much toward the future success and development of the Society. The Chairman or Secretary of each of the fourteen Sections was present and in addition there were delegates from the Providence Association of Mechanical Engineers, which is affiliated with The American Society of Mechanical Engineers, and from several industrial centers where the members of the Society anticipate the formation of Sections.

The delegates and members of the Committee on Sections in attendance were Elliott H. Whitlock, Chairman; W. F. M. Goss, L. C. Marburg and Walter Rautenstrauch, of the Committee on Local Sections (D. Robert Yarnall, the fifth member of the Committee, was absent owing to serious illness); Park A. Dallis, Secretary, Atlanta Section; H. N. Dawes, Chairman, and W. G. Snow, Secretary, Boston Section; David Bell, Chairman, Buffalo Section; H. M. Montgomery, Chairman, Chicago Section; J. T. Faig, Secretary, Cincinnati Section; W. W. Smith, Chairman, Los Angeles Section; L. E. Strothman, Chairman, Milwaukee Section; W. H. Kavanaugh, Chairman, Minnesota Section; E. H. Lockwood, Secretary, New Haven Section; Edward Van Winkle, Chairman, and H. R. Cobleigh, Treasurer, New York Section; R. H. Fernald, Chairman, Philadelphia Section; C. F. Braun, Secretary, San Francisco Section; Edward Flad, Chairman, St. Louis Section; P. B. Morgan, Chairman, Worcester Section; A. H. Annan, Vice-President, and J. A. Brooks, Secretary of the Providence Association of Mechanical Engineers.

Others present during the Conference were I. E. Moultrop, Boston, Chairman of the Committee on Increase of Membership; Max Toltz, member of the Council and of the Minnesota Section; A. L. Williston, Boston Section, and A. M. Greene, Jr., Troy, N. Y., member of the Council.

Three business sessions were held, each being preceded by a luncheon of the delegates and the officers of the Society. At these luncheons, the delegates had opportunity to become better acquainted with one another and with the members of the Council, Past-President James Hartness, President John A. Brashear, President-Elect D. S. Jacobus, Secretary C. W. Rice, Vice-Presidents H. L. Gantt, New York, E. E. Keller, Detroit, and H. G. Reist, Schenectady; also M. E. Cooley, Ann Arbor; W. H. Carrier, Buffalo; H. H. Esselstyn, Detroit; Lee C. Moore, Pittsburgh; J. V. V. Colwell, New York; T. C. McBride, Philadelphia; L. D. Burlingame, Providence; P. A. Poppenhusen, Chicago, and F. E. Bausch, St. Louis.

It was the consensus of opinion that the development of Sections is one of the vital needs of the Society, and that regular meetings should be held in every locality where there are sufficient members to insure success.

At future Annual Meetings, it is planned to continue this feature of a Conference of Local Sections as part of the program, and the opportunity given to members in all parts of the country to be brought into close contact through their duly elected delegates with the officers of the Society and its activities cannot fail to promote the best interests of the Society.

CONFERENCE LUNCHEON OF DELEGATES FROM THE LOCAL SECTIONS OF THE SOCIETY

These luncheons were held each day of the Annual Meeting and all Local Sections were represented. Those present at the first luncheon, reading from the head of each table and in a clockwise direction, were:

FIRST TABLE	SECOND TABLE	THIRD TABLE	FOURTH TABLE
James Hartness	D. S. Jacobus	John A. Brashear	Paul P. Morgan
Edward Flad	H. M. Montgomery	John T. Faig	H. L. Gantt
E. H. Lockwood	C. W. Obert	J. T. Whittlesey	Carl F. Braun
L. C. Marburg	M. E. Cooley	Park A. Dallis	Calvin W. Rice
W. H. Kavanaugh	W. F. M. Goss	E. H. Whitlock	Robert H. Fernald
Max Toltz	Ernest Hartford	W. W. Smith	E. E. Keller
L. G. French	J. A. Brooks	H. G. Reist	I. E. Moultrop
	Alex. C. Humphreys	H. H. Dawes	Arthur H. Annan
	Louis E. Strothman		

JOHN FRITZ MEDAL AWARD

The John Fritz Medal, awarded annually for notable scientific or industrial achievement, was in 1915 awarded to Dr. James Douglas, eminent mining engineer, for "notable achievements in mining, metallurgy, education and industrial welfare."

It was originally planned to present the medal to Dr. Douglas at the International Engineering Congress in September, 1915, but his health did not permit of his taking the journey to San Francisco. Accordingly, on December 5, 1915, the medal was handed him at his home at Spuyten Duyvil by Dr. Albert R. Ledoux, Past-President of the American Institute of Mining Engineers.

James Douglas was born at Quebec, Canada, in 1837. He entered the University of Edinburgh in 1885 and studied there for two years. Returning to Canada he graduated from Queens University, Kingston, Ontario, with the degree of Bachelor of Arts, having also studied medicine and later theology. After his graduation he traveled extensively in Europe and in the Orient, and then returned to Edinburgh where he continued his course in medicine.

At this time his father's gold and copper mine investments in Canada were in jeopardy because, while the mines contained considerable 2 per cent copper ore, there was no satisfactory process for its economical extraction. He abandoned his studies and teaching and went into the mining field to endeavor to rehabilitate his father's interests; and in association with Dr. Hunt he worked out the well-known Hunt and Douglas process for the extraction of copper.

He came to the United States in 1875, being employed to apply this process to the product of the Jones mine in Berks County, Pa., as superintendent of the Chemical Copper Co. at Phoenixville. The plant was afterwards destroyed by fire and Dr. Douglas was for a time without fixed employment, although he did some professional work in mining and metallurgy. He made several visits to Butte, Mont., and it has been said that he was the first to predict the secondary enrichment in this area.

Through William E. Dodge, he was brought into contact with the old metal house of Phelps, Dodge & Co. When this firm took over the Copper Queen mine, the management was placed in his hands and he was given an interest in the concern. Later, upon the incorporation of the firm, Dr. Douglas became its president. Under his active management the most modern devices have been adopted in the company's mills and smelteries, and the mines and railroads controlled by it have been very profitable.

During his years of active business life, busy with invention and adaptation of processes, and with expansion and consolidation, Dr. Douglas has found time to make numerous contributions to the literature of mining and of general science, and many of his papers and articles have appeared in the transactions of various technical and other societies. In addition, he has published four historical volumes, including the journal and reminiscences of the life of his father, James Douglas, M.D.

Both Queen's University and McGill University have conferred on him the honorary degree of LL.D. He has been twice President of the American Institute of Mining Engineers. He has been the recipient of the gold medal of the Institution of Mining and Metallurgy.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED FOR ON FEBRUARY 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The Candidates will be balloted upon by the Council unless objection is received by February 10, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Brown, Benjamin F., Pres. and Mgr., The Brown Bag Filling Mch. Co., Fitchburg, Mass.
Cookson, Thomas J., Pres., The Cookson Steam Specialty Co., Cincinnati, Ohio
Cummings, Henry H., Pres., Cummings Mch. Wks., Boston, Mass.
Dodson, Clarence F., Supt. of Wks., Irving Iron Wks., Long Is. City, N. Y.
Everett, Charles J., Treas., Revolute Mch. Co., New York
French, David W., Supt., Hackensack Water Co., Weehawken, N. J.
Freysinger, John B., Ch. Draftsman, Winchester Repeating Arms Co., New Haven, Conn.
Guthrie, James, Auto. Engr., Briscoe Freres, Jackson, Mich.
Hile, Charles H., Ch. of Maintenance, Boston Elev. Rwy. Co., Boston, Mass.
Hill, B. Houston, Pres., Steam Equipment Mfg. Co., Pittsburgh, Pa.
Jones, William T., Engr., Cons. Engrg. Co., Boston, Mass.
Kaupert, Richard, Master Mech., Douglas Co., Cedar Rapids, Ia.
Kenney, William J., Ch. Engr., The Under-Feed Stoker Co. of America, Chicago, Ill.
Kihn, Julius J., Supt., R. Hoe & Co., New York
Lanham, Edwin J., Franklin, Pa.
Larsen, Charles, Mech. Engr., M. J. O. Fallon Supply Co., Denver, Colo.
Lockwood, J. B. C., Cons. Engr., Portland, Ore.
Lundquist, Wilhelm E., Ch. Draftsman, The Edison Elec. Ill. Co., Boston, Mass.
McGrew, John A., Supt., Saratoga & Champlain Div., Delaware & Hudson Co., Albany, N. Y.
Mahy, Arthur H., Ch. Engr. and Supt., North Adams Gas & Elec. Lgt. Co., No. Adams, Mass.
Meyer, Julius M., Partner, Vaughn, Meyer & Sweet, Cons. Engrs., Milwaukee, Wis.
Moody, V. D., Cons. Engr., Moody Engrg. Co., New York
Mulliner, Richard H., Mgr. and Part Owner, Mulliner-Eulund Co., Syracuse, N. Y.

Newhall, Henry B., Jr., Vice-Pres., N. J. Fdy. & Mchy. Co., and Newhall Chain Forge & Iron Co., New York
Nilson, Lars G., Pres. and Ch. Engr., Nilson-Miller Co., Hoboken, N. J.
Rhoads, Joseph E., Mem. of Firm, J. E. Rhoads & Sons, Wilmington, Del.
Roberts, Odin, With Roberts & Cushman, Boston, Mass.
Ross, John A., Jr., Prof. of Mech. Engrg., Clarkson College of Tech., Potsdam, N. Y.
Schafer, W. H., Mech. Engr., The Cincinnati Bickford Tool Co., Oakley, Cincinnati, O.
Sheldon, Arthur N., Mem. Firm, F. P. Sheldon & Son, Engrs. and Arch., Providence, R. I.
Sperling, Nathaniel J., Supt. Mech. Dept., Astoria Light, Heat & Pwr. Co., Astoria, L. I., N. Y.
Streiff, Abraham, Engr., Fargo Engrg. Co., Jackson, Mich.
Valentine, Warren R., Supt., Shop No. 2, Pittsburgh Plate Glass Co., Ford City, Pa.
Wallace, John D., Mfg. Engineer, Chicago, Ill.
Wason, Leonard C., Pres., Aberthaw Constr. Co., Boston, Mass.
Welles, Edward R., In charge Mech. Engrg. Dept., The J. G. White Engrg. Corp., New York
Wintroath, John A., Mech. Supt., Layne & Bowler Corp., Los Angeles, Cal.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bancroft, George H., Tech. Asst. to Ch. Engr., Steere Engrg. Co., Detroit, Mich.
Baum, I. Albert, Engr.-in-charge, Martin Free Bridge, Camden, Ark.
Benster, Lucien H., with Moline Scale Co., East Moline, Ill.
Cameron, James S., Supt. of Plant, Northern Elec. Co., Ltd., Montreal, Canada
Dempsey, Michael J., with Chase Metal Works, Waterbury, Conn.
Dixon, Wallace C., Draftsman, Hopkins & Allen Arms Co., Norwich, Conn.
Dolan, George F., Inspector, Panama Canal, Washington, D. C.
Farrington, Thayer B., Genl. Foreman, Louisville Div., Southwest System, Penn Lines West, Louisville, Ky.
Jenner, Otto G., Indus. Engr., Inland Steel Co., Chicago Heights Wks., Chicago, Ill.
Lockwood, Harold R., Supt. of Eng. Dept., Douglas Robinson Charles S. Brown Co., New York
Porter, Robert, Engr. and Mgr., New England Branch, Diamond Pwr. Specialty Co., Detroit, Mich.
Schmidt, John D., Asst. Engr., The Natl. Sugar Refinery, Yonkers, N. Y.
Sihra, Nand S., Touring, Visiting manufacturing and engineering plants, Stockton, Cal.
Snyder, Frederick W., Instr. of Mchy., Williamson Free Sch. of Mech. Trades, Williamson School, Del. Co., Pa.
Tiechman, Henry F., Engr. Draftsman, Lukens Iron & Steel Co., Coatesville, Pa.
Tulloss, Joseph C., Ch. Engr., Fire & Accident Prevention Co., Baltimore, Md.
Ycasiano-Roxas, Francisco, Mech. and Testing Engr., Bureau of Science, Dept. of Int., Govt. of Philippine Is., Manila, P. I.

FOR CONSIDERATION AS JUNIOR

Ackerman, Henry C., Asst. Master Mech., Hercules Pwdr. Co., Kenvil, N. J.
Allen, Clifton H., Mech. Engr., The Walker Mfg. Co., Denver, Colo.
Billmyer, Carroll D., Draftsman, Off. of Asst. to Pres., Norfolk & Western Rwy. Co., Roanoke, Va.
Buenger, Albert, Heating & Ventilating Engr., with W. L. Steele, Sioux City, Ia.
Buford, Edwin H., Engr. of Design and Erection, Monsanto Chemical Wks., St. Louis, Mo.
Edwards, Henry H., Mech. Engr., The Bantam Anti-Friction Co., Bantam, Conn.
Garrison, Wyckoff L., with The Babcock & Wilcox Co., Bayonne, N. J.
Kunz, William J., Mech. Engr., Otis Elev. Co., Yonkers, N. Y.
Miller, Ernest P., Jr., Indus. Management, Cheney Bros., So. Manchester, Conn.
Moul, Harry A., Asst. to Wks. Mgr., Amer. Steel Foundries, Indiana Harbor, Ind.
Nofsinger, Lewis E., 1st Asst. in Mch. Shop Practice, Kansas City Poly. Inst., Kansas City, Mo.
Schulte, Max J. L., Engrg. Dept., Combus. Engrg. Corp., New York
Sparkes, John G., Mech. Engr., Patent Law Off., R. D. Johnston, Jr., Atty., Birmingham, Ala.
Taylor, Paul H., Mech. Engr., H. French & A. Hubbard, Boston, Mass.
Thomas, Winthrop G., Circuit Lab., Western Elec. Co., New York
Willson, Hubert E., Steam Expert, Joliet Wks., Illinois Steel Co., Joliet, Ill.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Barnum, Starr H., 2nd., Secy., The Bigelow Co., New Haven, Conn.
Benner, Henry L., Secy. and Treas., Amer. Insulating Mchy. Co., Philadelphia, Pa.
Crute, William R., Engr. Elec. Pwr. House, Norfolk & Western Rwy., Pocahontas, Va.
Freeman, Frederick C., Constr. Dept., The United Gas Improvement Co., Philadelphia, Pa.
Hoffman, Roscoe C., Mech. Engr., Sun Motor Car Co., Buffalo, N. Y.
Hood, Warren B., Shop Engr., Angus Shops, Canadian Pacific Rwy. Co., Montreal, Canada
Knoop, Theodore M., N. Y. Mgr., Epping-Carpenter Pump Co., New York
Kremers, Clarence H., Constr. Engr., Mammoth Copper Mining Co., Kennett, Cal.
Loutrel, Cyrus H., Factory Mgr., Natl. Lock Washer Co. Newark, N. J.
Peterson, Eric H. A., Ch. Draftsman & Mech. Engr., The Hutteman & Cramer Co., Detroit, Mich.
Turno, Walter G. W., Engr. and Estimator, Johns-Manville Co., New York

SUMMARY

New Applications	71
Applications for change of grading:	
Promotion from Junior	11
Total	82

NEW MEMBERS

Hereafter there will be published each month a summary giving data regarding the current ballot for new members, as to the type of positions held, the average age of those being considered by the Council for each grade, and the number who are college graduates.

Beginning with the February issue a list will be published of those new members who qualify each month, so that hereafter it will not be necessary for the members to wait until the new Year Book is published to discover those who have been added to the Society's rolls during the year.

This additional information will undoubtedly be of particular interest to the membership and testify to the excellent character and high standing of those joining the Society under the present strict requirements.

PERSONALS

George L. Clouser has accepted a position with the Baldwin Locomotive Works, Philadelphia, Pa., as draftsman. He was until recently associated with the motive power department of the Philadelphia and Reading Railroad, Reading, Pa.

Cornelius J. Allaart has become affiliated with the engineering department of the Curtiss Motor Company of Buffalo, N. Y.

Julius G. Hatman, formerly associated with the R. H. Beaumont Company, Philadelphia, Pa., has accepted the position of efficiency engineer with the Semet-Solvay Company, Ensley, Ala.

George P. Sonn has resigned his position with the Chase Metal Works, Waterbury, Conn., to accept a position with the engineering department of the Bridgeport Brass Company of Bridgeport, Conn.

Charles L. Samson has become affiliated with The Amalgamated Machinery Corporation of Chicago, Ill.

Clarence J. Harter has become associated with the Pratt and Whitney Company of Hartford, Conn., in the capacity of mechanical engineer. He was until recently in the employ of the Remington Arms Union Metallic Cartridge Company, Bridgeport, Conn., as technical adviser to the purchasing department.

Courtney N. Mitchell has severed his connections with the Chandler Motor Car Company, Cleveland, O., and is now employed as chief engineer of The Eclipse Motor Company, Cleveland, O.

Frederick A. Krehbiel, president of the Krehbiel Company, engineers and constructors, Chicago, Ill., announces that he has secured as a partner Edward N. Lake, formerly in charge of the Chicago office of the Stone and Webster Engineering Corporation. The business will be continued under the present firm name, with Mr. Lake as treasurer and manager and Mr. Krehbiel continuing as president.

J. N. Caughell, formerly connected with Dodge Brothers of Detroit, Mich., as chief engineer of power plant, has accepted the position of mechanical superintendent of the United States Department of Agriculture, Washington, D. C.

Morris A Hall, until recently managing editor of Motor Life, New York, is now connected with the advertising department of The Locomobile Company of America, Bridgeport, Conn.

Charles E. Paul, professor of mechanics at Armour Institute, Chicago, has been retained as consulting engineer by the National Lumber Manufacturers' Association.

William A. Cattell, consulting engineer of San Francisco, who filled the office of secretary-treasurer of the International Engineering Congress, has been retained by the Honolulu Rapid Transit and Land Company as a witness in the injunction suit brought by the Territory of Hawaii against that company. He will investigate the plant of the company and testify as to the physical valuation and cost of its property.

Elliott H. Whitlock, Manager, Am.Soc.M.E., consulting engineer, has been appointed general superintendent of the Sandusky Portland Cement Company, with headquarters in Cleveland. Mr. Whitlock was formerly associated with the National Carbon Company.

H. P. Camp, for the past few years associated with the Union Metallic Cartridge Company, Bridgeport, Conn., has resigned to accept a position as efficiency engineer with the Western Cartridge Company, Alton, Ill.

A brief article on a Novel Combination Locomotive by E. C. DeWolfe appears in the December 4 issue of Coal Age.

Nathan C. Johnson contributed the first of three articles on the making of better concrete to the December 4 issue of Engineering Record. This article, entitled Materials vs. Methods—Testimony of Moving Pictures in the Study of Concrete, deals with mixing, suggests necessary function of a concrete mixer and points out the evil of the short mixing period. The second article, which appears in the December 11 issue, deals with abuses common in the handling of sloppy wet mixtures, and the last article, published December 18, contains analytical studies made in regard to the placing of concrete by methods in present vogue and the effect such methods have upon the quality and durability of concrete.

V. W. Zilen is the author of a series of articles on Design of Steel Passenger Equipment, now appearing in the Mechanical Edition of the Railway Age Gazette. The first part is published in the September issue and will be continued after January 1 in the Railway Mechanical Engineer, which is the new title for the Mechanical Edition of the Railway Age Gazette.

John R. Freeman, Past-President, Am.Soc.M.E., and Prof. Rolla C. Carpenter are among the ten eminent engineers, geologists and scientists who have been designated to go to the Isthmus of Panama to investigate the entire subject of the slides on the Panama Canal and to submit a report to the President thereon. Mr. Freeman is a specialist in hydraulics and was consulting engineer for the Isthmian Canal dams and locks from 1907 to 1909 and is consulting engineer to the Canadian Government on water power conservation. Professor Carpenter is an authority on cement and cement construction.

W. Wallace Boyd has been appointed assistant inspector of weights and measures at the Bureau of Standards, Washington, D. C. He was until recently in the employ of the Buffalo Scale Company, Buffalo, N. Y., in the capacity of scale engineer.

John Hunter, Manager, Am.Soc.M.E., represented the Society at the Annual Christmas Entertainment of the St. Louis Railway Club, Friday, December 10, at Trimp's Academy, St. Louis, Mo.

John W. Sheperdson has resigned his position of assistant general superintendent of the Central Iron and Steel Company, Harrisburg, Pa., and has accepted one with the Morgan Construction Company of Worcester, Mass. Mr. Sheperdson will take up his new duties in the early part of January.

Frank L. Glynn has accepted the invitation of the State Board of Industrial Education of Wisconsin to become general superintendent of the trade schools of that state. Mr. Glynn established the Boardman Trade School in New Haven in 1913, and under his management has become unique in trade school history. Previous to this he had organized the Albany Trade School and had had charge of the Bridgeport Trade School.

Thomas F. Fournier has accepted the position of general manager of The Standard Machinery Company of Mystic, Conn. He was formerly associated with the Becker Milling Machine Company, Hyde Park, Mass., in the capacity of chief engineer.

Richard E. Miller, recently associated with The J. W. Frazier Company as mechanical and electrical engineer, has become a member of the firm of Poland-Miller Company, Cleveland, O., which has been organized to conduct a general engineering business and will specialize in the design and inspection of coal, coke and ore handling machinery, docks and industrial plants.

Harry R. Westcott has opened an office in the Chamber of Commerce Building, New Haven, Conn., for general engineering practice and is prepared to investigate, design and supervise the erection and operation of power stations, mills, electrical installations, etc. Mr. Westcott was recently superintendent of construction for the United Illuminating Company of New Haven.

A. E. Berggren has accepted the position of mechanical engineer with the Faultless Rubber Company, Ashland, O. He was formerly instructor of steam and gas engineering at the University of Wisconsin, Madison, Wis.

Oliver M. Davis has become affiliated with the Oil Mill of Swift and Company at Augusta, Ga., in the capacity of constructing mechanical engineer. Mr. Davis was recently connected with The Shelby Company Cotton Oil Mill at Memphis, Tenn.

H. C. Beckwith, until recently Chicago manager of T. L. Smith Company of Milwaukee, has located at Ravenna, O., as treasurer and general manager of the Byers Machine Company, manufacturers of hoisting and excavating machinery.

Frederick W. Ballard of Cleveland, O., has been engaged by the city of Terre Haute, Ind., to act as the municipality's representative in lighting contract negotiations pending. Mr. Ballard is commissioner and chief engineer of the division of light and heat of the city of Cleveland.

At the December 17 meeting of the Worcester Polytechnic Institute branch of the American Institute of Electrical Engineers, Edwin B. Katte, chief engineer in charge of design, construction and operation of the New York Central lines, delivered an illustrated lecture on The Electrification of the Grand Central Terminal.

Thomas W. Ransom, consulting mechanical engineer in the office of the city engineer of San Francisco for a number of years, has tendered his resignation. Mr. Ransom retires to take up private practice and has opened engineering offices in the Merchants Exchange Building, San Francisco.

Charles S. Gooding has removed his offices from 28 School street to 27 School street, Boston, Mass., where he will continue his practice as solicitor of patents, mechanical engineer and expert in patent causes.

Frank E. Law, vice-president of the Fidelity and Casualty Company of New York, who is known not only as an underwriter of wide experience but also as a student of the subject of workmen's compensation, in answer to a communication from Miss Irene Sylvester, representing the American Association of Labor Legislation, gave his views and suggestions on the various amendments which it is proposed to ask the New Jersey Legislature to make in the New Jersey Workmen's Compensation Law. Mr. Law's letter to Miss Sylvester is published substantially in full in the issue of The Economic World for December 4, 1915.

Bertram W. Burtsell has accepted the position of sales manager of the Whitney Manufacturing Company of Hartford, Conn. He was formerly affiliated with the Packard Motor Car Company of Detroit, Mich., in the capacity of assistant factory manager.

Bertram G. Welchans has become associated with Stanley G. Flagg & Company, Pottstown, Pa., as mechanical engineer, in charge of manufacturing and machine design. He was recently connected with the Canadian Westinghouse Company, Ltd., Hamilton, Ont., Canada, in charge of the rate department.

Charles T. Main, Manager, Am.Soc.M.E., has been appointed chairman of a committee of this Society to coöperate with the Bureau of Standards in the matter of making suggestions for the tests of all sized columns in the Underwriters' Laboratories at Chicago.

Charles A. Stone, one of the two original members of the firm of Stone and Webster of Boston, Mass., and one of the most widely known men in the public-utility field, has been appointed president of the American International Corporation, recently formed to exploit the foreign trade of this country.

Charles P. Steinmetz delivered a lecture on Illuminating Engineering at the joint meeting of the Philadelphia section of the Illuminating Engineering Society and the Engineers' Club of Philadelphia, held on December 17.

F. H. Newell, professor of civil engineering at the University of Illinois, was one of the speakers at the first convention of the American Association of Engineers, Chicago, December 10 and 11. He outlined the problems of the engineer from the welfare standpoint.

NECROLOGY

JAMES MAPES DODGE

James Mapes Dodge, Past-President of the Society, died at his home in Philadelphia, December 4, as a result of an attack of pneumonia contracted while returning from a visit to the Panama-Pacific International Exposition.

He was born at Waverly, N. J., June 30, 1850. His father was a member of the New York bar and his mother, Mary Mapes Dodge, was for many years the editor of the St. Nicholas Magazine, and the author of many delightful stories and poems for children.

Mr. Dodge was educated at Cornell University and at Rutgers, and had mechanical training in the shops of the Morgan Iron Works, New York City, and those of John Roach, the

James Mapes Dodge

shipbuilder, at Chester, Pa., where he advanced to positions of foreman and superintendent of erection.

Shortly after the Centennial at Philadelphia, in 1876, he left the shipyard and later went to Chicago and joined with William D. Ewart, the inventor of the Ewart link belting, and his associates in the development of the chain business. At that time, about 35 years ago, the application of chains to power transmission was exceedingly limited and their use in elevating and conveying machinery was practically unknown. Mr. Dodge was alive to the opportunity and new types of chain, new methods of manufacture and new conveying and elevating appliances were brought out in rapid succession.

After this period of development Mr. Dodge entered into partnership at Philadelphia with Edward H. Burr, to represent the Ewart Manufacturing Company of Indianapolis, and out of this partnership grew in 1888 the Link-Belt Engineering Company in which Mr. Dodge carried out his idea of development along strictly engineering lines, with a highly-specialized engineering staff. Among other developments was the Dodge system of storage for anthracite coal, by which

the coal is stored in large conical piles and handled entirely by machinery, both in and out of storage. The Dodge Coal Storage Company was formed, and in 1892 Mr. Dodge was made president of this company, and of the Link-Belt Engineering Company. In 1906, when these and allied companies were merged and known as the Link-Belt Company, he was elected Chairman of the Board of Directors.

For many years Mr. Dodge was a close friend of the late Frederick W. Taylor and was the first to adopt in its entirety, at the Philadelphia plant of the Link-Belt Company, the Taylor system of Scientific Management. He made many contributions to the literature of scientific management and in these as well as in his spoken words and in the practical application of the system in his own plants, he held to the necessity for the mutual advancement of employee and employer. He showed always the greater concern for the welfare, happiness and success of the employee. His relations with his employees were both cordial and intimate, and his influence was to inspire self help, initiative and ambition, as well as to aid them when needed in every possible way.

Mr. Dodge was deeply interested in civic affairs and was president of the Public Service Committee of One Hundred and a member of the Committee of Seventy in Philadelphia, and in other ways was closely identified with the best interests of the city.

He became a member of The American Society of Mechanical Engineers in 1884 and served the Society in many ways thereafter. He was Manager from 1891 to 1894; Vice-President, 1900 to 1902, and President in 1903. He has been Chairman of the Public Relations Committee and of the Sub-Committee on Administration and in 1908 was Chairman of the Nominating Committee. His interest and belief in young men were shown by his presidential address before the Society on Money Value of Technical Training. At the meeting in Germany, one of the two papers presented by this Society was by Mr. Dodge on Industrial Management. Two other papers by him contributed to other meetings were: The History of the Introduction of a System of Shop Management, and New Method of Stocking and Reloading Coal.

The following brief appreciation by Prof. F. R. Hutton comes as a result of his intimate knowledge of Mr. Dodge, particularly in his relations with the Society:

Mr. Dodge had personal qualities of unusual charm. Many members of the Society first learned of his capacity for clever nonsense at the Atlantic City meeting of the Society in 1886, where he kept his audience in smiles with jest and story. Again in 1910, on the steamer trip across the Atlantic Ocean, his number on the program of entertainments was a delight. At solemn meetings of the Council of the Society, a quip or a jest from Mr. Dodge would relieve tension and clear the air. This made him much in demand for after dinner speaking.

It is to Mr. Dodge also, that the Society owes the original concept of placing the member's name on the lapel of the coat during the meetings of the Society. He was President of the Society for the year when the Carnegie gift to Engineering was made in 1904 of a building to house the national societies in New York. He was one of the first conference appointees, and later served on the building committee and on the Board of Trustees of the United Engineering Society. When the plans for the building were being worked over, Mr. Dodge had a wooden model made of the two lower floors from the architects' plans, and those who had decisions to make were greatly helped by the study of proportions which this model made possible.

Mr. Dodge had great capacity for friendship. No man was more appreciative of good work by others and he was generous in his expressed commendation. He will be missed sorely by many who came near to him.

GUSTAVUS TYLER LUCKETT

Gustavus Tyler Luckett was born at Owensboro, Kentucky, on February 26, 1870. He received his early education in the schools of Owensboro and then went to Trinity College near Louisville, Ky. From 1888 to 1896, he held a position as machinist and pattern maker, and molder superintendent, with the Novelty Foundry and Machine Company at Owensboro, Ky. From 1898 to 1900 he was assistant superintendent in charge of construction for the N. Y. Edison Company. He left them to go with the Best Manufacturing Company as their New York representative. From 1901 to the time of his death, he was with the M. W. Kellogg Company. He had active charge of designing steam and hydraulic piping, machines for the manufacture of Van Stone joints and improvements thereon, welding flanges, forge welding shells, piping, piping outlets and construction and erection of piping systems. Mr. Kellogg died at his home in New York City on July 16, 1915.

THOMAS L. RANKIN

Thomas L. Rankin was born at Ripley, Ohio, on June 16, 1839. He received his education at Iberia College at Iberia, Ohio, from which he graduated in 1855. In 1869, he began to build isolated refrigerating cars in the West at Barney and Smith, Dayton, Ohio. In 1873, he built 50 of the refrigerator cars at Wasson Works in Springfield, Mass. Previous to this date, he had laid many iron floors for refrigerating breweries and packing houses. From 1873 to 1877, he was superintendent of the Arctic Ice Machine Company, with many plants in Texas, Arkansas and Louisiana. During this time and through 1891 he continued the construction of ice machines at Phoenix Works, Houston, Texas, at the Atlas Works, Indianapolis and Reading Iron Works, Reading, Pa. He later had charge of the ice machine department of the Pennsylvania Iron Works Company of Philadelphia, Pa.

Mr. Rankin became a member of the Society in 1892. He died at his home in Sacketts Harbor, N. Y., on November 12, 1915.

BAXTER D. WHITNEY

Baxter D. Whitney was born in Winchendon, Mass., in 1817. His early education was received in Winchendon, Hancock, N. H., and Fitchburg, Mass., but his business life started in his father's woolen mill when he was very young. When he was ten years old, he constructed a saw mill, run by water, which, while merely a boy's effort, was prophetic of the line which his activities later followed. When he was 13 years old, he went to Worcester to help build some looms for his father.

At 16 years of age, he constructed an 18 in. by 6 ft. engine lathe, designing and making the patterns and machining the castings. It had a large wormwheel feed and a V-bed which he milled with a special fixture comprising wooden beams laid in the floor.

In 1836, he began the construction of machinery for making tubs and pails and had 28 men working for him. The next year, he built sixteen looms for cashmere and later he built two or three steam jigs. In 1845, he built for himself a foundry and machine shop and the next year the first Whitney wood-planing machine, which took six weeks to construct, was built. This is still in existence and is claimed to be the first cylinder planer ever made which was a practical success.

In 1857, he built a scraping machine and also a shaper and the famous Whitney gage lathe. During the Civil War, he was busy making gun-stock machinery.

Mr. Whitney received medals for his machines at exhibitions in Paris (1867), Vienna (1873) and Philadelphia, (1876).

Mr. Whitney became a member of the Society in 1886. He died at his home in Winchendon on October 17, 1915.

STEPHEN BETTS WHITING

Stephen Betts Whiting was born at Reading-Ridge, Connecticut, on January 22, 1834. After attending the public schools of his native town and of New Haven, Conn., Mr. Whiting finished his schooling with a year at the New Haven Collegiate & Commercial Institute.

When fifteen years of age, he was apprenticed to the machinist trade and, before he was sixteen, he designed and constructed a miniature steam engine. When seventeen years of age, he designed and built an air-pump. At this time, also, he went to work as a full-fledged journeyman.

In 1855, when Mr. Whiting was only twenty-one years of age, he was sent to Urbana, Ohio, to take charge of the shops of the Urbana Machine Company, and in 1857 he went to Alton, Ill., as superintendent of the Illinois Iron Works.

In 1860, he returned East and took charge of the Kaighn's Point Iron Works at Camden, N. J. At this time he came in contact again with his old friend and schoolmate, Charles G. Wilcox; the two men formed a partnership, bought the Kaighn's Point Iron Works and operated it under the firm name of Wilcox & Whiting.

This firm built and erected the superstructure of the Chestnut Street Bridge over the Schuylkill River in Philadelphia. The date of the contract covering this work was July 18, 1861, and the contract price was $134,577.00. The firm also built the U. S. Monitor Koka, which was one of the light-draft monitors designed by John Ericsson. The date of this contract was May 18, 1863, and the contract price was $386,000.00. Some of the principal dimensions of this vessel were as follows: Overall length, 225 ft.; beam, 45 ft.; draft, 6½ ft.; diameter of turret, 20 ft.; height of turret, 9 ft. The motive power consisted of two 22 by 30 in. single-cylinder engines direct connected to two propeller shafts, each of which was fitted with a 9 ft. propeller. The armament consisted of one 11 in. gun and one 150 lb. rifle.

Early in 1865 the Kaighn's Point Iron Works were sold and on July 1, 1865, Mr. Whiting went to Pottsville, Pa., as superintendent of the Colliery Iron Works.

In this position his inventive faculty often came into useful play in connection with the design and manufacture of machinery for the coal regions. He designed the so-called Whiting system of rope driving, hauling and hoisting machinery which was first installed at the Lehigh & Wilkesbarre planes at Solomon's Gap, Wilkesbarre, Pa. At later dates this system was adopted for the Mahoney planes of the Philadelphia & Reading Coal & Iron Company, for the Brooklyn Bridge, for the Red Jacket or Whiting shaft of the Calumet & Hecla Mining Company, and for a number of the diamond mines of South Africa.

On September 1, 1878, Mr. Whiting entered the employ of the Philadelphia & Reading Coal & Iron Company as mechanical engineer. On April 1, 1880, he was promoted to chief engineer, and on March 1, 1883, to general manager, which latter position he held for five years.

On May 1, 1888, Mr. Whiting entered the employ of the Calumet & Hecla Mining Company as general manager, which position he held until April 30, 1901, when he retired from active life.

While with this company he recommended and supervised the sinking of the Red Jacket or Whiting shaft. This is a vertical, six-compartment shaft which intersects the lode at a depth of about 3300 ft. and reaches the level of the lode at the property line at a depth of 5000 ft. The cross-section of the shaft measures 15½ by 25 ft.

Mr. Whiting was a charter member of The American Society of Mechanical Engineers, manager from April 1880 to November 1882 and vice-president from 1882 to 1883. He was also a member of the American Society of Naval Engineers, the American Institute of Mining Engineers, the English Institution of Mechanical Engineers and the North of England Institute of Mining & Mechanical Engineers.

Mr. Whiting died at his residence in Cambridge, Mass., on December 23, 1915.

MEETINGS

CINCINNATI, NOVEMBER 18

The regular November meeting of the Cincinnati Section of the Society was held as a joint meeting with the Engineers' Club of Cincinnati on November 18. C. R. Underhill, chief electrical engineer of the Acme Wire Company, New Haven, Conn., spoke on Electromagnets. Mr. Underhill in his talk first reviewed briefly some of the steps in the historical development in the study of solenoids. The fundamental principle and properties of solenoids were demonstrated experimentally by means of suitable apparatus and attention was called to changes in their behavior when supplied with alternating instead of direct current. The reasons for the less satisfactory operation of the A.C. solenoid as regards its holding power and noisiness were discussed and the remedies employed and being studied, were outlined. Attention was called to the early theoretical analysis of solenoids by Clerk Maxwell and by a reference to his fundamental force equation

$$F = 2\pi T^2 + TH + \frac{H^2}{8\pi}$$

it was shown that in the study of solenoids and magnets, the design is greatly facilitated by regarding the three components of the total force independently, that is, the force reaction between the solenoids or parts of solenoids, the force between solenoids and plungers, and the force manifested at air gaps. Emphasis was placed upon the fact that many of the methods of procedure in the design of magnets and solenoids are cumbersome because of the attempt to consider the force developed as the function of a single composite field; some methods are inadequate because they fail to recognize that it is the magnetic leakage that calls for the greatest consideration.

Lantern slides were shown exhibiting the correspondence between theoretical and observed performances of solenoids. Views were also presented showing some common commercial applications of magnets and solenoids such as, lifting magnets, magnetic clutches, magnetic chucks or separators, magnetic brakes, electromagnetic impact tools, etc. At the conclusion of the paper a discussion occurred which was followed by the usual Dutch lunch. About 100 members and guests were present.

CHICAGO, NOVEMBER 19

The first meeting of the Chicago Section of The American Society of Mechanical Engineers for the 1915-16 season was held on November 19, with H. M. Montgomery, *Chairman*, presiding. Dinner was served promptly at 6:30 p.m. to 122 members and guests.

The speakers were Frank B. Gilbreth, Mem.Am.Soc.M.E., consulting engineer, Providence, R. I., and Hon. Jacob M. Dickinson, receiver, Chicago, Rock Island & Pacific Ry.

Mr. Gilbreth gave an illustrated lecture on the subject of Helping Crippled Soldiers. He explained that he had been requested by representatives of foreign educational departments to train teachers in the theory and practice of motion study in order that they may be able to develop methods and means by which it will be possible for the maimed and injured soldiers at the close of the war to become productive units in the industrial development of their respective countries. By doing this, the cripples can be made self-supporting, which will relieve their country of a considerable burden and at the same time provide occupation for the men with the accompanying increase in happiness. The experience gained by the study of motion study is expected to assist in the determination of occupations for the injured soldiers, provided they are incapable of following their previous trades, and the arrangement of the tools with which they work so that they can perform their work in an efficient manner and with minimum fatigue. He explained in some considerable detail, the methods followed in making motion studies and showed by means of lantern slides many interesting problems, such as machine tool work, brick laying, etc., in which the fatigue of the worker had been materially lessened by the placing of the materials used in his work in more convenient positions. The method followed in such cases was to take photographs of the paths followed by the worker's hand in making one complete cycle of operations. This was accomplished by fastening a small electric light to the workman's hand, the path of this light being clearly shown in the photograph. The electric current to the lamp was interrupted at regular intervals measured to the thousandth of a second, the interruptions being controlled by tuning forks of a predetermined number of vibrations per second. This produced in the picture an intermittent series of light and dark spots in the path of the lamp which gave an indication of the speed of the workman's hand throughout the cycle of the operation. From these photographs, wire diagrams were made for the purpose of more carefully studying the complete cycle of the motion with the idea in view of simplifying them with the accompanying reduction in fatigue to the workman and increase in output.

Mr. Gilbreth laid great stress on the importance of providing every means possible for the occupation of the injured soldier after the war, from the standpoint of the soldier himself, his country and the world at large. He solicited information from all who had any suggestions to offer regarding this line of work, and from those especially who knew of any devices used by men who were physically handicapped in performing their work in the ordinary way.

Mr. Dickinson, the second speaker of the evening, expressed much interest in the lecture given by Mr. Gilbreth, and spoke of the urgent need of such work in the warring countries. Having been in the Civil War he appreciated greatly what opportunities were ahead of Mr. Gilbreth. He spoke of former Governor Nichols of the state of Louisiana who emerged from the Confederate army with one leg and one eye, as illustrative of two points that should be considered; namely, that a man need not despair on account of misfortunes incurred in the war and the effect of the pension system. General Nichols served in the Confederate army and his country was unable to give him a pension at the end of the war, so he went back to his profession, the practice of law, and notwithstanding his injuries, was eminently successful, becoming governor of Louisiana. Had he received a pension he would have been able to retire and the country might have lost the civil service of an able man. While Mr. Dickinson did not want to be understood as opposing a pension to those who become dependent on account of service to their country, he believed that from the study he has given to the question that a great deal of harm comes from indiscriminate pensions. He told how, after the Civil War, the pension system was dominated by the claim agents who lived on the percentages of the pensions obtained for those who were not very discriminating regarding the matter of disability. In this way a vast amount of money was bestowed on people whose injuries were far from making them non-supporting.

This indiscriminate pensioning was quite extensive in eastern Tennessee and its effect on the following generation was clearly shown at the close of the Spanish War. Four regiments from that state were raised for the Spanish War; one from the eastern part, one from the middle, one from the western part, and one called the "regiment of immunes," the idea being that those immuned from yellow fever would be liable to be called for service more rapidly. After the war was over and all these soldiers were mustered out of service they were asked whether or not they claimed anything for disability on account of serving the government and a record was made of these claims. Those soldiers from east Tennessee who were individually just as good men as the soldiers of west Tennessee, but who had been imbued with this idea of the pension system and of the duties and obligations of the government arriving simply from the fact of having rendered service, presented claims for 60 per cent of their number, whereas the regiments from the middle and west Tennessee put in claims for less than 10 per cent of their number.

In closing, Mr. Dickinson called Mr. Gilbreth's attention to the big field for his motion study work in the process of picking cotton in the South, stating that up to this time there has not been invented a satisfactory cotton picking machine and all that work has to be done by hand.

WORCESTER, NOVEMBER 23

At a meeting of the Worcester Section of the Society on November 23, Frank B. Gilbreth presented his paper on Motion Study for Crippled Soldiers in substantially the same form as it appeared in the December issue of The Journal.

BOSTON, NOVEMBER 30

At a meeting of the Boston local section of the Society on November 30, a paper was presented by Frank B. Gilbreth, Mem.Am.Soc.M.E., on Motion Study for Crippled Soldiers. Mr. Gilbreth stated that there are today over two million men living in Europe who have suffered the loss of limbs, faculties, or both, as a result of injuries in the great war. He said that provisions must be made for enabling these millions of crippled soldiers to become self-supporting, that they must be taught and fitted for some sort of productive work and the work must be specially modified and adapted to their individual physical defects and shortcomings, that the problem is an exaggerated new form of vocational guidance, vocational training and systematic placement of men. Mr. Gilbreth visited many hospitals and recovery homes and has seen first hand the frightful needs. Having crossed more than a dozen European frontiers since the war began, Mr. Gilbreth stated that he felt justified in emphasizing the necessity of this great movement of systematic teaching of crippled

soldiers. Mr. Gilbreth described a number of slides showing motion study of various kinds. By the analysis of the various motions it is possible to work out new sequences, cycles, and methods of doing many a type of work that has been formerly considered possible only for the man who is in complete possession of all his members and faculties. It is possible to take a maimed soldier or other worker to be helped, specially equip or fit him for a new set or new sequence of motions which will enable him to achieve an output of production not only large enough to allow him to be considered an active and productive member of society but also, with some types of work, to hold his attention and interest sufficiently to enable him to progress continually in his learning and skill.

ST. LOUIS, NOVEMBER 24

On November 24, a joint meeting of the Associated Societies of St. Louis was held under the auspices of the American Society of Civil Engineers. H. R. Stanford, U.S.N., Chief of the Bureau of Yards and Docks, gave an illustrated lecture on the Pearl Harbor Dry Dock. He discussed the dock from start to finish, particularly dwelling on the difficulties encountered through the bursting upward of the bottom of the dock through hydraulic pressure. The attendance was about 125.

ST. LOUIS, DECEMBER 1

On December 1, a joint meeting was held under the auspices of the American Society of Engineering Contractors. Hillis F. Hackedorn, president of the Hackedorn Contracting Company of Indianapolis, and also president of the American Society of Engineering Contractors, gave a paper on Equitable Specifications and Contracts. The paper was presented from the contractor's point of view. Mr. Hackedorn's contention was that the average engineer or inspector possesses no more of the qualities of angels than does the average contractor, and that a specification which places the final decision on all matters in the hands of a possible faulty inspector is not a just paper before the law. Such a contract further lacks many of the elements of common sense in its makeup. Mr. Hackedorn pleaded for a uniform building contract which would be fair to all parties concerned and advised that such a form was pretty well developed and it is to be before long that no contractor will undertake work unless this contract form is used.

BUFFALO, DECEMBER 1

At a meeting of the Engineering Society of Buffalo on December 1 Fay B. Williams, Mem.Am.Soc.M.E., engineer of the Lamson Conveyor Company, of Boston, Mass., gave a lecture on Internal Conveyors. The lecture was very profusely illustrated with slides and the various types of conveyors consisting of tubes, overhead wires, runways, etc., were thoroughly gone into. Mr. Williams described various systems of conveyors for carrying packages, parcels, goods, mail, etc., inside buildings. According to him, modern efficiency methods demand just as efficient means of internal transportation as of road transportation. About 175 members were present.

BUFFALO, DECEMBER 15

At a meeting of the Engineering Society of Buffalo on December 15, C. E. Drayer, Secretary of the Cleveland Engineering Society gave an address on Engineers in Politics. On January 1, the city of Buffalo enters on a new form of government, a commission form of government with four councilmen and one mayor as the governing body of the city. Mr. Drayer said that the building of railroads, canals, water-supply and sewerage systems, are fundamentally public service but do not relieve the engineer of his other duties as a citizen. On the other hand, the public character of his work creates new opportunities for civic leadership and increases his responsibility as a citizen. Mr. Drayer argued that the usual engineer was lax in his duties as a citizen, that he had special knowledge and training which might be turned to the common welfare of the community. He said that the local society of engineers could at least furnish through its committees and open meetings, a forum where analytical minds can help solve the problems about which engineers are qualified to speak. Mr. Drayer told what had been accomplished in Cleveland by the engineers of the city, how they are called on by the mayor and council in settling engineering questions. He showed many slides and newspaper clippings to show what interest was aroused by the Engineering Society in Cleveland and the great variety of topics that might be suggested for public discussion. This meeting was attended by approximately 175 and the tone of the meeting was one of heartiest coöperation in all forms of civic life.

PROVIDENCE, DECEMBER 15

The last meeting of the Providence Association of Mechanical Engineers for the year 1915, was held at Brown University on December 15. Prof. Charles W. Brown, head of the Department of Geology, addressed the meeting on Geology and Engineering. His talk was very well illustrated by the use of an epediascope, by means of which photographs and microscopic projections were thrown on the screen. At the close of the lecture the members had an opportunity to inspect the museum of the University with particular reference to the geological specimens.

CINCINNATI, DECEMBER 16

A joint meeting of the Engineers' Club of Cincinnati and the Cincinnati Section of the Society was held on December 16. Instead of the usual formal address, the retiring president of the Engineers' Club, F. L. Raschig, chose as his subject Engineering Features of the Panama Pacific International Exposition, following a paper which was presented at the San Francisco Meeting of the Society in September by Guy L. Bailey, Mem.Am.Soc.M.E. Through the courtesy of Mr. Bailey, about 90 lantern slides illustrating many of the engineering features of the Exposition were shown.

MINNESOTA, DECEMBER 16

The regular meeting of the Minnesota Section was held in St. Paul on December 16. Prof. J. J. Flather, Mem.Am. Soc.M.E., gave a paper on Engineering Education in the British Isles, and Mr. Brink presented one on Government Specifications with special description of a 50 ton crane which the American Hoist and Derrick Company is building for the Government.

Quincy A. Hall, in the absence of the Chairman, Mr. Toltz, made the following report of the Nominating Committee: C. W. Tubby, *chairman;* J. B. Martenis, *vice-chairman;* F. W. Rose, *secretary and treasurer.* F. W. Rose resigned and placed in nomination Quincy A. Hall, who was elected.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The December Meeting of the Armour Institute of Technology Student Branch was held on December 2. B. S. Carr, who is a senior mechanical and employed by the Grip Nut Company of Chicago, gave a talk and demonstration on grip nuts. He explained the entire process of their making and by means of a Riehle Testing Machine demonstrated the locking power of the grip nuts. Following Mr. Carr's talk, an open discussion was held on the subject of The Testing of Glued Wood Surfaces for Tension.

CARNEGIE INSTITUTE OF TECHNOLOGY

A meeting of the Carnegie Institute of Technology Student Branch was held on November 10, at which Prof. G. H. Follows, head of the department of machine design, addressed the Branch on Some Things that Experience Has Taught Me up to Date. He opened his talk with a summary of the positions that he had held in his past twenty-four years of engineering experience, which included almost everything that a mechanical engineer could do and still retain his calling.

Professor Follows said that the greatest lesson he ever learned was that interest in the work is the key note of success. Following this, he spoke at some length on requirements for a design to be good and also spoke of the poor returns from working with patents. He closed his talk with a very fine discussion of efficiency in general and personal efficiency. Following the address an informal discussion was held by Professor Follows and those present.

At a meeting of the Branch on December 8, H. H. Hower, of The Willys Overland Company in Toledo, gave an illustrated lecture on the subject of The Sleeve Valve Motor of the Silent Knight type. Mr. Hower presented each man with a paste board working model of the sleeve valve motor, and made use of these, in addition to a number of slides, to illustrate the points of his talk. The following is a brief summary of the considerations taken up:

The sleeve valve motor differs from the poppet valve motor only in the method of making passage for the inlet and exhaust gases. The other essential parts correspond very closely with those of the usual poppet valve motor. These passages are made by two concentric sleeves around the piston reciprocated by eccentrics on a counter shaft so that at the proper time the ports in the sleeves register with each other and with the ports in the cylinder walls proper allowing a large clear passage for the gases. The cylinder head fits down in the inner sleeve and has a junk ring to hold the compression. The sleeves are so arranged and operated that no port is exposed to the fire of the explosion, and the inner sleeve operates in the direction of the piston on the compression and power strokes.

In comparing it with the poppet valve, the following points were brought out in favor of the sleeve valve: Positive, quiet action; spherical combustion chamber; large clear passages; no grinding; and better possible wearing qualities.

Contrary to the general idea, the lubrication of the sleeves and piston assembly is more than adequate. A simple splash system is used, and in tests, bearings have been burnt out for want of oil while the sleeves were running well under the same supply as the bearings. The grooves in the sleeves have to be cut to prevent too much oil from working up the sides of the sleeves.

A discussion followed the talk. The question of whether cam and spring operated valves were positive in action at high speeds was taken up at some length. It was brought out that aluminum could not be used for pistons or valves in this kind of a motor because excessive heat expansion would prevent its being used where there were a number of close running fits. The cost of manufacture was found to be much in excess of that of the poppet valve motor.

COLORADO AGRICULTURAL COLLEGE

The Student Branch of the Colorado Agricultural College held a meeting on October 11, at which Oliver P. Hall, Mem.Am.Soc.M.E., gave a talk on the testing of automobile motors. His discussion was mainly in regard to the Standard Test. In discussing the apparatus used, he said that of prime importance is some sort of a brake to measure the horse power of the motor, in some cases a prony brake is used, while in others the electrical dynamometer is used. The latter instrument is the newest piece of apparatus used at the present time for the testing of motors. Mr. Hall gave a detailed description of the dynamometer, illustrating with blackboard drawings, and told of the methods of carrying on the test.

At a meeting of the Branch on October 25, Mr. England gave a talk on Compressed Air Mining Machinery. In his discussion he took up the old style steam, electric and gas engine compressors, and also the new electric compressors. In his talk, he touched upon the subject of drills and drill machines used at the present time. His talk was based on actual experience as gained in the metal mines of the Cripple Creek district.

Another meeting of the Branch was held on November 22. T. H. Sackett gave a talk on the ore-dressing machinery and processes of ore-dressing as used in the metal mines of the Telluride district of Colorado. He described by use of diagrams on the board the following pieces of apparatus used: Ore crushers, bins, stamps, amalgam plates, amalgamator classifiers, Wolfley tables and other apparatus used in the amalgam and cyanide processes of gold extraction. His discussion was well received and very interesting.

A fourth meeting of the branch was held on December 13, at which Prof. L. D. Crane gave a talk on National Preparedness. Prof. Crane made his remarks on the subject of civilian or voluntary service such as is now in vogue in the Navy Department of our Government under Secretary of the Navy, Josephus Daniels.

COLUMBIA UNIVERSITY

At a joint meeting of the electrical and mechanical engineering societies of Columbia University on November 23, Captain Robinson, C. E., of the 22nd Regiment, N. Y., spoke of The Work of the Military Engineer. The speaker was introduced by Dean F. A. Goetze, Mem.Am.Soc.M.E., and of the Faculty of the School of Applied Science. Captain Robinson pointed out strongly the great difference between civilian and military engineering. This difference is so great that, though a man is an engineer in everyday life, he is not fitted for military work without special training. This work includes all the regular infantry training in addition to the duties as an engineer. As Captain Robinson spoke of the different features of his subject, he illustrated the lecture with slides, motion pictures and models. The models of the different types of military bridges, small sized pontoons, etc., were remarkable. The military engineer has to be destructive as well as constructive, and, to illustrate this, two reels of moving pictures were run off showing explosions of earth mines and those under water with the resultant effects. Included in this were pictures showing the demolition of bridges and railroads.

KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College Student Branch on December 2, Lieut. Mathews, Commandant of Cadets at the College, gave a talk on Engineering as Applied to Field Fortification. He brought out the comparison between the ancient and modern methods of fortification. He spoke of the part that the engineer is expected to do in regard to field fortification, and also described the kinds of field obstruction and fortifications which are being used in Europe at the present time.

Prof. R. A. Seaton of the Applied Mechanics Department gave a description of A Trip to the Pacific Coast in an Auto. He described especially the kinds of roads and bridges in the west and in the mountains.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Student Branch of the Massachusetts Institute of Technology opened the year on October 9 with a trip through the new Institute buildings now under construction in Cambridge, at which one hundred and sixty-two men were present. The party was split up into small groups and shown about the buildings by instructors in the Mechanical Engineering department. Although no machinery has as yet been installed, the men were able to see the magnitude of the work and the general arrangement of the different departments. The me-

chanical laboratories were equipped with two canals in the basement which will furnish all the water used in the hydraulic work and also for the condensers. On the first floor will be placed the testing units, most of which will be entirely new. The power house, which is connected with the main building by a tunnel, is rapidly nearing completion. 2000 h.p. of Babcock and Wilcox boilers will be installed in 300 h.p. units.

The first smoker of the year was held in the Technology Union, the speakers being Professors Miller and Hayward of the Institute and A. B. Carhart, Mem.Soc.M.E., of the Crosby Steam Gage Company. Professor Miller spoke of the advantages of membership in the Am.Soc.M.E., while Professor Hayward gave some interesting advice to the men in regard to promptness and zeal in the work they undertake. Mr. Carhart outlined the progress in the past along engineering lines, and also mentioned some ways along which advancement may be expected in the future.

On October 30, a trip was made to the Chestnut Hill Pumping Station of the Boston Water Works with an attendance of sixty. On reaching the station each man was given a paper on which the most interesting points were noted. This particular station was of much value to the men, as there is such a variety of equipment. The boiler room has seven vertical fire tube boilers, one of the locomotive type, and three horizontal boilers running with stokers and forced draft. The pumping engines are of 35, 45, 20 and, two of 8 million gallons a day capacity. There is also an Allis engine that for a number of years held the world's economy record.

On November 11, W. S. Perkins of the Walker Pratt Foundry gave an illustrated talk, which followed the progress of the metal from the mine to the finished product.

On November 27, there was a trip to the L Street Station of the Boston Edison Company, where eight vertical turbo-generators of 96,000 kw total rated capacity were seen in operation. The coal handling system from vessel to boiler was one of the interesting features that was noted. Here as in the former trip neostyled sheets were given out showing where to see the interesting points: these also contained considerable data and a general description of the plant. From the Edison plant, the men went to that of the Boston Elevated system, where three 15,000 kw units were seen in operation. A description of the condensers, main units, feed water heaters, boilers, etc., was given the men, and, in company with several professors and officers of the society, who went over the plant a few days previous, the piping system was traced out and different features of the equipment noted.

The officers for the ensuing year are: K. C. Richmond, '16, chairman; P. Y. Loo, '16, vice chairman; H. B. Gray, '16, secretary; J. W. Stafford, '16, treasurer; R. M. Snyder, '16; G. W. Tuttle, '16, and E. W. Rounds, '17, governing board.

PENNSYLVANIA STATE COLLEGE

At a meeting of the Pennsylvania State College on November 18, H. L. Mummert, '16, was appointed by the Advisory Committee as the representative of Pennsylvania State College to the Annual Meeting of the Society in New York.

Samuel Clark, '16, gave a lengthy discussion of the Willys-Overland automobile industry. He supplemented his talk with stereopticon views of the Toledo plant, showing views from nearly all of the departments, and more especially the motor assembly department. He described the methods used in assembling the motors, and also spoke of the accuracy demanded in making up the various parts. He illustrated with lantern slides the working parts of the motor, and especially the sleeve valve system, which he discussed in detail. The speaker helped to explain the sleeve valve by the use of a miniature working model of the motor in cross-section.

Mr. Clark also described the treatment of employees by the Willys-Overland concern, and explained several points in connection with the handling of the men.

At this meeting, G. S. West was chosen as vice-president to succeed Mr. Dunn.

POLYTECHNIC INSTITUTE OF BROOKLYN.

At a meeting of the Polytechnic Institute of Brooklyn Student Branch on November 6, George A. Orrok, Mem.Am. Soc.M.E. and chief mechanical engineer of the New York Edison Company, spoke on Tendencies of Central Power Station Design. He traced the development of central power stations from the first station built by Edison over thirty years ago to the model and standard stations of to-day both in Europe and in this country. He showed how boilers have been improved and how they can now produce a pressure of 350 lb. per sq. in., although the usual working pressure is 175 lb. Likewise the motive power for directly driven dynamos has passed through several stages, from compound engines to triple expansion, to quadruple expansion engines, back to compound engines, and finally to the highly efficient and economical turbine now in vogue.

In power plant design, there evolved two types of central power stations, the European and American Standard. The European design includes boiler room, turbine room, electric auxiliaries and economizers, while the American Standard involves boiler room, turbine room, steam auxiliaries and feed water heaters without economizers.

The greatest tendency in central power station design in this country is toward the extensive adoption of the economizer. This equipment, which raises the temperature of the water from the feed water heater before injecting it directly in the boiler is claimed to increase the efficiency 4 per cent.

The December meeting of the Branch was held December 10 at the rooms of the Society in New York. Fred R. Low, Mem. Am.Soc.M.E., and Editor of Power, gave an illustrated talk on the Panama Pacific Exposition. The Panama Exposition has been the only exposition with consistent layout of buildings, which can be explained by the fact that the site of the exposition was formerly under water. The speaker dwelt at length on the palace of machinery, which required 7½ million board feet of lumber and 15 tons of building hardware in its construction. Mr. Low impressed his listeners with the fact that the exposition contained very little to commemorate the Panama Canal or to impress the visitor with the immense strides which have been taken in engineering in the past decade. Colored slides portrayed the beautiful color scheme used in the decorations of the buildings.

PURDUE UNIVERSITY

A joint meeting of the Purdue University Student Branch of the Society and the A.I.E.E. was held November 22. W. A. Phillis, of the National Tube Company, gave a lecture on the manufacture of steel pipe and tubing. He illustrated his talk with three reels of motion pictures. The first reel showed the "open-cut mining" of the Great Lakes region being carried out on a mammoth scale. The advanced methods of loading and transportation were of special interest, and excellent pictures of the charging of the blast furnace were shown. The second reel portrayed the refining of the steel and the rolling and forming it into the finished product. The steel is refined in the Bessemer and open hearth furnaces, depending upon the style of pipe to be made and the quality of the iron. Probably the most interesting feature was the great amount of automatic machinery for handling the rolled stock. The steel is first rolled into sheets and then formed into the pipe, using a butt weld up to a certain size and then the lap weld in the larger sizes. The third reel concluded the manufacture of the pipe, and in addition showed the rigid tests to which the finished product is subjected. Every piece is tested for compression in both directions, the weld is tested, a water test and a personal inspection complete the test. A panoramic view of the immense factories at Lorain, Ohio, concluded the film. Few opportunities have been afforded the engineering societies for seeing such an unusual motion picture of a big industry as that shown to the engineering societies of Purdue by the National Tube Company.

Another meeting of the Branch was held December 7. The program consisted of talks given by three of the members. The first was a talk on ship-building, by Mr. Shoemaker. He is a native of Holland and has had considerable experience in repair work on large vessels. He gave a very instructive account of the method of re-boring worn steam cylinders by setting the mill right in the cylinder. An account of the exchange of propellers in mid-ocean was given. The cargo was shifted to the forward part of the ship until the propeller was out of water. A scaffold was then built around the propeller and it was removed. Mr. Shoemaker's statement that the bearing surface of the journal of the propeller was made of wood was received with a great deal of interest and curiosity.

The next talk was given by O. F. Hambrock, '16, on Replacing of Boiler Tubes. He gave the various methods of fastening the tube to the plate; by putting a bead on the inside by means of a special tool (pneumatic), and also a new theory proposed by a foreign experimenter, namely, increasing the thickness of the tube at its entrance to the plate by the addition of a softer metal. This, it is claimed, will remedy loosening of the tubes due to expansion in heating. Mr. Hambrock gave his ideas on the practicability of the scheme. He told of the probable difficulty in welding, and also of the decrease in size of the spaces between the tubes and the resultant increased opportunity for the lodgment of dirt. He also discussed the warping effect due to unequal heating of the pipes.

The third talk was a short discussion on Fallacies in Cement Testing. This was given by W. Rhoton '16. Lack of a more specific standardization of the constituents of cement and of the size of the mesh used in screening are the largest contributants to fallacious tests on cement. It was also brought out that tests run on the material immediately after manufacture are not a true indication of its quality after it has been stored away in bags for a time.

RENSSELAER POLYTECHNIC INSTITUTE

The third regular meeting of the Rensselaer Polytechnic Institute Student Branch was held on November 11. J. B. Lincoln, president of the Branch, gave a very interesting description of the "L" Street Station of the Edison Electric Illuminating Company in Boston, Mass. Among the interesting facts given by Mr. Lincoln were the following: The rated turbine capacity of this plant is 140,600 h.p.; the turbines are of the vertical Curtiss type and are eight in number; each turbine is installed as an independent unit and can be fed with steam from any one of 48 Babcock and Wilcox boilers. These boilers are placed in the boiler room parallel to and separated from the turbine room by only a brick wall, thus making short steam lines and consequently a small per cent condensation. Water is fed to the boilers from the city mains but a reserve auxiliary storage tank is kept filled as a reserve supply in case of shortage of city water. Since the plant is located on Boston Harbor, all coal is brought to the plant in ships and is stored in the open air in the rear of the Power House. This coal is carried to the boiler room by means of belt conveyors. Circulating water is pumped to the condensers from the harbor.

Prof. A. M. Greene, Jr., Mem.Soc.M.E., and head of the mechanical engineering department, then gave a very interesting discussion of the papers which appeared in the November issue of The Journal. Professor Greene confined his discussion chiefly to the papers on The Diesel Engine and its Application to Southern California by Walter H. Adams and The Heavy Oil Engine, its present Status and Future Development, by A. H. Goldingham. He laid special emphasis on Mr. Adams' comparison of the Otto and Diesel cycles and on the advantages and disadvantages of two cycle and four cycle engines.

STATE UNIVERSITY OF IOWA

The first regular meeting of the State University of Iowa Student Branch was held on December 1, at which Harry F. Helming was elected chairman to succeed C. W. Harrison; H. V. Swanson and Geo. Gartzke were elected members of the governing committee. At a meeting of the Branch on December 14, Mr. William Howe, member of the Branch, gave a short talk on the History of the Association and the advantages to be derived by the students in becoming affiliated with the Branch. He also emphasized the value of The Journal to the undergraduate.

SYRACUSE UNIVERSITY

At a meeting of the Syracuse University Student Branch on December 6, Hiram Percy Maxim gave a lecture on his invention, the Maxim Silencer. Mr. Maxim told in a very interesting way how the idea of his invention first came to him and of the interesting experiences he has had with trying it out. Mr. Maxim said that one morning as he was stepping out of the bathtub, he noticed a whirlpool with the air space in the center which kept the water from running out freely. Immediately the thought came to him that if he could make the gases coming from the barrel of a gun whirl in the same way they would be retarded and hence there would be no noise. Immediately Mr. Maxim set to work upon this idea and soon had a real silencer.

Mr. Maxim then explained why a gun having a silencer upon it is not absolutely quiet when fired. The noise which he cannot quiet is caused by the bullet passing through the air. This noise cannot be overcome without reducing the speed of the bullet.

Mr. Maxim also pointed out why a revolver is not silenced by his invention. The reason is that there is a space between the chamber and the barrel through which the gases escape. Mr. Maxim concluded his lecture by demonstration with different sized rifles and the revolver.

UNIVERSITY OF CALIFORNIA

At a meeting of the University of California Student Branch on November 23, H. Crow gave a paper on the Relation of Engine Balance to Automobile Vibration in which the author considered chiefly the four, six and eight cylinder engines.

C. Sebastian also gave a paper on the Electric Furnace and the Steel Industry in which the author considered the application of the electric furnace in the production of high grade steels.

UNIVERSITY OF CINCINNATI

On November 19, Mr. Walker of the Enger Motor Car Company addressed the University of Cincinnati Student Branch on the Twelve Cylinder Motor Car. He began by explaining the conditions leading to the adoption of the twin six by the Enger Motor Car Co. He said that the public was demanding of the motor car, *first*, more range of adaptability; *second*, smoothness, and *third*, less noise. The six cylinder motor is perfectly balanced, and thus reduces the vibrations in the car considerably, compared with the four, but when the six cylinder car is running slowly on high speed gear the explosions of the motor are so far apart that distinct vibrations are set up in the car. To remedy this either a heavier crank must be used, which means added weight, or more cylinders, which give less weight. It would seem that the twin four would be the next logical step after the 6 cylinder motor, but Mr. Walker pointed out that the eight cylinder motor is not balanced, and thus does not do away with vibrations in the car. In automobile design weight is a serious consideration. The twelve cylinder motor saves in weight in cylinder, piston, connecting rods, crank, crank case, and fly wheel.

UNIVERSITY OF COLORADO

At a meeting of the University of Colorado on November 11, C. H. McClintock, Student Member, gave a talk on the Arkansas Valley Plant of the American Smelting and Refining Company from his summer vacation work with the company.

At a joint meeting of the Branch and the Civil Engineering Society, on December 9, Ejnar Posselt, Mem.Am.Soc.M.E., gave an illustrated talk on Cement Manufacture.

UNIVERSITY OF KENTUCKY

At the December meeting of the University of Kentucky Student Branch, the members assumed the attitude of salesmen with the idea of selling a 300-h.p. unit for a manufacturing plant to three "buyers" representing the plant.

To this end, the class was divided into five sections, representing the Curtis turbine, direct connected to a generator with individual motor drive; the Parson turbine, direct connected to a generator with individual motor drive; the Corliss engine, belted to load; a cross compound engine, belted to load, and the Nordberg Uniflow engine, belted to load.

Each side endeavored to show that they had the specific unit which would fill the requirements in the most economical manner rather than that their competitors' machines were defective, and it was with difficulty that the "buyers" were able to decide, but finally, they "let" the contract to the salesman of the Curtiss turbine.

UNIVERSITY OF MINNESOTA

The regular meeting of the Minnesota Student Branch for December was held December 11, 1915. The speaker was Prof.

J. J. Flather, of the Mechanical Engineering Department, and his subject was "Engineering Education in England." The facts for his speech he had obtained, first hand, while pursuing special studies in engineering in Great Britain for the past year. While there, he visited the English engineering schools and also talked with employers of young engineers.

He told his audience that they should be thankful that they had the opportunity for studying their profession here in America. The opportunities of getting a higher engineering education in England are exceedingly limited; the cost is high, the shop requirements heavy and the results in the theoretical part of the work tend to be superficial. The courses, he said, do not appear to be developing industrial leaders, but rather mediocre foremen and designers.

Beside the regular meeting of the society, there were two meetings open to the whole college. The first of these took place Saturday, November 20, 1915. The speaker was Prof. F. B. Rowley, of the Drawing Department and his subject was "The Mechanical Equipment of Buildings." With the help of lantern slides, he explained the mechanical equipment of the Biology Building, one of the newest buildings on the University Campus. The second was a steropticon lecture furnished by the S. K. F. Ball Bearing Company. A. W. Hohnberg, of the Post-Senior Mechanical Class explained the slides.

UNIVERSITY OF MISSOURI

A meeting of the University of Missouri Student Branch was held on November 11. A. C. Lanier, professor of Electrical Engineering gave an interesting and instructive address on Present Requirements and Characteristics of Motors in Industrial Application. In his talk, he discussed fully the main kinds of drives, and the work for which each is adapted, pointing out the advantages of the electric drive, over that of other drives for many kinds of work, where formerly other drives have been used. Also he discussed the types of loads, and the factors determining the selection of motors for these various loads.

The largest meeting of the society took place on November 19, at which E. B. Morgan, safety engineer for the Commonwealth Steel Company, gave an illustrated address on the Relation of the New Efficiency Problem, Industrial Safety, to the Engineer. He told how his company had found that the so-called guarded machinery, as usually found in practice, was not only poorly designed and expensive but also failed to fulfil efficiently the purpose for which intended, namely that of reducing the number of accidents. Therefore under his direction a scientific study of the cause and remedy for the large number of accidents occurring annually in the plant was undertaken. The result is that the number of accidents has been materially decreased, and a large sum of money, which formerly was paid out for accident and death claims, is now saved by the company. Also in applying the remedies necessary for safety, it has been found that the efficiency of the plant has been increased in many instances by these changes. Some of the particular safety appliances mentioned and illustrated on the screen were the use of locks on all motor switches to lock the switch while repairs are being made on the machine, so that there will be no danger of anyone starting the machine while a repairman is at work; the use of especially designed goggles by the workmen, wherever the work is of such a character as to endanger their eyes; the construction of suspended passage ways for repair, oiling, etc., of overhead motors, belt drives, etc.

VIRGINIA POLYTECHNIC INSTITUTE

A meeting of the Virginia Polytechnic Institute Student Branch was held on November 27. A paper was presented by Messrs. C. F. Lawson and C. E. Parker on the Development of the Mechanical Stoker. An enthusiastic discussion followed the reading of the paper and many features of the stoker were commented upon.

It was announced that at future meetings, papers would be read on Low Water Alarms by Messrs I. N. Moseley and R. R. Connelly; Superheaters by Messrs W. R. Ellis and R. M. Hutchinson and the Diesel Oil Engine by Messrs. W. L. Cogbill and H. A. Davenport.

Mr. Kavanaugh, chairman of the Branch, announced that arrangements had been made for a series of lectures to be given in the near future by the following men: A. Kearney, Asst. Supt. of Motive Power, N. & W. Ry., who will speak on Train Resistance; C. M. Janelle, associated with the Baker Pelloid Company, who will speak on Valve Gears; C. H. Quin, chief electrical engineer N. & W. Ry., who will speak on The Development of Electrical Motive Power on the N. & W. Ry.; and F. H. Cunningham, associated with the Standard Stoker Company, who will speak on Mechanical Stokers.

WISCONSIN UNIVERSITY

At a meeting of the University of Wisconsin Student Branch on December 2, Mr. Barnett gave a talk on the substitution of aluminum for cast iron in automobile engine pistons. Mr. Barnett pointed out clearly how the vibrations of the engine would be decreased by making the reciprocating parts of this lighter metal. He also stated that the increase of cost of material would be reduced partly by the decrease in cost of machining.

WORCESTER POLYTECHNIC INSTITUTE

At a meeting of the Worcester Polytechnic Student Branch on November 5, F. L. Fairbanks, Mem.Am.Soc.M.E., Chief Engineer for the Quincy Market Cold Storage and Warehouse Co. of Boston, spoke on Some Experiments in Lubrication. He has under his supervision a line of engines, compressors and pumps giving a service of peculiar interest to engineers in that the service is a continuous one. He showed by description and sketches how, by means of especially designed bearings and by special methods of lubrication, the plant service had been improved to a point where, for some of the machines, the steam throttle had not been closed for a period of many months. He remarked that some of the oilers employed had never seen the engines at rest during their period of service. His lecture dealt especially with such bearings as those of the main machining and design were illustrated.

At the regular meeting of the Student Branch of the Worcester Polytechnic Institute on December 3, Hartley W. Bartlett, a Patent Attorney in Worcester, presented an exceedingly instructive paper on Inventions and the Patent System. To begin with, the speaker traced briefly the historical development of our Patent System and mentioned the essential features of its operation. He then took up the subject of patentable and non-patentable inventions.

The procedure necessary for obtaining a patent was then explained, the first step being the filing of the application, which contains: The petition; complete description; new features of invention; claims for the invention and reasons why the patent should be granted; oath of form. It was pointed out how difficult it is to frame the application, making the claims as broad and inclusive as possible and the specifications extremely definite, clear and proof against infringement. After the application with drawings, etc., is filed in one of the divisions of the Patent Office, it is considered by the Examiners.

After this discussion, Mr. Bartlett took up the matter of Interference and explained the difficulty of proving "priority of invention" and how some inventors are "beaten out" of their invention and patent by unscrupulous men. Infringement and court procedure in such cases was next treated and mention was made of the discouragement and failure which often comes to inventors without large means who are forced to fight large corporations for patent rights and privileges. The speaker pointed out one important difference in the Patent Laws of this and other countries in that owners of American patents are not required to "work" them while owners of most foreign patents may be compelled to do so.

A discussion of the preparation for entering Patent Law was then taken up including: Course in Mechanical Engineering; Civil Service Examination and position as Examiner; Study in night law school during work as Examiner; Admission to Bar and entrance into practice. When asked about the remuneration of inventors in general Mr. Bartlett said, "If you want to become a millionaire, go into business."

ACCESSIONS TO THE LIBRARY

This list includes only accesions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

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EMPLOYMENT BULLETIN

Beginning with this issue of the Journal the notices appearing in the Employment Bulletin are published in a form which indicates at a glance the classification

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.

399 Salesman on electric clock system, with acquaintance among New York architects and contractors. Salary commission basis. Name confidential.

401 Sales Engineer of highest merit. Must show excellent past record and be personally and closely acquainted with the engineering profession from the operating and consulting end in Greater New York; must be familiar with boiler plant practice and be a man of good personality and a high grade salesman.

402 Assistant Foundry Foreman for manufacturers of farm implements and heavy machinery. Must be man of tact and ability. Location Pennsylvania.

405 Instructor in machine design; desire young engineer having had some teaching and practical experience. Send references, recent photograph, full statement of training and experience. Location Middle West.

406 Instructor in mechanical engineering laboratory practice and steam engineering. Prefer young engineer with some teaching and practical experience. Send references, recent photograph, full statement of training and experience. Location, Middle West.

407 Sales Engineer for New York concern manufacturing fans, blowers and power house equipment.

408 Salesman, experienced, competent to sell refrigerating machines in Philadelphia and within a radius of 100 miles of Philadelphia.

409 Valve and Fitting Designer and Checker with large firm; good future to man with experience who is willing to hustle and work hard; others need not apply. State experience in full, salary expected and references. All correspondence will be strictly confidential.

413 Draftsman on box machinery to work under instructions. Maximum salary, $25. Location, New York.

417 Draftsman on jigs and fixtures. Salary, $20—$25. Location, New York.

418 Detail Draftsman at salary of about $18. Location, New York.

419 All around Draftsman on reinforced concrete structures. Possibility of having to go into field to complete work. Salary, $25 to $35. Location, New Jersey.

422 Inspector on installation of machinery; young technical graduate familiar with construction work, mill wright work and general factory maintenance.

425 Draftsman on automatic machinery. Salary depends on man. Location, New York.

426 Assistant in Research Work. Recent graduate as assistant in work of assembling figures and results. Location, New York.

427 Draftsman experienced in evaporator and drying work; not necessary that he be a designer. Apply by letter stating experience and salary expected. Location, New York.

431 Assistant Manager of phosphate mining company; both electrical and mining engineer; must be familiar with power house practice and thoroughly experienced in both gas and Diesel engines. Salary $200 per month. Position carries with it house to live in, electric light and water free. Location, Florida.

432 Engineer and Draftsman for work in the engineering department of paper manufacturing company operating four fine writing and cover mills; work includes design of buildings and machinery, layout of mill equipment, testing of power equipment and machinery, investigations, etc. Salary between $1200 and $1800 per year, depending upon capability of man. Opportunity for advancement.

433 Engineer capable of taking hold of design of new foundry under direction of engineer of company manufacturing cast iron and water pipe. Location, New Jersey.

436 Junior Engineer with some shop experience, capable of designing tools and doing ordinary mechanical drawing. Salary $100 to $125 a month. Location, New England.

437 High Grade Draftsman familiar with machine design. Location, New York.

438 Assistant Superintendent for plant consisting of foundry employing about 90 men and factory with about 700 men and 60 women. Want primarily a shop engineer, first-class mechanic with experience in designing machine tools, jigs, fixtures, etc., and manufacturing small parts on an absolutely interchangeable basis. Prefer man with experience similar to manufacture of sewing machines and cream separators. Salary depends on earning capacity of man. Location, New York State.

442 Chief Draftsman on design and installation of machinery. Location Jersey City, N. J.

443 Draftsman for same company as 442. Salary $20 to $25.

446 Draftsman, experienced and thoroughly reliable, with practical shop experience for designing automatic machines for paper products. Salary $1,200 to $1,500. Location, New York.

447 Detailer for automatic machines, quick and reliable, with practical shop experience. Location, New York.

449 Designer and Superintendent of installation on power work, electrical and steam. Salary about $1,800 a year. Location, New Jersey.

450 Machine Tool Draftsman. Salary $150. Location, New York State.

451 Draftsman on steam power plant piping layout and heating system. Man experienced in the piping work. Salary $25. Location, New York City.

452 Purchasing Agent for Connecticut concern manufacturing recording instruments. Location, Connecticut.

453 Expert Accountant for company listed under 452.

454 Building Estimator, capable and experienced in the purchase of building material. Young college man preferred. Excellent opportunity. Location Middle West. State experience in full, salary received, age and references in first letter.

455 Manager for creosoting plant in Florida; one experienced in this line of work. Salary $100 to $125 a month, including house, light, water, etc.

456 Assistant to Superintendent of Employment; young university graduate to develop a systematic plan for engaging, training and record of progress of employees; one who has made a study of psychology or at least with clear conception of the requirements of such a position. Location, New York.

457 Inspector of Materials and Supplies to work under the supervision of the head of bureau of tests of New York concern manufacturing paper products; to accumulate data which will form basis for research work leading to standardization of grades of paper and other materials used in manufacturing processes. One or two years experience in paper industry would be especially helpful. Location, New York.

458 Young Technical Graduates, preferably in mechanical engineering, to enter manufacturing department under direction of betterment department and be trained for positions of responsibility in factory and planning room of paper products company. Location, New York.

MEN AVAILABLE

The published notices of "men available" are made up only from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

A-1 Superintendent, age 33, first-class toolmaker and machinist, experienced in builders' hardware, small machines, instruments, speedometers, etc., six years with present concern, and who has held positions from toolmaker to superintendent desires to make a change. Location Eastern States, preferred.

A-2 Professor of Mechanical Engineering in a Canadian University, technical graduate of A-1 U. S. Institution, both M. E. and E. E. training, has held responsible position in large manufacturing plant as well as important U. S. government post as engineering expert, also has had four and one-half years successful teaching experience, and is author of engineering text books and numerous technical articles, desires teaching position in U. S. college.

A-3 Translator. Professor of applied mechanics in the University of Liége, Belgium, Mem.Am.Soc.M.E., Inst. of Mech. Engrs. and Iron and Steel Institute, is available for work in translation into French, catalogues or technical publications of American firms.

A-4 Works Manager, age 40, with large and long established company manufacturing power equipment, twenty-two years general shop experience, having handled men for fifteen years, experienced in large production, having supervised from fifteen hundred to eighteen hundred men, desires to make a change.

A-5 Position Wanted by student member, Columbia University 1915 M.E., in or around New York, which offers opportunity for advancement and good engineering experience, also fair salary to start. At present employed.

A-6 Executive. Member with wide experience in machine shop, grey and malleable iron work, desires business connection in an executive capacity with an established manufacturing concern.

A-7 Assistant to Consulting Engineer. Technical graduate, Junior member, age 26, five years assistant to consulting engineer, has been in responsible charge of general engineering work, tests, investigations and reports, desires position along similar lines or with public service company offering attractive opportunity.

A-8 Executive. Graduate M.E., Cornell 1906, age 32, married, four years experience testing and determining unit costs of steam, air, water, electricity and refrigeration, advancing to chief of tests. Four years as chief engineer of lime manufacturing plants, specializing in combustion engineering and design of elevating and conveying machinery; one year as purchasing engineer of same company, has reached the limit of present position and desires to make a change, following same lines of purchasing, engineering and efficiency study work. Salary $4000, with promise of advancement.

A-9 Advertising Manager. Graduate mechanical engineer, age 31, thoroughly experienced in modern publicity work as applied to products of a mechanical nature, is open for position as advertising manager. Replies are solicited only from high grade firms that believe in clean cut, dignified methods, and are willing to pay a suitable salary for capable services.

A-10 Executive. Member, age 35, technical graduate M.E., twelve years experience in general engineering work, civil, mining, and mechanical, steel plant and general construction, estimating, office and field work, wishes to locate a position in which broad engineering experience together with ability to handle men will be required. At present employed.

A-11 Production Engineer. Member, age 34, fourteen years experience, seven in charge of drafting room, and successful in working out original problems of design from a manufacturing standpoint with a view of interchangeability and low cost of production, desires similar position. At present employed as mechanical engineer with large corporation.

A-12 Executive for Smelter or Mine Plant. Mechanical engineer, age 35, specialist in the design and construction of smelters, mine plants and mills with machinery and appliances, also conveying machinery, experienced in acid plant construction. Fourteen years with mining-smelter companies and manufacturers, wishes responsible executive or engineering position with a mine or smelter company. Has had executive and sales experience. Now engaged in New York and would like to locate there or in vicinity.

A-13 Engineer on Oil Engines. Member, University training with extensive experience in the design and construction of marine and stationary four and two-cycle engines; has held positions with a leading German firm as co-worker in the development of the marine type into a commercial form; prepared to turn out simple and economical engines with experimental stage eliminated. Desires position as executive, chief engineer, manufacturing superintendent, or assistant engineer of tests with a first-class manufacturing concern producing oil engines.

A-14 Sales Engineer. Technical graduate, twelve years selling experience, especially Government work, at present in charge of Washington, D .C. office of large machinery manufacturer and desires similar position in New York.

A-15 Production Engineer. Associate-member, M.E., age 38, expert in interchangeable manufacturing, sheet metal stamping and evolution of shapes; economic production of duplicate parts, light mechanical devices and machinery. National reputation as mechanical expert and consulting engineer, author of numerous standard mechanical test books; developer and perfector of machines and devices for commercial efficiency and success, desires position as production engineer where ability to eliminate costs, operations and intricate mechanisms and effect maximum efficiency and output at minimum cost will earn $4000 per year, and more when results justify increase.

A-16 Sales Engineer. Graduate M.E., age 31, well posted on pumps and pumping machinery of all types, oil, gas and steam engines, drawing room and shop practice, sugar house work in Mexico and sales engineer in Brazil, desires permanent employment with reliable firm either in sales, office or shop. At present employed as salesman and expert on farm machinery.

A-17 Chief Engineer. Member, Cornell M.E. graduate, with several years successful experience as chief engineer and manager, and thoroughly trained and successful in shop, office and development work, desires a responsible position.

A-18 Works Manager. Member, age 37, technical education, wide experience in power plant design, construction and operation, power plant economy, piping, building construction and factory engineering, desires position as works engineer or mechanical superintendent.

A-19 Chief Draftsman, Mechanical Engineer and Superintendent. Member, technical education and fourteen years general engineering experience, perfectly familiar with design, construction and operation of plants manufacturing cement, coal mining and cooking plants; has made an especial study of elevating and conveying machinery in connection with cement making and coal handling. Has held positions as chief draftsman, mechanical engineer and superintendent. Now employed but to avoid traveling desires to get in touch with large company where experience and ability may gain him a permanent position.

A-20 Assistant to Superintendent. Associate-member, B.M.E., age 29, three years experience inventorying power plants, factory equipment, and buildings of two large plants in the South, past four years employed as mechanical engineer at an Eastern plant, has made all machinery layouts and superintended the installation of all of the machinery in plant, looked after up-keep, installed a modern cost-keeping system, and acted as general assistant to superintendent. Salary, $2400. At present employed.

A-21 Superintendent. Member, Stevens graduate, age 38, married, desires to make a change. Has had two and one-half years experience in shop and drafting room, steam and electric machinery and air compressors; three and one-half years designing and building electrical apparatus for naval vessels; nine years as assistant superintendent and superintendent of inspection department of two large casualty companies.

A-22 Manager, Superintendent or Sales Engineer. Member, graduate M.E., Lehigh University, several years in management of mechanical and purchasing departments of railroad, coal mining, and industrial corporations. Also extensive experience as sales engineer in railroad equipment. Good organizer and executive, qualified to fill position of manager of an industrial plant or coal mining company, or superintendent of motive power of a railroad. Can successfully represent manufacturers of machinery, power plant equipment, iron and steel.

A-23 Superintendent and Works Manager. Associate member, age 45, Scotch, with long experience as foreman, superintendent and works manager in large jobbing shop doing machine, smith and sheet iron work and also well versed in motor vehicle construction, desires to change position.

A-24 Executive. Mechanical engineer, technical graduate and member with broad shop, mill and power plant experience, desires important executive position with large progressive concern.

A-25 Shipbuilding Engineer. Member, technical graduate, age 36, experienced in design and construction of structural steel work, machine tool, shop layout and arrangement of machinery, efficiency management, accounting and costs, works management, planning and routing, orders and stores, also experience as sales engineer, desires to become associated with a shipbuilding concern or an allied industry. Location preferred New York or Philadelphia.

A-26 Power Plant Engineer. Student member, 1915 graduate in M. E., wishes position along lines of power plant engineering. At present employed with manufacturing concern.

A-27 Superintendent. Member, over twenty years experience along engineering lines; twelve years shop practice and eight years office. Experienced in locomotives, cars, boilers, engines, special machinery, shop layouts and structural work. Has held positions from machinist to superintendent of construction. At present employed.

A-28 Superintendent. Member, graduate engineer, age 32, possessing exceptional executive ability, ten years experience in shop work, drafting, erecting, operating, purchasing and selling; familiar with steam, gas and oil engines, and refrigerating machinery, desires a permanent position as superintendent, or engineer with reliable company near Philadelphia. Salary $3000. Temporarily employed, but available January first.

A-29 Superintendent. Member, technical graduate, age 37, fifteen years office and shop experience as designer, engineer and superintendent in United States and abroad, is open for engagement. Broad experience in designing, manufacturing and testing special machinery, turbines, automatic railway air connectors, etc. Thorough knowledge of German. At present employed.

A-30 Works Manager. Member, M.E. and E.E., analytical mind, initiative, originality, balanced by commonsense, knows how to get larger output, lower costs, better information, greater profits, broad experience in machinery, metal and wood manufacturing, designing, production, efficiency, costs, accounting, auditing, management, desires position as works manager.

A-31 Sales Engineer. Mechanical engineer, graduate Columbia 1912, experienced in design and construction work, desires permanent position, preferably in sales or where there is a chance to work into sales or commercial end of business. Location immaterial.

A-32 Sales Engineer with Patent. Member, recently granted U. S. patent (not yet issued) on improved shop appliance for which there is a wide and profitable market, wishes to arrange for manufacture and exploiting with established concern possessing ample facilities and resources for handling the business. Is thoroughly conversant with advertising and sales methods in this particular line, and capable of organizing and managing department which should be financially satisfactory to all concerned.

A-33 Research Engineer, Engineer of Tests. Mechanical and electrical engineer with scientific training, experienced in the organization of testing and research departments, and the construction of scientific laboratories, desires position, temporary or permanent, which requires the exercise of business judgment and executive ability, in addition to a knowledge of the fundamental sciences entering into work of this character. Has built and organized chemical, physical, electrical, metallurgical, metallographic and strength of materials laboratories, as well as laboratories for special research.

A-34 Chief Inspector. Mechanical engineer, age 27, wide experience in factory inspection, rating of plants, compensation work and guarding of machinery, desires position as chief inspector of mutual company. Salary, $1800.

A-35 Manager. Member, technical education, twenty-seven years practical experience on pumping machinery, compressors, pneumatic machinery, both design and construction, conducting power and efficiency tests, handling engineering correspondence, will accept position of engineer or manager, or other executive position with manufacturing firm or consulting engineer.

A-36 Junior Member, technical graduate, age 27, four years shop and about one year's drafting room experience, also special organizing work and in production department of company making centrifugal pumps and power plant auxiliaries. Salary, $1500.

A-37 Assistant to Consulting Engineer or Contracting Firm. Mechanical engineer with thorough technical training desires connection with consulting or contracting firm. Has had splendid experience in planning work for machine shops and in testing.

A-38 Inventor and Executive. Mechanical engineer, member, age 39, university graduate, twenty years experience in various engineering fields, inventive and executive ability, desires position, preferably in or around New York. English, French and German correspondent.

A-39 Metallurgical Engineer. Member has had extensive experience in design and operation of gas producers, foundry practice, manufacture of steel for ordnance, and expert in the properties of materials.

A-40 Manufacturers Representative. Member with office and wide acquaintance with manufacturers, public utility officers, consulting engineers and architects, desires to add to representation in Ohio, Buffalo, Pittsburgh and Detroit districts.

A-41 Works Manager or Assistant. Junior member, technical graduate, shop, selling and shop management experience, desires position as works manager or assistant works manager. At present in charge of manufacturing department of large plant building special machinery. Has reduced operating expense and cost of production.

A-42 Member, Stevens graduate, mechanical engineer, thirteen years experience design and construction steam electric plants, pumping stations, industrial works, heavy foundations involving pneumatic caisson method, reports and appraisal, also business experience, is open for engagement.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

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Philadelphia: Robert H. Fernald
San Francisco: Frederick W. Gay
St. Louis: Edward Flad
Worcester: Paul B. Morgan

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and it will also be published in the February 1916 issue of the Journal.

ENGINEERING SURVEY

Wadkin propeller-shaping machine—Flow of air in round ducts—Swedish type Diesel engine—Propelling machinery, U. S. S. "Maumee"—Southwark-Harris valveless engine—Exponent m, expansion line, internal combustion engines—Gas producer air-steam ratio—Heat treatment of modern steels—Ghost lines in large steel forgings—Segregation and sponginess in ladle test ingots—Physical properties of hydraulically forged wrought iron and steel—High grade alloy steel at low cost—Carbon and physical properties of heat treated carbon steel—Plate fulcrum track scale—Gunite timber piles in tropical waters—Apparatus for measuring velocity of gases—Measurement of coefficient of cyclic variation—Power requirements for wire drawing—Engineering charts—Crankshafts for high-speed engines—Flow of superheated ammonia through orifices—Safety valve for ammonia compressors—Reversed heat engine as drying machine—Loss of heat from steam heated surfaces—Letters of James Watt—Artificial arm.

In 1912 was established a section of The Journal called at that time the Foreign Review. It included abstracts, at first quite brief and then somewhat longer, of articles in engineering periodicals printed in foreign languages only. In 1914 this activity of the Society, which from the start, if one may judge from letters received, met with the approval of the membership, was extended by the addition of a review of the proceedings of engineering societies. Finally, at a meeting of the Council on October 8, 1915, it was voted to approve the recommendation of the Publication Committee to include in The Journal a review of the world's technical press. In accordance with this resolution, the Engineering Survey will contain, in addition to the material as hitherto published, abstracts from engineering publications in the English language. This feature will be developed gradually, beginning with the publication of a few abstracts in each issue selected with a view to placing on record the more important developments in mechanical engineering. It is the desire to arrive finally at a publication which would cover the field of mechanical engineering as completely as may be desirable for all practical purposes. A new feature to which attention is called is a list of the more important engineering articles published at the end of the Engineering Survey. The Library receives now close to 1000 publications in more than a dozen languages, and an attempt will be made to keep this list as up-to-date as possible and as complete as the space available will permit.

THIS MONTH'S ARTICLES

In the section, Aeronautics, is described the Wadkin Propeller Shaping Machine, really a copying machine having some peculiar features of its own.

In the next section, Air Engineering, is given an abstract of a discussion of Phenomena Accompanying the Flow of Air in Round Ducts, containing among other things some data of interest in connection with test of fans by means of Pitot tubes.

The section on Internal Combustion Engineering is of particular interest. It contains a reference to a Swedish type Diesel engine built in this country; a description of the propelling machinery for the U. S. S. Maumee, and of the Southwark-Harris valveless engine, the latter a very interesting type in many respects. A discussion of the Determination of the Exponent in the Equation for the Expansion Line of Internal Combustion Motors is abstracted from a German periodical. In the same section is abstracted an article on the maintenance of exact proportions between draft and steam admitted under a producer grate, as well as losses from incorrect driving.

In the section on Materials on Construction will be found an abstract from an advance publication of a paper by Prof. J. O. Arnold on The Cause and Effect of Ghost Lines in Large Steel Forgings, of particular interest because the author has had a somewhat unusual opportunity to ascertain the exact nature of unforged ghosts. Another paper on the Segregation and Sponginess in Ladle Test Ingots abstracted from the Bulletin of the American Railway Engineering Association is of interest in that it shows why test ingots taken from the same batch may give entirely misleading results, and next in that it recommends additions to rail specifications covering shape and size for ladle test ingots as well as standardizing the methods of taking them. The Influence of Temperature and Mechanical Work in Hydraulic Forging on the Physical Properties of Wrought Iron and Steel is discussed in a paper by Dr. Fuchs abstracted from a German publication. A rather unexpected fact found during the tests described in that paper is that the force and work required for forging, instead of gradually decreasing with the increase of temperature of forging, increases at first and does not begin to decrease until about 850 deg. cent. A development of high grade alloy steel at low cost, the chemical and mechanical relations of the carbides of iron and molybdenum and gunite coated piles for use in tropical waters, are some of the other articles abstracted in the same section.

In the section on Measuring Apparatus is continued from the December issue an abstract on apparatus for measuring the velocity and pressure of gases. There is also given an abstract of a description of a Plate Fulcrum Track Scale, a type representing in several respects a radical departure from the usual design of track scales.

In the section Mechanics attention is called to the article by Prof. J. von Rohonyi concerning the measurements of the coefficients of cyclic variation in the motion of prime movers. Other articles in the same section are a critical consideration of the factors affecting power requirement to be met in the manufacture of wire in drawing rods; a mathematical discussion of the apparent vagaries of performances of screw propellers on ships in actual service, and a reference to the Horseless Age engineering charts. The beginning of the abstract of a paper by P. M. Heldt on the Design of Crank Shafts for High Speed Engines is also given.

In the section on Refrigeration are abstracted from the Journal of the American Society of Refrigerating Engineers two articles, one on the Flow of Superheated Ammonia Through Orifices, giving among other things two plots from which, knowing the head pressure and the degree of superheat, the volume of a pound of superheated ammonia at the condition in the orifice can be read. The other article describes an improved ammonia safety valve.

The Loss of Heat from Steam Heated Orifices, and the Reverse Heat Engine as a Drying Machine are discussed in the section on Thermodynamics.

Aeronautics

The Wadkin Propeller Shaping Machine.

It is a curious fact that the particular part of the mechanism of an aeroplane in which the very highest finish and the utmost possible delicacy are required, should have been carried out purely by hand and left to the touch of individual workmen as has hitherto been the case in regard to aeroplane propellers. This anomaly may have been due to the varying nature in grain, hardness and specific gravity of the timber employed for this purpose. Still, where quickness of output is essential and the article is strictly standardized, great advantage might be derived from the use of mechanical propeller shaping machinery. Such a tool has been placed on the market in England by Wadkin & Co. (Fig. 1).

The machine will handle propellers up to 12 ft. diameter and will produce an exact fac-simile of the original placed into the machine. This "original" consists of a single blade only, together with the hub, which is mounted on a mandrel in a horizontal plane opposite to a carriage arranged to slide longitudinally on a bedplate. This carriage is adapted to support two pivoted arms, the lower of which carries the original roller, and the top one, the cutterblock mounted on a reciprocating headstock. At their opposite ends, the two pivoted arms are connected by a link which is adjustable to enable the size of reproduction to be varied if desired. The headstock supporting the two arms is reciprocated across the bed by means of a crank motion so that the cutters will traverse across the work. As each end of the stroke is reached, the carriage is moved longitudinally ⅛ in. so that cutting takes place both on the forward and backward stroke across the work, thus saving considerable time. The cutterblock is fitted with 12 cutters, six on the front and six on the back. The drive is by means of a flat endless belt running over a two-step pulley mounted on ball-bearings and carried by a bracket fixed to the sliding headstock.

The "original" consists of one blade and the hub portion and is made preferably of cast iron, identical in shape with the blade to be formed, thus enabling existing gages and templates to be used to insure accuracy of the original. It is essential that the shape of the blade should be kept accurately along its longitudinal edges, so that means must be provided to prevent the original roller from falling abruptly. A few holes should be drilled and tapped along the edges of the original to permit of screwing to it a wooden guide shaped to enable the roller to run down a slight incline. When one side of the blade has been cut, it is only necessary to reverse the work and also the original in its supports.

The feature of the machine is that an old broken propeller may be used as the "original" and an exact duplicate made from it. (*Aeronautics,* vol. 9, no. 108 (new series), p. 315, November 10, 1915, 2 pp., 2 figs. *d*).

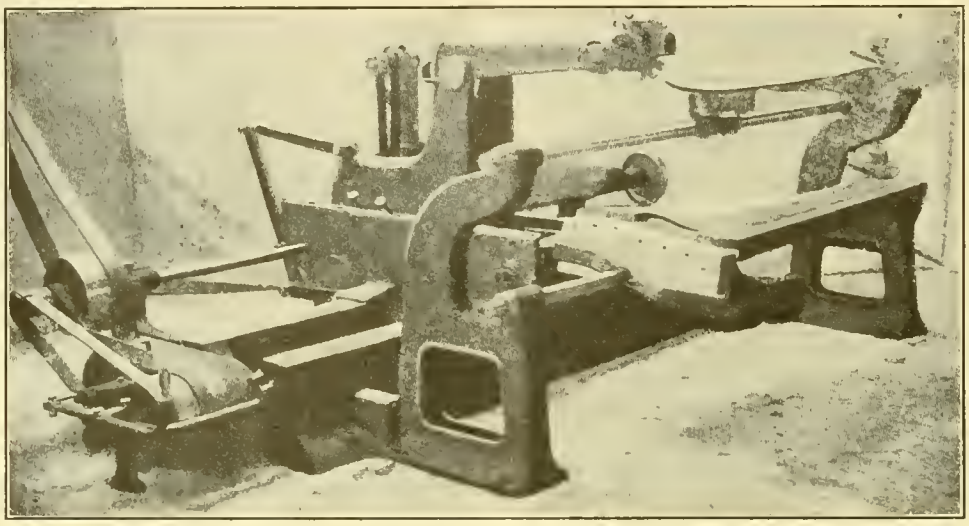

Fig. 1 Wadkin Propeller-Shaping Machine

Air Engineering

Some Peculiarities of Air Flowing in Round Ducts

Prof. J. E. Emswiler

Discussion of phenomena accompanying the flow of air in round ducts.

The author begins by a discussion of the distribution of velocity across the section of pipe. The assumption that the air is moving fastest near the center and slowest at the perimeter is true only for a section of the pipe located at a considerable distance from the fan, or from an elbow, or any source of disturbance of the stream line flow. In other words, the condition of high center velocity prevails when the flow is relatively quiet, but at the section very near the fan, it is found that the velocity at the center is nearly equal to that along the walls, while the maximum velocity occurs between the center and walls. Tests made in the mechanical laboratories of the University of Michigan with a very long pipe (100 feet long) showed that maximum divergence between the center and wall velocity occurred at the greatest distance from the fan.

Connected with this difference in velocity distribution across the pipe at different distances from the fan is the effect on the frictional resistance. Tests in the University laboratories have shown that if observations are made at three points along the length of a long straight pipe, one near the fan, one near the end of the pipe, and the third midway between the first two, the frictional resistance of the first section is appreciably higher than it is in the second section. The reason for this difference most likely lies in the velocity distribution in the tube sections, as the frictional resistance of air moving in a pipe is due to two causes; *first,* the friction of the air against the walls of the passageway, and, *second,* the friction of the particles of air sliding or rolling upon each other, which latter is due to the fact that all the particles do not

move at one speed. Of the two causes of loss the first is the greater. The *average* velocity of the air is the same at all points along the pipe but the average velocity of the air which comes in contact with the perimeter of the pipe is greater near the fan because of cross currents; hence, the pipe friction proper is greater in that part of the pipe near the fan.

The flow of air in a duct is not symmetrical, as the maximum velocity may be considerably greater on one side of the pipe than on the other; in fact, the place of maximum velocity in a pipe may travel in a screw path along its length. Ultimately this corkscrew motion will die down, but within the limits of the length of the customary test pipe which is about twenty diameters, such a movement of the air is nearly always present; hence to obtain accurate data for the calculation of average velocity, it is necessary to traverse the pipe on two diameters at right angles.

When a fan is tested by means of a Pitot tube placed in a test pipe the tube should be located about five-eighths of the distance from the fan to the end of the test pipe. The static pressure is then a measure of the friction in the test pipe lying beyond, and it might be thought that this would furnish a comparatively easy means of determining the friction coefficient of pipes. Actually this is not quite so. The total friction effect of a section of pipe discharging freely into the air is made up of two parts: *first*, the normal friction of flow within the pipe, and *second*, the exit loss at the point of escape. The latter may be small for a pipe whose discharge end is perfectly smooth, but the least little obstruction around the edge seems to cause an abnormal increase in loss (a similar or much larger obstruction placed much further back in the pipe has far less influence on the friction loss).

The following tests were made to illustrate the foregoing statements: Air was delivered through a 7 in. test pipe by a small Buffalo blower operated at constant speed. The Pitot tube was located above five-eighths the length of the pipe from the fan. With no obstruction at the end of the pipe a certain static pressure was observed. Then a screw-driver with a wooden handle about 1¼ in. in diameter was laid in the pipe 18 in. from the end. This obstruction increased the static pressure at the Pitot tube 15 per cent. Then a ruler ⅝ in. wide was placed diametrically across the pipe, first entirely across, and then extending partially across by varying amounts; the effect was to increase the static pressure above that when the exit was unobstructed, to the extent of from 10 per cent, when the percentage of obstruction was 0.4 per cent, to 200 per cent, when the percentage of obstruction rose to 11.3 per cent, which shows that an obstruction at the end produces a vastly greater loss than one placed in the pipe some distance from the end. (*The Michigan Technic*, vol. 28, no. 3, p. 204, October 1915, 3 pp., *et.*)

Internal Combustion Engines

Swedish Type Diesel Engine.

The article briefly describes and illustrates the Diesel engine manufactured by the McIntosh & Seymour Corporation of Auburn, N. Y. This Diesel engine is essentially that of the Aktiebolaget Diesels Motorer, Stockholm, Sweden (*The Iron Trade Review*, vol. 57, no. 21, p. 988, November 18, 1915, 1 p., 2 figs. *d*).

Description of Main Propelling Machinery for the U. S. S. Maumee, Lieutenant C. W. Nimitz, U.S.N.

The article describes the main propelling machinery for the U. S. S. Maumee (which was inspected on one of the excursions of the members of The American Society of Mechanical Engineers at the Annual Meeting, December, 1915). The U. S. S. Maumee is one of the twin-screw fuel ships authorized by the Naval Appropriation Act of August 22, 1915 (her sister ship is the *Kanawha*).

The Maumee has as propelling machinery two Diesel engines of 2500 b.h.p. each. Each main engine, which is built to turn outboard when going ahead, drives the following attached auxiliaries (described in the paper): Three high pressure air compressors for fuel injection and for charging air-starting bottles; three scavenger compressors for cylinder scavenging; two salt-water pumps for cooling all water jacketed parts of engine except pistons; one fresh-water pump for piston cooling; one lubricating oil pump for thrust block, main, crank pin and cross-head bearing lubrication; two general service water pumps for fire, bilge or sanitary purposes; twelve mechanical lubricators for cylinders and for minor bearing lubrication; one fuel oil supply pump for pumping fuel from ship's bunker tank to engine supply tanks; six fuel oil measuring pumps for supplying fuel to cylinders from engine room tanks; one speed governor; one tachometer; and one revolution counter.

For purposes of starting, compressed air at about 650 lb. per sq. in. from the air-starting bottles is led to those cylinders whose cranks are in the proper position for running in the desired direction. After the engine starts to run, starting air is admitted to each cylinder from 10 deg. past top center to 85 deg. past top center, until the engine has obtained sufficient speed for fuel admission. This speed is usually obtained in a very few revolutions. The operation of the reversal consists merely in cutting off all fuel from the engine, which causes it to stop very quickly and then to start in the reverse direction by compressed air as described above. (*Journal of the American Society of Naval Engineers*, vol. 27, no. 4, p. 794, November 1915, 27 pp., 5 figs. *d*).

Southwark-Harris Valveless Engine

One of the weak points in existing Diesel engines is that ice cold air is admitted at high pressure into the hot working cylinders to reverse or start up. Air stored in bottles or tanks at 600 to 1000 lb. per sq. in., when expanded through a valve, drops in temperature below the freezing point and its entering a cylinder heated to a high degree may be the cause of cracked cylinders, cylinder heads, and pistons. This is especially true in the case of marine engines when a vessel is coming into port after perhaps several hours or even days of continuous running in one direction with its cylinders and pistons heated to a high degree. To berth this vessel at the wharf possibly ten or fifteen orders may be rung down to the engine room in as many minutes. To carry out each of these orders, the engine is turned for a few seconds with this ice cold air and the next second after it is cut off, the contents of the cylinders are expected to be heated up over 1000 deg. This sets up very severe expansions and contractions, and may easily cause trouble.

The Southwark-Harris valveless engine is so designed as to never admit cold high pressure air into the working cylinders. It has a scavenging pump or low pressure compressor of the step piston type, that is, the piston of the scavenging pump is an enlarged extension of the main piston working in its own cylinder below the working cylinder. The scavenging cylinders are utilized for starting purposes, becoming immediately converted into air motors on movement of the starting lever either ahead or astern by the automatic cutting out of the suction and delivery valves. The air starting valves come automatic-

ally into play with the camshaft and keep the engine running by the action of the compressed air on the step pistons instead of on the main pistons. By continued movement of the handling lever the atomizer begins to open and the fuel commences to be supplied to the working cylinders, the engine still running, however, on compressed air in the scavenging cylinder without affecting the working conditions in the main cylinder, and thereby avoiding admission of the usual high pressure air into the working cylinder just at the time when it is necessary to build up the temperature.

Another peculiarity of the Southwark-Harris engine is that it has no valves in its cylinder heads. Each cylinder has only one cam working (the atomizer cam) when the engine is running in either direction. The use of the step piston for air starting does away with the necessity of air starting valves in the cylinder heads. The scavenging air is admitted to the working cylinder through ports in its circumference. The exhaust gases pass out through ports located opposite the scavenging ports and are so arranged that the piston opens and shuts them at the correct time during its travel. There remains, therefore, only one small opening to be provided for in the cylinder head for the admission of oil from the atomizer.

One of the disadvantages of the ordinary trunk piston type of Diesel engine is that it is necessary to give the pistons considerable clearance between the piston and the walls of the cylinder on account of the expansion of the pistons which is especially true in the case of a two-stroke cycle engine. This excessive clearance causes the piston in a trunk type of engine to take the side thrust of the connecting rod, which sets up a side flogging with its consequent noise. In the Southwark-Harris engine, this difficulty is avoided by the use of the step piston, the wrist pin being comparatively cool in the step or lower piston which practically does not expand; therefore, it can be made a nice fit in the lower cylinder and acts as a circular crosshead guide for the main piston. The main pistons can have ample clearance between themselves and the walls of the cylinder and let the rings do the work they are there for.

Another advantage of these step pistons when acting as scavenging pumps is that they draw in upon themselves and around the working piston on its outgoing stroke, a charge of atmospheric air for scavenging purposes. This air helps to cool the working pistons, and being in itself thus slightly heated, when the scavenging air enters the working cylinders, it is never as cold as is the case with four cycle engines. In the Southwark-Harris engine, it is possible to take off the inlet valves of the scavenging pump entirely, and owing to the peculiar design of the engine, it will still continue to run. Thus, if the inlet valves were to break down at sea it would not prevent the ship from working into port.

The Southwark-Harris valveless engine governs on a special and variable stroke principle controlled by the governor. Once the line is clear of air, there is always a solid stream of oil from the service tanks to the atomizers and the slightest movement of the pump plunger produces a corresponding movement of the column of oil so that if the stroke is increased by the governor, a corresponding additional amount of oil will be supplied. The oil is delivered from the service tank to the pumps under pressure supplied by the engine, making it immaterial where the service tank is located. As a result of such an arrangement the engine can be started in five seconds after having stood idle for a week or more. In fact, it will start under load like a steam engine.

The air under pressure, when allowed to act on the step pistons will turn the engine over even with its load on, so long as the engineer desires to do so, and after the momentum of the engine is built up, the oil can be given to the main cylinders, still, however, allowing the air to act on the step pistons. This in no way affects the working condition in the main cylinder which is of importance for locomotives of interurban car service and especially in vessels, as it causes the ship to respond more quickly and with more certainty in a case of reversing from full speed ahead to full speed astern or vice versa.

The reversal of the Diesel engine by movement of the cam shaft on end requires considerable power to compress all the valve springs; in the new engine reversing is done by moving one rod on each cylinder so that however large the engine might be, practically no power is required. In fact, the Southwark-Harris engine is only of the Diesel type in its principle, the details of the engine being of an apparently novel design. (*Steamship*, vol. 27, no. 317, p. 109, November 1915, 5 pp., 1 fig. *d*).

Concerning the Exponent m in the Equation for the Expansion Line of Internal Combustion Engines

Dr.-Eng. Münzinger.

The experimental determination of the exponent m of the expansion line of internal combustion motors can be carried out best on a Diesel engine, because, due to the fact that the pressure variations occur in it in a more uniform manner than in other gas engines, observations suffer less from interference due to oscillations of the indicator. In the present investigation, which has been carried out in the Machine Design Laboratory of the Technical High School in Berlin, Dr. Münzinger used a 15 h.p. Diesel engine built by the Augsburg-Nurnberg Machine Works, and the Maihak indicator which is only slightly affected by frictional and mass forces, the purpose of the investigation being to determine the law of functional dependence of the exponent m on temperature.

From the usual equation of the expansion line, $p_1 v_1^m = p_2 v_2^m$ where p_1 and p_2 are specific pressures and v_1 and v_2, specific volumes, by the use of logarithms, the following expression is obtained for m: $m = \dfrac{\log p_1 - \log p_2}{\log v_2 - \log v_1}$

If, therefore, at a point of an expansion curve plotted on the logarithmic scale, a tangent is drawn, m can be determined by the tangent of the angle between the volume-axis and the tangent drawn. The magnitude of m is affected by the chemical composition and temperature of the mixture. The exponent of the adiabatic line is known to be $k = c_p/c_v$, where c_p is the specific heat at equal volume. For all gases, $c_p = c_v + 1.985/m$ and hence $k = 1 + 1.985/mc_v$ where m is the molecular weight. According to Langen, the following equation holds for carbon dioxide: $(mc_v)_m = 6.7 + 0.0026t$ where t is the temperature of the gas. Likewise, Pier found for steam $(mc_v)_m = 6.065 + 0.0005t + \frac{0.2}{10^9} t^3$ while for biatomic gases holds the equation $mc_v = 4.88 + 0.00106t$.

The value of the exponent is therefore affected by the conditions of carbon dioxide and steam, as well as by increase in temperature. Hence, the exponent m is smaller at the beginning of the expansion than at the end of the stroke. The cooling action of the cylinder walls has, as a result, the effect that the expansion line goes down more rapidly than the adiabatic line. It may be taken as established that the amount of heat conducted away per unit of time is proportional to the active area and is a function of the temperature difference between the walls of the cylinder and the gas. The coefficient of heat transmission, in its turn, depends on the density, the

state of motion, the temperature and the space distribution of the gas with respect to the surfaces of the walls. A good intermixture of the charge is, for example, very desirable from the point of view of perfect combustion, but comparatively poor when it comes to the carrying off of the heat. The piston velocity likewise affects the cooling action of the cylinder walls, since upon it depends the amount of time available for purposes of heat exchange. Finally, the expansion curve is made flat through after-burning of the charge. In Fig. 2A there are plotted over the pv diagram the values of m, as functions of the various positions of the piston. The gas temperatures are then determined for the various points of the diagram and

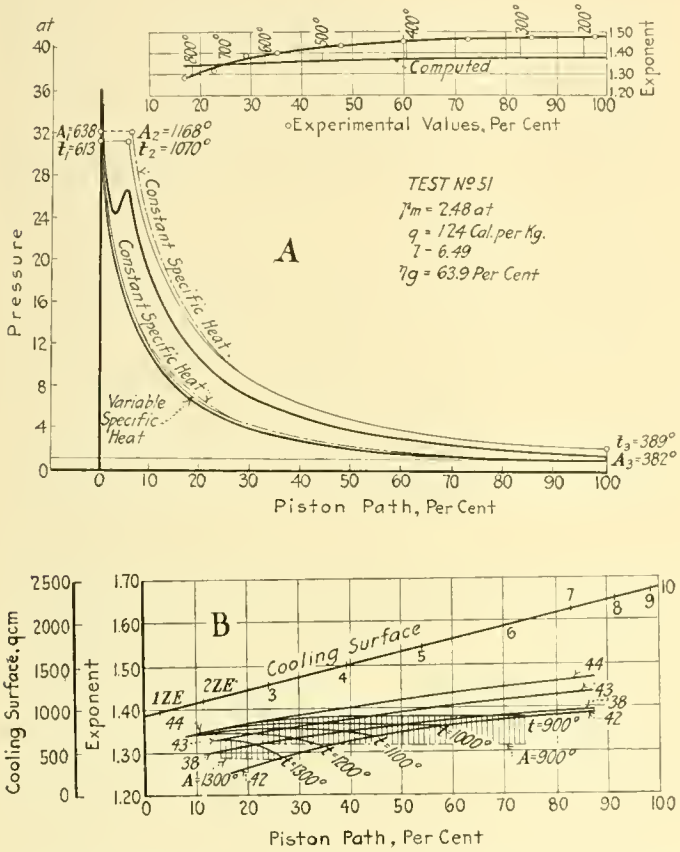

Fig. 2 Determination of the Exponent m in the Equation for the Expansion Line of Internal Combustion Engines

are calculated for these points under the assumption that no exchange of heat takes place. The values obtained are likewise placed on the diagram so that the influence of the walls and the after-burning can be seen from the difference between the exponents calculated and those obtained from the diagram.

One can see that the curves thus obtained intersect at low load; then form a flatter angle so that they run nearly parallel to each other, and finally when the load increases still more, intersect again. With average loads, the mv curve is nearly a straight line. In the extreme cases, it curves at the beginning of expansion and approaches the shape of a parabola. As the piston moves on and the cooling surfaces increase, the difference between m and k increases. In Fig. B are collected values of m from tests in which the m and k curves did not intersect. At high indicated pressures the curves thus obtained lie lower than at low pressures. The curves of equal temperatures, plotted in the same figure, run, for average temperatures, nearly parallel to the abscissae. If now the k curves be plotted for 900 deg. cent. and 1300 deg. cent. (1652 and 2372 deg. fahr.) it will be seen that at the lower temperatures the difference between m and k increases with the increase of the cooling surface and attains its maximum at 45 per cent of the piston stroke. On the other hand, at 1300 deg. cent. the m and k curves approach each other with the progress of the piston stroke because of the after-burning. In tests in which the efficiency approached the maximum, the curve for m was nearly a straight line. If at the beginning of the expansion, the curve of exponents approaches the shape of the parabola, the efficiency goes down, especially if at the same time there was a continuation of combustion during the expansion period. (*Die Ermittlung des Exponenten m der Expansionslinie von Verbrennungsmotoren*, Dr.-Ing. Münzinger, *Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 174, and *Dinglers polytechnisches Journal*, vol. 330, no. 22, p. 433, October 30, 1915. *e*).

Maintaining Gas-Producer Air-Steam Ratio, Franz Denk

The article discusses the importance of maintaining exact proportions between draft and steam admitted under a producer grate as well as losses from incorrect driving.

In particular, it discusses the methods applied for blowing air and steam into the producer. The main objection to using jet blowers is to be found in the irregular working of this apparatus because steam and air often cannot be blown in the fixed proportion required for the economical work of the producer, as sometimes, if enough steam is blown, the air is deficient and if enough air is forced in, it can be done only by blowing too much steam.

The author gives two curves (Fig. 3), showing the connection between the amount of air and steam blown, from tests made on the Koerting blower and the Eynon Evance blower. These curves show that if the necessary amount of steam is blown, the deficiency of air amounts to 25 per cent. At a steam pressure of 25.5 lb. there is enough steam, but an air deficiency of 19.5 per cent, while at a steam pressure of 40.5 lb. there is enough air but a steam excess of 28.8 per cent. These conditions are due partly to the variation of the back pressure and also to the fact that not enough attention is paid to the quality of the steam, notwithstanding the fact that the blower is an apparatus designed for dry saturated steam. There is a great difference in the velocity of steam and water flowing from nozzles under equal pressure, and the more water the mixture of both contains the less will be its velocity. When steam leaves the nozzle with 25 per cent moisture, the loss in velocity amounts to 13.6 per cent.

Superheated steam is blown partly to insure the proper quality of the steam and also to prevent the loss in coal due to having to convert the moisture in the wet steam into dry steam. The possible objection that the cost of installing a superheater may counterbalance the advantages in savings due to the use of the superheated steam is hardly valid, as steam can be superheated by the gas leaving the producer by passing the steam through one or two pipe coils hung in the downcomer. The steam takes up heat from the gas and becomes superheated without a material cooling of the gas proper. As the author shows, for a plant with 60 producers such an installation would cost only about $90.00 against which there is a saving of $1740.

The author comes to the conclusion that as ordinary steam blowers are not particularly suitable for gas producers to make a good gas in an economical way, the best solution of the problem is to blow the steam and air in separately. (*The Blast Furnace and Steel Plant*, p. 1039, December 1, 1915, 3 pp., 1 fig. *p*.)

Materials of Construction

Heat Treatment of Modern Steels, Robert R. Abbott.

The article discusses the heat treatment of modern steels, defining heat treatment in its broadest sense as the transformation of an alloy from a mechanical mixture of two substances into a homogeneous solution of a single substance. The article is illustrated by several micro-photographs showing the constituent parts of steel such as troostite, martensite, etc. (*The Iron Trade Review*, vol. 57, no. 21, p. 981, November 18, 1915, 6 pp., 21 figs. Cp. also The Journal, May 1915, p. 267. *g*).

The Cause and Effect of Ghost Lines in Large Steel Forgings, Prof. J. O. Arnold.

The paper gives an account of various investigations conducted during the past 20 years by the author, on the phenomena of ghosts in forgings of very large steel ingots ranging from 40 to 80 tons in weight. By ghosts or ghost lines are meant in this connection, parts of the ingot having

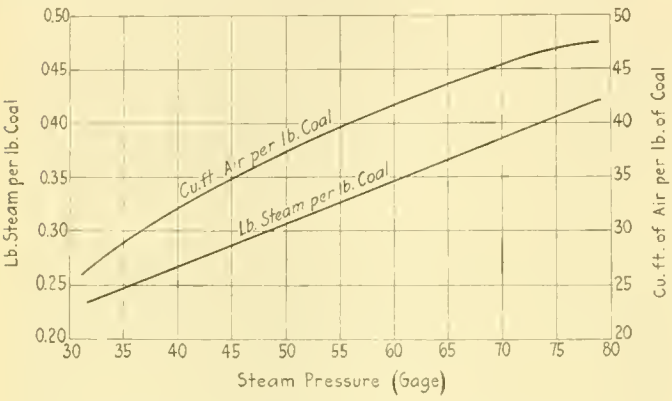

Fig. 3 Curves Showing the Connection between the Amounts of Air and Steam Blown into Gas Producers

a slightly different color from the rest of the metal. During the turning operations, these ghost lines usually show up quite plainly and in slight relief against the steel gray color of the mass, and by the means of a fine, sharp engraver's tool, they may be dug out and analyzed along with portions free from ghost lines. Analysis of the two give the following:

	Portions of forgings showing ghosts. Per cent	Portions of forgings ghost-free. Per cent
Carbon	0.380	0.320
Silicon	0.310	0.080
Manganese	0.920	0.680
Sulphur	0.045	0.020
Phosphorus	0.050	0.035

This shows an apparent segregation of all the five elements, although it is known now that the elements showing true segregation are carbon, sulphur and phosphorus, many large ghosts being almost free of silicates. From carefully carried out mechanical tests of stresses, tensile, torsional and alternating, the conclusion is drawn that ghost lines are little detrimental to the mechanical properties of structural steel so long as the plane of stress is at right angles to the direction of the ghost lines; in other words, when the material is in tension, torsion or under alternating stresses.

Comparatively recently, the author had the opportunity to ascertain the exact nature of unforged ghosts, some of which were 5/8 in. in diameter and 9 in. long, there being about fifty in the casting head. The casting of a mild steel chrome-nickel ingot, about 57 tons in weight, was just completed when a burst-out occurred at the bottom. This was stopped in about two minutes, but in that time the ingot was hollow for about 21 in. down, having "bled" about 17 tons of steel. On cutting off the hollow portion of the ingot and then cutting this longitudinally into four pieces, an extraordinary discovery was made, viz., in each octagonal angle was found a series of protruding frozen ghosts. With so much material available, it was easy to make an extensive chemical and microscopic examination, as some of the ghosts were protruding to an extent of 3/8 in. The surfaces of the steel free from ghosts showed decisive projecting ingots of octahedral crystals. The ghosts seem to have caught on the angle where the body of the ingot turns upward to the feeding head, seeming to have been mechanically trapped on what may be termed a series of metallurgical futtock shrouds.

While it has been the generally accepted dogma that ghosts, being higher in carbon, sulphur and phosphorus than the main mass of steel, necessarily freeze last, the present research shows that the ghosts freeze first at many degrees above the main mass freezing point.

The author and G. R. Bolsover have previously shown the existence of a definite solution or compound of iron and sulphide of manganese, which appeared to freeze before the main mass of the ingot, and on cooling, broke up into a mixture of iron and dots of sulphide of manganese. The composition of this mixture was tentatively suggested as 88 per cent iron and 12 per cent sulphide of manganese. Such a composition would be possessed of a relatively low specific gravity and would tend to rise through the still unfrozen main mass of steel. The author suggests that as this definite substance rises in a thick pasty or semi-frozen state, it forms in different parts of the ingot nuclei which gather to themselves the migratory particles of steel, viz., the carbon, phosphorus and in nickel steels, the nickelide of iron. (Paper read before the Institution of Mechanical Engineers, November 19, 1915, abstracted from preliminary publication, C).

Segregation and Sponginess in Ladle Test Ingots, Robert W. Hunt & Co.

In a recent case, where it was desired to have a check for the manufacturer's chemical analysis of each heat represented by a batch of open hearth steel rails, the result of the analyses of the inspectors differed so widely from those reported by the mills that it was finally deemed advisable to make some investigation of matters pertaining to ladle test ingots, and principally to the possibility of their segregation and soundness. From the outset, it has become clear that ladle test ingots were subject to unsoundness and segregation exactly as are all large ingots, the only difference being one of degree. Of particular importance is the fact that when the ladle test ingot is segregated and unsound, the drillings taken from it may not be representative of the steel or heat as a whole and the reported results will be misleading and untrue.

At the mill at which the tests were made, the ladle test ingot mold was about 2½ in. square at the top, 2 in. square at the bottom and 5 in. high. When the ingots were drilled, many cavities were encountered. The analysis of the drillings taken from the various parts of the ingot showed that the outside portions of the ingots differed from those near the inside, and different locations of the drillings with respect to the height practically always gave different results. The degree of porosity is apparently somewhat greater in the

ingot from the first part of the heat than that from the last and further addition of the dioxidizing agent, ferro-silica, experimented with in one case, made that ingot absolutely sound for the greater part of its height. In this connection, the article shows an interesting collection of diagrams of various ladle test ingots adopted by prominent rail manufacturers in this country.

Soundness or freedom from blowholes, etc., is a very important feature for ladle test ingots to possess, as the more unsound one is, the more it is inclined to be segregated and also in drilling steel that is full of blowholes, minute particles break off from the sides of the holes and render a chemical determination for carbon by combustion methods more difficult of accuracy than one for which flake-like drillings are furnished. The authors arrive at the following general conclusion: That while the soundness of the test ingot is not predicted by its shape, this slab-like shape is preferable because of its tendency to chill quickly and thus solidify with the minimum amount of segregation; the disadvantage of this shape of test ingot lays principally in the difficulty of obtaining sufficient drillings for the requisite number of analyses.

The writers recommend, therefore, as additions to rail specifications, the following: *First*, a standard shape and size for ladle test ingots with directions as to the size of drilling and location of the borings on which the analysis is made; *second*, the addition of aluminum, preferably in the dipper, when necessary, to insure a sound setting steel in the ladle test ingots with freedom from blowholes. (*Bulletin of the American Railway Engineering Association*, vol. 17, no. 179, p. 27, September 1915, 8 pp., 9 figs. *e*.)

Influence of Temperature and Mechanical Working in Hydraulic Forging on the Physical Properties of Wrought Iron and Steel, Dr. Otto Fuchs

The tests referred to in this article were made by Committee V of the Austrian Association for the Testing of Engineering Materials, and had for their purpose to establish what influence temperature and mechanical work in forging, drawing and rolling of wrought iron and steel had on the mechanical properties of the latter. The article describes in a general manner the method of testing adopted in this connection and gives data obtained in the form of curves.

In the first place, it was desired to investigate how the force applied and the work necessary to change the shape of the material vary with the temperature at which it is forged. From previous experience, it was expected that with increase of temperature, the force and work required would gradually decrease, but the curves obtained showed that such lowering of the curve of power consumption begins only at about 850 deg. cent. (1562 deg. fahr.), but previous to that it increases with the increase of temperature of forging. The author ascribes this phenomenon to allotropic transformations in the iron.

In order to obtain an insight into the relation between the pressure temperature curves (Fig. 1) and the points of transformation Ar_2 and Ar_3, the latter have been determined by the differential process of Roberts-Austen, and it was found that each rise of the line is located within the region of transformation of the iron. Through the segregation of the crystals of the β iron from the solid solution (that is at point Ar_3) the alloy becomes softer, which lasts until the β iron is transformed into α iron. In the case of iron-carbon alloys, where Ar_3 and Ar_2 coincide and in general in alloys containing more than 0.5 per cent of carbon, there is observable a certain unsteadiness in the consumption of power. It must be observed, however, that with the apparatus available, it was generally difficult to obtain a reliable work (or pressure)-temperature curve, since it was hardly possible to carry out the jumping of the metal at the instant of transformation. Therefore the curves *c* and *d*, corresponding to a material in which, notwithstanding the presence of only 0.2 per cent of carbon, the formation of the β iron in the cooling test could not be clearly established, showed a considerable uncertainty in shape. Hence no attempt was made for the region of critical temperatures to connect the experimental values denoted by a smooth curve. It appears to be likely that, as with the increase in carbon content the points Ar_2 and Ar_3 approach each other, the temperature periods within which the above described softening occurs will also become smaller, with the result that within that region the consumption of power will undergo a sudden alteration.

Since in the material treated in the tests we have a case of constrained state, it appeared in the light of previous experience with constituents either unstable or metastable at room

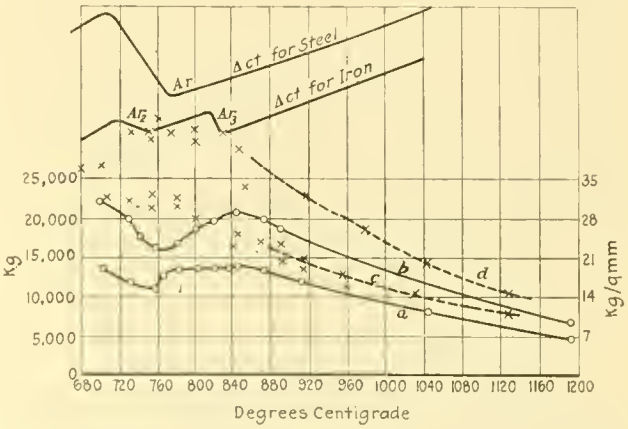

Fig. 4 Pressure-Temperature Curves for Wrought Iron and Steel

a, jumping of iron, 10 per cent; *b*, same, 20 per cent; *c*, same for steel, 10 per cent; *d*, same for steel, 20 per cent. *ct*, lines for the critical points. Abscissae, temperatures; ordinates, differences of thermo-electric forces.

temperature (martensite, osmondite, troostite and sorbite), to be important to determine whether the usual constitution of the metal would appear through heating to a temperature beyond the critical range. It appeared that this did not happen in the case of a short heating to a temperature of 1000 deg. cent. (1832 deg. fahr.), but after a two hours' heating, up to 1200 deg. cent. (2192 deg. fahr.), and then a slow cooling, the grained structure reappeared with perfect clearness, the grains of ferrite being considerably larger than before.

The influence of the temperature of forging on the grain structure, which was observed with soft and hard material, led to the expectation that there would also be observed a difference in the physical and mechanical properties. Hence the materials were also tested for hardness and it was found that material upset within a critical range of temperatures was softer than that worked at temperatures either above or below the critical range. This might have been expected since within that range the material is more plastic and therefore a special softness was likely to appear in worked material, even after cooling.

The dependence of the structure of the material on the temperature of forging might be explained in the following manner: The test pieces were heated in a similar manner up to the maximum temperature obtainable in the muffle oven, which is somewhere around 1200 deg. cent. (2192 deg. fahr). The

size of grain, which tends to grow in all specimens, must, according to Heyn, be the same for all of them at the time when they are taken from the furnace; then all the test pieces were also cooled in a similar manner with that single essential difference that at various temperatures during the period of cooling they underwent a certain amount of mechanical work. The structure which can be seen in the iron under a microscope is that due to the transformations which occur in the region of temperatures between 900 and 780 deg. cent. (1652 and 1436 deg. fahr.) and is not at all the structure of solidification since the latter is covered over by the new grain formation produced by recrystallization. The small grain structure is, therefore, determined by the fact of how far the recrystallization has been allowed to occur without outside interference. Provided the process of transformation occurred without outside interference the size of the grains will depend on the velocity with which this range of temperature has been gone through, the lower the velocity the larger the size of the crystals. The segregation or crystallization is possible only if the smallest parts of the alloy affected by the transformation have a sufficient mobility, and if the mobility in the region of temperatures between 900 and 780 deg. cent. was interfered with by the high pressure applied to the test piece the formation of the grains will be likewise more or less interfered with, and it is well worth attention that the structure formed when the grain growth was interfered with is noticeably lower in hardness. (*Der Einfluss von Temperatur und mechanischer Arbeit beim Pressschmieden von Flusseisen und Stahl,* Dr. tech. Otto Fuchs, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, No. 45, p. 915, November 6, 1915, 4 pp., 3 figs. *e.*)

A Development of a High Grade Alloy Steel at Low Cost, Lieutenant J. B. Rhodes, U.S.N.

Description of the manufacture and qualities of an alloy steel which has been found to furnish high grade castings and forgings at a comparatively low cost. No originality is claimed for this alloy but the writer believes that it has been regularly manufactured for use for the first time. It is also of interest because its production is largely based on the utilization of metal scraps which would otherwise be sold at a low price.

The problem was to find a steel which could be used for forgings when the latter are required to show the following minimum physical values in a transverse direction.

Torsional strength, 95,000 lb. per sq. in.
Proportional limit, 65,000 lb. per sq. in.
Elongation, 18 per cent.
Reduction of area 30 per cent.

The development of the present steel was based on the following considerations: First, it was believed that in order to obtain a steel of high physical properties with considerable ductility and good machining qualities, it is necessary to produce a pearlitic steel. Hence it was decided to limit the percentages of each hardening or toughening element and to increase the pearlite by the use of additional elements; namely, by adding copper and manganese to the usual nickel-steel alloy. It was further decided to limit the carbon to 0.35 per cent and manganese to 1.20 per cent or about 0.60 per cent higher than normal. It was found that nickel could be obtained in turnings from 3 per cent nickel-steel in sufficient quantity to give 1 per cent to 1.5 per cent in the steel, and nickel with copper could be obtained in the form of monel-metal scrap in turnings containing approximately 65 per cent nickel and 30 per cent copper.

The increase in manganese by 0.6 per cent or 6 lb. per 1,000 can be made by adding not more than 10 lb. per 1,000 of material, which in the form of 80 per cent ferro-manganese, costs about $0.06 per lb. for manganese, an increase of 60 cents per 1,000 lb. or $0.006 per lb. Nickel-steel turnings are worth about $10.00 a ton more than ordinary scrap (as based on sale of own scrap), which means that nickel in this form is obtained for $0.05 per lb. instead of $0.35 or $0.40 per lb. To obtain 1.0 per cent to 1.5 per cent nickel, 15 lb. per ton are added, at a cost of 75 cents per 1,000 lb., or $0.00075 per lb. To obtain 0.50-0.75 per cent copper, monel-metal scrap at $0.12 per lb. is added. Two per cent of monel-metal gives 0.70 per cent copper and 1.20 per cent nickel, at a cost of $2.40 per 1,000 lb., or $0.0024 per lb. The cost of these additions are as follows:

Manganese	$0.0006
Nickel	0.00075
Monel	0.0024
Total	$0.00375

So that for an increase of less than $0.004 per lb. we obtain a steel equal in properties to a 3 per cent nickel-steel. The composition of the steel may be taken to be as follows:

Carbon	0.30 per cent to 0.35 per cent
Silicon	0.25 per cent to 0.35 per cent
Phosphorus and sulphur.	not over 0.05 per cent
Manganese	1.00 to 1.20 per cent
Nickel	1.50 to 1.80 per cent
Copper	0.50 per cent to 0.80 per cent

which steel will show properties equal to those specified.

It is believed that the excess manganese prevents red shortness due to copper oxide by combining with any oxygen present in the bath. Castings are remarkably free from checks, cracks, blowholes and shrinks, and ingots are normal. (*Journal of the American Society of Naval Engineers,* vol. 27, no. 4, p. 911, November 1915, 5 pp., *dp*).

The Effect of Carbon on the Physical Properties of Heat-Treated Carbon Steel, J. H. Nead

Description of experiments undertaken with a view to investigating thoroughly the influence of carbon on the tensile and impact physical properties of carbon steel.

In the steels investigated the carbon content varied gradually from 0.14 to .46 per cent and the manganese content from 0.20 to 0.67 per cent. (It was thought that the variations in manganese content were not sufficiently great to disturb seriously the conclusions to be drawn as to the effect of the carbon).

The paper describes in detail the layout of heat treatment, and gives annealing and hardening temperatures used for each steel, the results of the tests being summarized in the form of tables and curves. Under the annealed condition, the maximum unit of strength reaches a maximum value at eutectoid composition, that is, 0.80 per cent carbon, and then decreases slightly with increasing carbon. With the heat treated steel, however, the falling off of the maximum strength does not begin until a composition of .20 per cent carbon is reached. The curves obtained show a rapid rise of tensile strength with increasing carbon to eutectoid composition; then a less rapid increase to 1.20 per cent carbon, followed generally by a slight falling off. The curves representing elongation and contraction generally show decreasing values with increasing carbon. (*Bulletin of the American Institute of Mining Engineers,* No. 108, p. 2341, December, 1915, 18 pp., 29 figs. *cA.*)

Carbides of Molybdenum, J. O. Arnold.

Paper on the chemical and mechanical relations of iron, molybdenum and carbon, representing an investigation of the method of manufacture, heat treatment and mechanical properties of molybdenum steels. It appears that at about 18.25 per cent molybdenum, free carbide of iron disappears and double carbide of iron and molybdenum is obtained, corresponding to the formula, $Fe_3 Mo_3 C$. (Constitutionally, the formula is $Fe_6 Mo_6 C_2$).

The conclusion from the paper is that one atom of carbon is about 2.28 times as powerful in producing hardenite in true ferro-molybdenum steel as it is in forming the hardenite in true tungsten steel, which roughly agrees with the estimation of practical Sheffield steel metallurgists to the effect that the steel hardening power of molybdenum is from two to three times as great as that of tungsten. Unfortunately, however, molybdenum is much more erratic in its behavior than tungsten, and the author calls attention to the very poor mechanical properties of molybdenum steels as compared with corresponding steels containing tungsten. High molybdenum steel, quenched at the proper hardening temperature, is very brittle and only a low percentage of molybdenum should be used, either alone or to replace about two and a half times its percentage of tungsten. Tungsten completely replaces carbide of iron when about 11.28 per cent is present; molybdenum when about 18.25 per cent, but molybdenum combines with a large proportion of the carbide of iron forming a very stable double carbide. Very high molybdenum seems to cause ferro-cementite to segregate more readily in annealed steel. Ferro-molybdenum hardenite also resembles that of vanadium in brittleness when quenched above its complete transformation temperature. (From abstract in the *Journal of the Institution of Mechanical Engineers* (London), No. 8, 1915. Complete paper not yet published).

Experience with Protected Timber Piles in Tropical Waters, at San Juan, Porto Rico, J. P. Carlin

The paper discusses the use of so-called "gunite" coated piles in tropical waters.

The gunite coating consists of wrapping an ordinary wooden pile for a distance to be exposed to the water, with wire mesh secured by staples. Upon this mesh reinforcement is placed a coating of cement mortar applied under air pressure and by means of a cement gun. In the experiments made by Lilley and Thurston, of San Francisco, the thickness of this coating, including the reinforcements, was about 1 in. to 1⅛ in., and it appeared that satisfactory results were obtained. The same type was used in the construction of the San Juan bulkhead in Porto Rico, but in that, two thicknesses of metal fabric were spirally wound about eight-¼ in. rods, held by a staple and running the length of the coated pile. The thickness of the gunite material was increased from 2½ to 3 in. A number of these coated piles were prepared, kept wet for several days and allowed to set for at least 30 days before driving. The condition of the ground was such that very severe driving was necessary and many of the piles were damaged, which finally made the method prohibitive and forced recourse to solid concrete piles. Among other things, the article describes a method of repairing damaged cement coated piles under water. The author believes that if some method can be devised of rotating the pile without sagging during the application of the gunite and also of handling the piles from the rollers to the seasoning yard, this method can be satisfactorily and economically employed. (*The Cornell Civil Engineer,* vol. 24, no. 2, p. 50, November 1915, 5 pp., 2 figs. *dp*).

Measuring Apparatus

Plate Fulcrum Track Scale, A. W. Epright

Description of a track scale of a new type installed in the gravity yard at East Tyrone, Pa., by the Pennsylvania Railroad, in several respects a radical departure from the usual design of track scales. In the present case, no pivots, knife edges, bearing steels, loops or links, are employed in connection with the vibratory system to transmit the load from the platform to the indicating poise beam. Instead, a "plate fulcrum" has been substituted and a series of tests under both concentrated and distributed loads are claimed to have demonstrated that the plate fulcrum construction possesses certain advantages over the "knife edge and pivot" construction, the principal among which is the fact that the sensibility does not materially change under varying increments of load but is almost the same under maximum load as with an empty balance. There is no motion whatever, either transverse or longitudinal, to the bridge or fulcrum supporting the weighing rail, and as a result the action of the lever system is not affected by change in repose of the weighing platform as the latter does not oscillate under moving loads.

The checking of the bridge is accomplished through massive stay-plates instead of check-rods. A wide departure from the previous construction lies in the fact that no parts of the scale are permanently bolted to the scale bridge proper, the bridge being supported by rollers which rest on hardened plates, the rollers being placed intermediate between the bridge and the lever system, so that the load is centrally distributed on the plate fulcrums in the main levers.

The scale installed at East Tyrone is 54 ft. long being built on a 0.8 per cent grade and equipped with mechanical hump. It still remains to be seen what will be the effect on the action of the scale of continued hard usage, but its operations to date are claimed to have been entirely satisfactory. A feature worth noticing is the elimination of many levers and fulcrums. In this case, there are four sections in the scale, the primary system or main levers being arranged transverse to the direction of the traffic, while the secondary system is arranged longitudinally. There are no compound levers which perform the function similarly to what is known as the middle extension lever, which greatly simplifies the adjustment when calibrating the scale leverage. (*Scale Journal,* vol. 2, no. 2, p. 5, November 25, 1915, 3 pp., 8 figs. *d.*)

Apparatus for Measuring the Velocity and Pressure of Gases, E. Stach

Apparatus for measuring the velocity of gases. Continuation of the article abstracted in *The Journal* for December, 1915, p. 715.

Among the apparatus described here are of particular interest those intended for measuring very low velocities, say under 0.5 m per second, for which purpose wing anemometers are not dependable, as their internal friction is too high. For such purposes R. Fuess has developed the highly sensitive anemometer shown in Fig. 5A, in which the wing is set into motion by a little fan driven by a spring at a velocity which may be adjusted by means of the screw *r*. The screw *s* applies the brake to the driving spring when the measurement has been ended.

If, now, this fan be located in an air current, the direction of which is opposed to the flow of air from the fan driving the anemometer wing and the velocity of which is lower than that of the stream coming from the fan, the motion of the wing will be retarded, and on the scale *z* a lower value will appear than that in stationary air. The difference between

the two readings indicates the velocity to be determined. By means of this anemometer, velocities as low as 0.03 m per second can be read.

For continuous measurements in pipes carrying high pressures, or at the end of such pipes, e.g., in compressed air piping, Rosenmüller builds an automatic anemometer (Fig. B) in which the entire gas stream must pass through the anemometer wing. These anemometers are built with wing diameters up to 145 mm, and when built into the piping, join the pipe by means of smooth-walled nozzles, whenever the diameter of the piping and wing do not coincide. Attention is here called to the middle section of the apparatus, which adapts itself to the direction of the stream lines, protects the arms of the wing device and automatically leads the entire flow of gas through the area of the wings. The scale, which can be seen through the glass cover, is divided into cubic meters. To this anemometer can also be adapted a chronograph for distant readings.

Wing anemometers, because of their delicate construction, are only good for velocities up to about 10 mm per second, since at the higher velocities there begins to occur excessive bending of the wings and excessive axial pressures. Therefore, for higher velocities, such as in compressed air piping, ventilation passages of mines and meteorology, cup anemometers, such as that of Robinson, (Fig. C) are considered preferable.

Figs. D and E show two devices of cup anemometers, the first built by Rosenmüller and the second by Stach-Fuess, respectively, with electric attachments for distant reading. The anemometer shown in Fig. E in particular is provided with caps over the axial bearings and electric contacts, making it both dust and water tight, which is of advantage for use in dusty places and for meteorological purposes. The chronograph used in connection with the Stach-Fuess anemometer is shown in Fig. F.

The recording is done in the following manner. After 200, 500 and 1000 revolutions of the cup device, (in accordance with the sensitiveness of the anemometer) a mark is drawn on the paper roll of the chronograph by a stylus attracted through an electric contact of the magnet screw. This magnet, with its stylus, is deflected upward by the spindle *s*, rotating at the same speed as the drum *u*, so that the stylus marks on the paper spirals which are interrupted by the vertical contact records. As the drum *u* makes one full revolution per hour, the distance between the contact and vertical marks is therefore a function of the measuring gas velocity, the magnitude of which is determined experimentally and expressed in a proper equation.

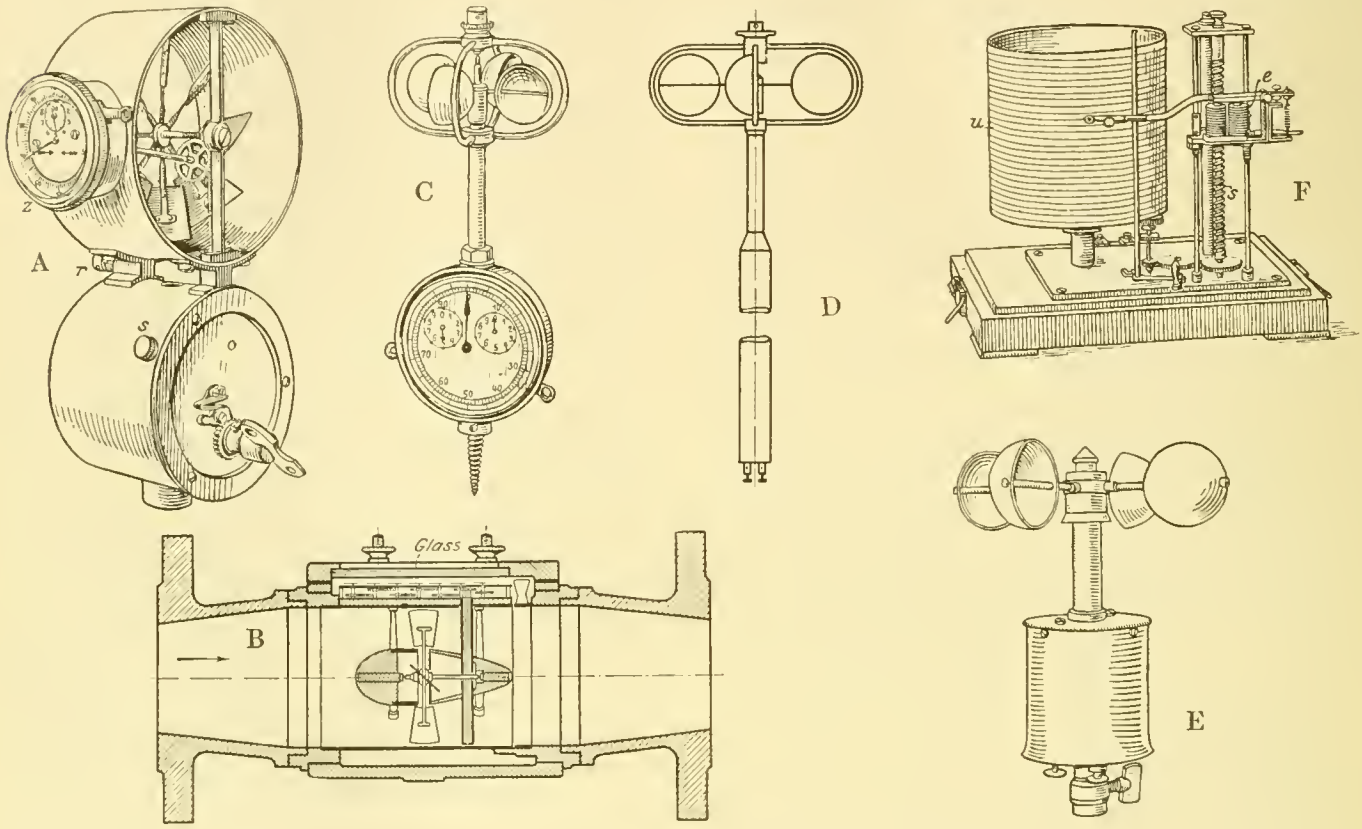

Fig. 5 Apparatus for Measuring the Velocity and Pressure of Gases; A Schultz-Fuess Anemometer for Low Air Velocities; B Rosenmuller Built-in Anemometer for Measuring Air Velocities in Compressed Air Piping; C Robinson Cup Anemometer; D Rosenmuller Cup Anemometer; E Stach-Fuess Cup Anemometer; F Chronograph

The article proceeds to describe methods of testing anemometers and among other things describes and illustrates the special apparatus for callibration of anemometers used at the Bochum School of Mines. (*Messgeräte für Druck und Geschwindigkeit von Gasen,* E. Stach, *Zeits. des Vereines deutcher Ingenieure,* vol. 59, no. 43, p. 878, October 23, 1915, article not finished).

Mechanics

Concerning Measurements of the Coefficient of Cyclic Variation, Prof. J. von Rohonyi

The article discusses methods of measuring the coefficient of degree of uniformity in the motion of prime movers.

The first impetus toward precise determination of the de-

gree of uniformity in the motion of prime movers was given by Radinger, in his work "Steam Engine With High Piston Velocity" (Third edition 1892, p. 338, in German). Since then, a number of other investigations have been published and the author of the present article, among others, has carried out a series of independent tests on the subject in 1911 for which he describes the experimental arrangement.

A disc *a* (Fig. 6A) with a large moment of inertia, is connected to another disc *b* by an elastic coupling *c*, which in its turn rigidly is connected with the axis of the engine. In the case of radial motion with varying velocities, the relative positions of the two discs change with respect to one another and in particular when the axis of the engine, together with the disc *b* are under an acceleration, the disc *a*, because of its inertia tends to lag, while in the case of the retardation of the disc *b*, the disc *a* tends to lead it.

The relative displacement of discs *a* and *b* denoted here as "pendular motions" can be recorded by means of a lever arrangement or spring device (Fig. B) or by means of a mirror in such a way that they would give a diagram from which the oscillations in velocity could be seen. If it be assumed that the forces acting on the crank of the engine vary in accordance with a sine function (Fig. C), the velocity diagram will give a similar curve, lagging by $\pi/2$, which means a cosine curve. The tangential forces can here be denoted as "pendular" forces, as they give the greatest relative displacement of the two discs (or "pendular" motions of the discs), provided one considers as an axis of abscissae not the o — o line, but the axis of symmetry of the curve.

The paths which are travelled over because of the displacements of the discs *a* and *b*, due to their relative rotations or pendular motions, may be plotted as ordinates of a sine curve, but with a displacement equal to $\pi/2$. The points of inflection of the pendular curves are called by the author "meeting points" (denoted by *B. P*), since the points on the discs *a* and *b* which are equivalent while the discs are at rest, meet at these points during the pendular motions of the discs and in the moments of time corresponding to these points there is neither lead nor lag in their relative motions. This permits the determining of the coefficient of cyclic variation with a precision sufficient for practical purposes, by drawing through the point of inflection a tangent line, whereupon the angle formed by the line with the horizontal (Fig. C) or $\operatorname{tg} \alpha = v \Delta$ represents nothing but the positive and negative variations in velocities with respect to the average velocity. Since, however, it follows from the velocity diagram that

$$v_{max} - v_{min} = 2v$$

hence the coefficient of cyclic variation in the motion of a prime mover is $\delta \dfrac{v_{max} - v_{min}}{v} = \dfrac{2r\Delta}{v} = \dfrac{2\operatorname{tg}\alpha}{v}$

The average velocity v may be precisely determined by means of a tachometer or speed counter.

The diagram of pendular motions is, however, affected by a source of errors. The motion of the disc *b* undergoes a damping because of friction and air resistance, and since, through its drive, by an elastic coupling, is not uniform in itself, the disc will rotate with a similar degree of cyclic variation. This error is, however, apparent only in the peaks of the diagram of pendular motions, and since, for practical purposes, this part of the curve need not be considered, the error is of no importance. The author further considers it advisable to make the records in such a manner that the displacements should be magnified to such a degree that the peaks of the curves are beyond the field of vision. As an example of his method, he gives two diagrams which are not reproduced here. He also describes an apparatus designed by him for the measurement of the degree of uniformity in accordance with the above established general principles. (*Über das Messen des Ungleichformigkeitsgrades*, Prof. Ing. Julius von Rohonyi, *Dinglers polytechnisches Journal*, vol. 330, no. 23, p. 441, November 13, 1915, 3 pp., 5 figs. *ed*).

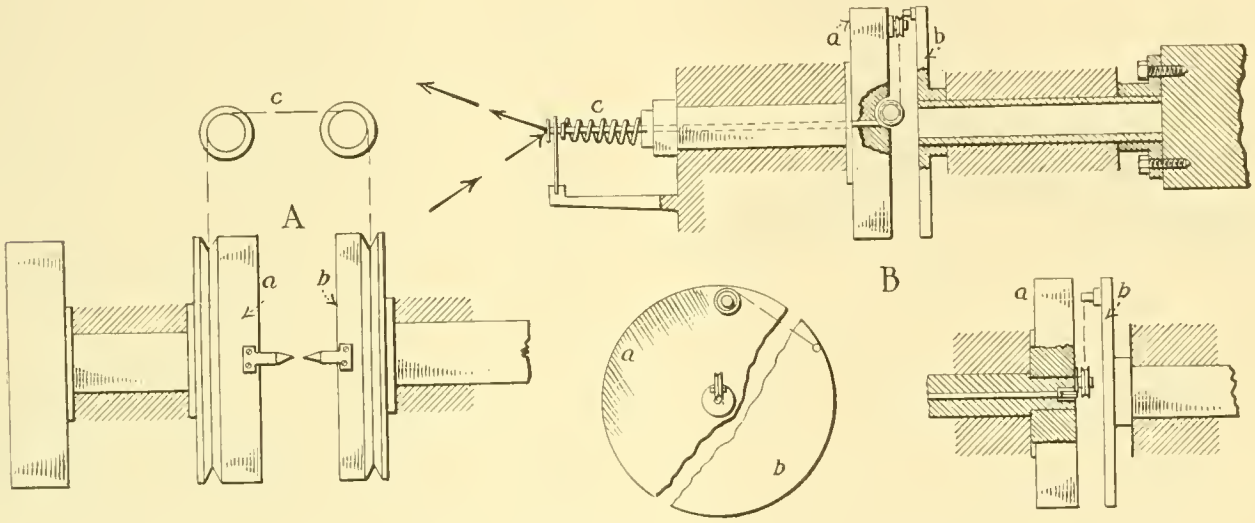

Fig. 6 A, B Experimental Arrangement for Measuring the Coefficient of Cyclic Variation in the Motion of Prime Movers

Power Requirements for Wire Drawing, Kenneth B. Lewis

The paper presents a critical consideration of the factors to be met in the manufacture of wire and in drawing rods.

The calculation of the power required in wire drawing operations is constantly becoming a problem that calls for more accurate solution. Wire mills working on a general line of production drawn from the No. 5 rod do not feel the need of such a solution, but a master mechanic of wire drawing equipment must be also prepared to figure the power for a single unit under a very definite set of operating conditions. With motor drive, it is advisable to know not only the average, but also the power demanded under the most adverse conditions, in other words, the peak load. This is particularly true of

rod benches with blocks engaged in heavy work. Then sometimes definite assurances must be given to users of cold drawn products that the motor furnished will carry their peak load. Finally, motor driven heavy bull frames with one or two blocks are replacing the straight draw benches for products between 1 in. and ½ in. in diameter; they handle much longer lengths than the straight benches, and as they generally carry two independently operated blocks their cycle is very different, and the motors must be in reserve for peak load if both blocks happen to start simultaneously.

The writer has checked up the existing rule of thumb method for figuring wire drawing power with about 60 actual motor readings made under known conditions and covering a

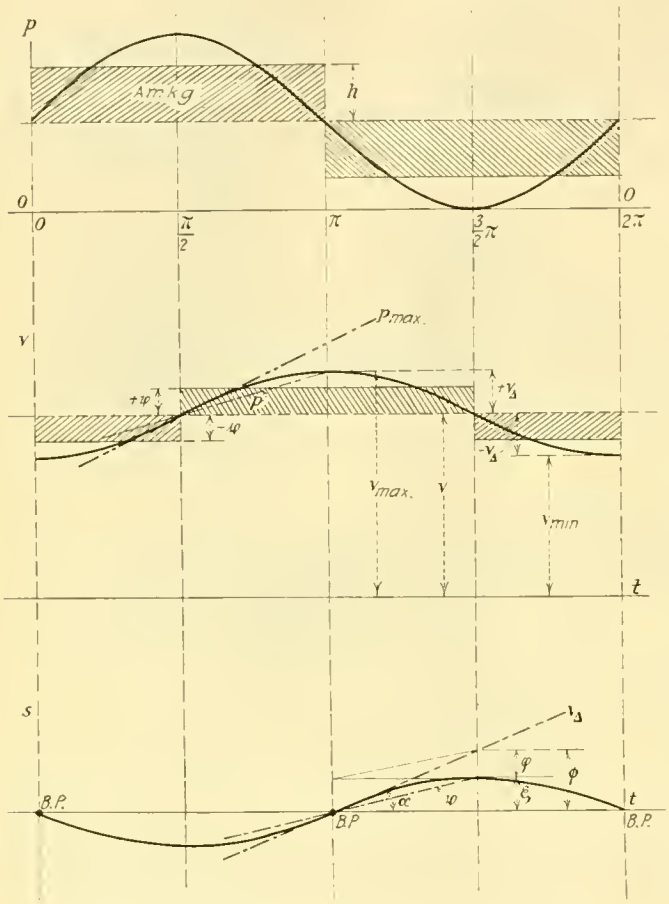

Fig. 6C Diagrams of Pendular Motions

very wide range as to size and material. The power called for by the formula averages about one-half that shown by the motor readings. The most serious difficulty with the formula is that in its present form, even when its value is doubled, many observed motor readings vary from it by as much as 60 per cent or 70 per cent, over and under. The reason seems to be that the figure representing the material displaced is the only factor in the equation which carries a suggestion as to the size of wire. The author proposes, therefore, an amended formula as follows:

$$HP = TS \times (A - a) \times S \times F/33000$$

where

TS = tensile strength per sq. in. of stock before the draft
S = speed in feet per minute
A = area of wire before drawing
a = area of wire after drawing
F = factor chosen from a chart which is given in the article

This formula which the writer has found fairly satisfactory does not take into account certain factors which cannot be determined in practical working, such as shape of the bearing in the die, efficiency of lubricant, amount of friction in the machine, etc.

The formula as developed is not what might be called a logical equation as its derivation is not strictly consistent. There is another formula which not only gives as satisfactory results in practical work as the above, but also gives consistent values at both ends of the scale of reduction. It is the formula of Victor E. Edwards for rolling mill operations as follows:

$$HP = TS \times T \times \log \frac{A}{a} \times F$$

where TS = tensile strength in lb. per sq. in. of stock before the draft
T = tons per minute delivered
A = area of section before the draft
a = area of section after the draft
F = variable factor

The author has analyzed results obtained by this formula in connection with motor readings and finds that the value F varies inversely with the percentage of reduction, its variation in the usual range of draft being from 0.12 to 0.08, and is apparently perfectly regular. This formula may be also applied without change to continuous wire drawing operations in which many reductions are performed simultaneously upon the same wire. In such cases T is figured for the product of one die only while the values for TS and F are averages. All these formulae are good for round wires only. Hexagons and squares conform to these figures more or less, but other shapes do not. (*The Blast Furnace and Steel Plant*, December 1915, p. 1031, 4 pp., 3 figs. *pe*).

The Horseless Age Engineering Charts

The article refers to a series of handy computing charts, the purpose of which is to provide short-cuts in the making of calculations. One of the charts is for computing the valve springs for mushroom cams by means of which it is possible to determine exactly the spring pressure required for a motor of any maximum speed using mushroom cam followers having reciprocating parts of any weight and employing any size of cam. Other charts give the capacity of cone clutches, capacity of dry disc clutches, critical speed of solid and hollow shafts and brake mean effective pressures. (*Horseless Age*, vol. 36, no. 13, p. 497, December 1, 1915, 2 pp., 2 figs. *p.*)

Design of Crankshafts for High-Speed Engines, P. M. Heldt

The paper discusses the design of crank shafts for high speed engines and gives equations for the proportions of some of the various types of crank shafts for engines of different numbers of cylinders.

The author calls attention to the fact that crank shafts have become more substantial and more rigid from year to year largely on account of the demand for high engine speed combined with quiet vibrationless operation. The crank shaft must be made rigid in order to obviate excessive torsional vibration at so-called critical speeds. Formerly, the crank pin diameter was made directly proportional to the cylinder bore and independent of the stroke, but in recent years piston speeds have been so greatly increased that it is the inertia of the reciprocating parts rather than the explosion pressure that is now the chief factor in determining the load on the piston pin. At high engine speeds there is

very little pressure on the crank pin during the first part of the explosion stroke, as the force of the explosion is nearly balanced by the opposite stroke force of inertia on the piston on the upper end of the connecting rod. Initial forces, due to reciprocating parts, are acting during all four strokes, and therefore it may safely be said that at high speeds the greater part of the bearing load on the crank pin is due to initial forces.

The author gives empirical rules for dimensioning crank shafts in automobile motors, based on carefully selected data of recent motors. These cover three bearing 4-cylinder crank shafts, three bearing 6-cylinder crank shafts and four bearing 6-cylinder crank shafts.

The article is to be continued. (*Horseless Age*, vol. 36, no. 13, p. 498, December 1, 1915. *pt.*)

The Mystery of the Screw Propeller, C. W. Dyson.

The paper discusses in a mathematical manner the seeming vagaries of performances of screw propellers on ships in actual service. Some of these vagaries are attributed to the effect of variations in hull form as interfering with the proper flow of water to the propeller or producing more or less wake and so adding to the propulsive efficiency, or the vagaries in propeller efficiency may be due to incorrect estimates of effective horsepower required for a given speed because of neglecting the resistance due to appendages such as struts, bilge keels, etc. The remaining portion of the mystery may be due to variations in blade form and sections of the propeller itself, and to incomplete understanding of propeller performances proper.

The author comes to the conclusion that the efficiency of performance of a propeller is seriously affected by its position in relation to the hull of the vessel which it is driving, and by the fullness of the hull lines at the afterbody. For any given propeller working under constant hull conditions of form, the effective horsepower for any given engine power remains constant and thus is independent of the speed of the vessel. For any given propeller working under constant hull conditions of form the revolutions necessary to deliver any given effective horsepower vary with the speed of ship, the engine power remaining constant. Model tank effective horsepower curves are correct, but results obtained from model tank experiments with model propellers are correct only when the model is properly proportioned to the full size propeller which does not mean that the pitch ratio of the propeller and of the model shall be the same. (*Journal of the American Society of Naval Engineers*, vol. 27, no. 4, p. 743, November 1915, 50 pp., 5 figs., *dm.*)

Refrigeration

Flow of Superheated Ammonia through Orifices, Edward F. Miller

At the instigation of the Massachusetts State Board of Boiler Rules, F. L. Fairbanks, L. Williams and E. F. Miller, as members of a committee appointed by the American Society of Refrigerating Engineers, together with Prof. C. A. Read, of Worcester Polytechnic Institute, and G. H. Clark, of the Massachusetts Institute of Technology, have carried out a series of tests at the plant of the Quincy Market Storage and Warehouse Company, on the flow of superheated ammonia through orifices and several other cognate matters.

Among other things, orifices of different diameters, of different lengths and with different radii of entrance curves were tested. The diameter of the discharge outlet and of a discharge pipe 100 ft. in length which would be required to take care of the amounts of gas discharged with 5 lb. accumulation pressure at the entrance end, and atmospheric at the exit end, was figured by the Babcock formula. It was found that it would have been impossible to use discharge pipes of the large diameters called for and the committee decided to arrange a safety valve to discharge into a pipe where the pressure might accumulate at time of maximum discharge, to 0.585 the entrance pressure, or with 275 lb. gage entrance pressure to 154 lb. gage. In such a valve the back pressure must be kept from acting on the back of the valve. Such a valve has been made by Mr. Fairbanks. (Description of this valve will be found on page 97.) The same idea has been embodied in a new steam safety valve which, on test, was found to work perfectly.

The Committee found no data available from which to calculate the diameter of a pipe of a given length which is to discharge the given weight of gas per minute entering at 154 lb. gage and leaving at atmospheric pressure. Therefore a run of pipe was erected and some data obtained. Further, a straight run of 2 in. pipe, 260 ft. long, was also installed and a known weight of saturated steam at high pressure sent into one end of the pipe, the other end being open. From the data thus obtained, the committee felt warranted in fixing the sizes of the discharge pipes as shown in Table 1. For the second 100 ft., the pipe should increase one pipe size and so on for each additional 100 ft. Pipe bent to a radius at least as great as five pipe diameters has to be used when it is necessary to turn a corner.

A number of tests were made on flow of superheated ammonia gas through an orifice, of which data are reported in three tables in the original article. It appears from these tests that the radius of the curve at entrance should be at least one-half the diameter of the orifice and that the straight part of the orifice should be 1½ diameters long. In such orifices, the absolute pressure in the orifices may be assumed to be 0.585 of the absolute head pressure and the throat back pressure is not greater than 0.585 times the head pressure. If the back pressure is greater than 0.585 the head pressure, then the pressure in the orifice may be assumed to be a slight amount, perhaps 1 lb., above the back pressure. If an adiabatic expansion be assumed from head pressure and conditions to throat pressure, then the weight going through the orifice per second may be calculated from the following formula:

$$V = 224\sqrt{H_e - H_o}; \frac{V \times a}{z} = \text{weight}$$

where V = velocity in feet per second; a = area of orifices in square inches divided by 144 or the area of the orifices in square feet; z = volume of 1 lb. of ammonia gas at the throat pressure and condition in the orifice; H_e = heat content of 1 lb. of ammonia at head pressure and condition; H_o = heat content of 1 lb. of ammonia at throat pressure condition.

TABLE 1 SIZES OF DISCHARGE PIPES

Piston Displacement Cubic Feet Per Min.	Diameter of Valve	Diameter of Discharge Pipe for First 100 Feet
120	½ inch	1
280	¾ "	1¼
510	1 "	1½
830	1¼ "	2
1200	1½ "	2½
2120	2 "	3

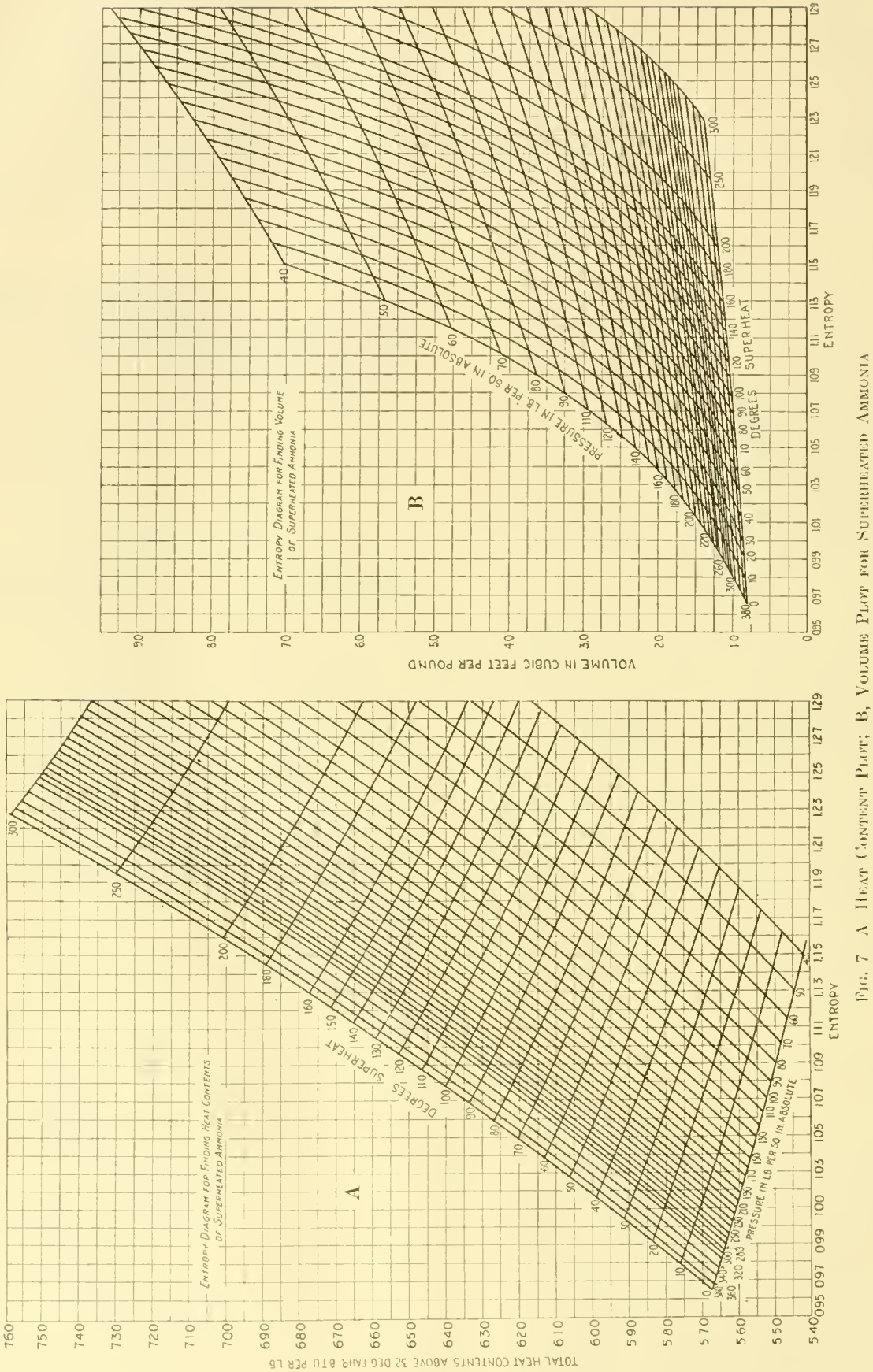

Fig. 7 A Heat Content Plot; B, Volume Plot for Superheated Ammonia

Directions for Use of the Plots

Knowing the head pressure and the degree of superheat, the *Heat Contents* H_e can be read off from Fig. A. The entropy is noted. Following down at constant entropy to the pressure in the orifice, the Heat Contents H_o can be read; also the number of degrees the gas in the orifice is superheated.

On the plot Fig. B, follow up on the same entropy to the pressure in the orifice and Z, the volume of a pound at the condition in the orifice, can be read.

To save interpolation in the Goodenough and Mosher's tables, the authors offer two plots from which, knowing the head pressure and the degrees of superheat, the volume of a pound at the condition in the orifice can be read. (A.S.R.E. Journal, vol. 2, no. 3, p. 5, November 1915, 10 pp., 6 figs. *ep.*)

The Quincy Market Safety Valve for Ammonia Compressors, F. L. Fairbanks

While assisting the Massachusetts Board of Boiler Rules in its endeavor to find a reliable safety valve for ammonia compressors, the writer had occasion to perfect a valve previously in use at the plant of the Quincy Market Cold Storage and Warehouse Company in Boston, Mass. During the above referred to tests, six different makes of ammonia safety valves were investigated under various conditions and pressures. The general conclusions drawn from six tests were as follows:

a That valves with iron and steel seats were not safe for the reason that the disc is readily corroded to its seat by a small amount of moisture. Two of the six valves tested failed to open at 350 to 375 lb., although they were set at 250 lb. On being dissembled, these valves were found to be rusted solidly to the seat and to the winged guide in the port.

b That the cast iron valve discs with winged guides in the port, would not stand the excessive chattering and hammering on the seats, to which most of the valves may be subjected when opening and closing. One of the valves broke off its winged guide in the port and wedged the disc so that the line had to be shut off. Examination showed that the cast iron in both seat and guide was good and sound, the fracture being caused by the heavy chatter and pounds as it opened and returned to its seat.

c That the capacity of all the valves except the pop valve was very low.

d That the pop valve gave practically no warning when it was about to blow, and for this reason it would be dangerous to anyone who might be in the path of the discharge when it opened. Also, that the seat of the pop valve could not stand the blow of the valve when closed and remain tight.

e That none of the valves, notwithstanding their low capacity, could discharge through a pipe line no larger than their discharge outlet, and still maintain their setting and character.

The Quincy Market safety valve is shown in Fig. 8. It has no guide in the port, being guided by a bushing pressed into the valve port and by a cylindrical piston which has a port of what would be called the valve disc.

The face bushing is bored and reamed after being pressed in and the alignment of the valve depends upon this bushing, the seat being reamed through it as a guide, thereby making all parts of valve body and bonnet self centering and self aligning. The valve is cone pointed to present the least possible resistance to the flow of gas and is turned to an angle of 60 deg., the seat being reamed 1/32 in. wide and the angle being 57 deg., thus allowing the valve to seat on an edge and not on a flat surface. The piston guide is of sufficient excess area to secure the characteristics called for in the regulations and to cause the valve to open wide as the gas discharge increases and the back pressure builds up, the construction being such that the valve has the same features whether it is discharged through 500 ft. of pipe or directly from the valve outlet.

Like an old fashioned lever safety valve it opens at any predetermined point giving the operator sufficient warning to enable him to remedy the trouble in many cases. When this point is reached the valve continues to open as the pressure of the discharge side backs up on the increased area of the piston guide, the entire range being gradual and continuous until the back pressure reaches 0.585 of the initial pressure, thus giving in a valve practically the capacity and character of a Napier orifice. In tests the valve easily handled a displacement of 1700 cu. ft. per minute with 30 lb. to spare on the outlet side of the valve without chatter, shock or any other sign of distress. (*A.S.R.E. Journal,* vol. 2, no. 3, p. 45, November 1915, 5 pp., 2 figs. *d.*)

Thermodynamics

The Reversed Heat Engine as a Drying Machine, Paul J. Fox

The article represents an attempt at establishing principles and at designing an apparatus for air drying, based on the Kelvin principle of a multiple heat engine. This principle has been applied before in the design of a heating installation which would produce ice as a by-product.

In this case, the author states that the drying machine consists of three essential parts: *First,* a large metal expansion cylinder with a piston; *second,* a vessel in which the air

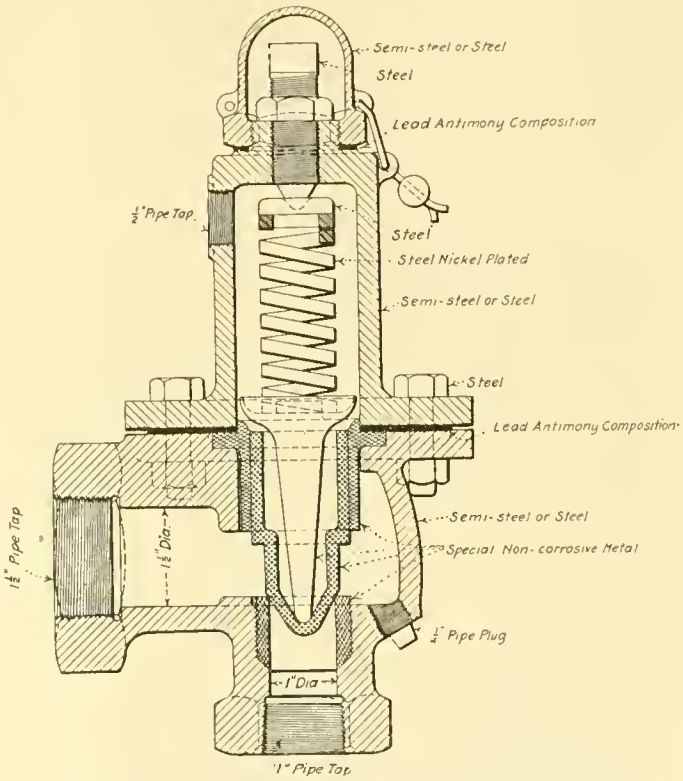

Fig. 8 Fairbanks Safety Valve for Ammonia Compressors

in the machine is allowed to come to atmospheric temperature and which may be called the atmospheric heater; and *third,* a large metal compression cylinder, also with a piston. The two pistons are connected to one piston rod. The cycle would be as follows: The gas would be allowed to come up to atmospheric temperature at the reduced pressure by retention in a suitable vessel, and finally compressed again to atmospheric pressure, the compression resulting in an increase of temperature. A single half stroke or single complete movement of the piston in one direction, completes a set of operations and delivers to the drying chamber the weight of the air taken in, which in the following is assumed to be 1 lb. in all cases. The atmospheric heater is merely a vessel for allowing the cooling and expanding air to come to atmospheric temperature. It may be a long tube or block or coil of tubes formed of thin metal to conduct heat to the enclosed air as rapidly as possible and to avoid mixing the warm and

cold gases. The tube would be of larger bore where the temperature difference between the atmosphere and the atmospheric heat was greatest. Because of the slowness with which the heat is communicated to a gas, the operation would be substantially adiabatic, although in the house warming engine, as proposed by Lord Kelvin, it is implied that the expansion of air *in the cylinder* should be isothermal; at least it is assumed adiabatic in the following: The atmospheric heater is then essential to bring the cold and expanded air up to the atmospheric temperature, and as the reduction of pressure amounts to only a few pounds, the walls of the heater would not have to be very heavy. In the heater the air expands from specific volume v_1 to v_2, and passes from temperature t_1 to t. The author makes the thermodynamic calculations for the engine as a drying engine, and finds formulae for all the magnitudes as well as for the constants. By applying the calculations to a concrete case, it takes the atmospheric temperature $t = 519$ absolute, or nearly 60 deg. fahr., and assumes that it is desired to dry at 100 deg. fahr., or 559 deg. absolute; then p of outside atmosphere and of drying chamber is equal to 14.7, v (specific volume of outside atmosphere in cu. ft. per lb.) = 13.085, t (temperature of outside atmosphere in deg. absolute fahr.) = 519, and t_3 (temperature of air on leaving compressor and in drying chamber in deg. absolute fahr.) = 559. The formula $p_1 = B\left(\frac{t}{t_3}\right)^{3.463}$ gives $p_1 = 11.40$, and $v_1 = \left(\frac{p}{p_1}\right)^{0.7113} v$ gives $v_1 = 15.68$. The characteristic equation $PV = RTm$ gives $v_2 = 14.093$, $v_2 = 16.87$ (on leaving atmospheric heater), and $t_1 = 482.2$ deg. fahr, absolute.

In discussing quantitatively the thermodynamic operation of the engine, the author summarizes the operations as follows: Each pair being a correlative process, he gives a plus or minus sign to each process, the plus sign being given when the process tends to turn the machine in the same direction as the power applied, and the minus sign when it opposes the power.

1 + is the taking of air from the atmosphere by the expansion cylinder.

1 — is the delivery of air by the compression cylinder to the drying chamber.

2 + is the expansion of the air in the expansion cylinder.

2 — is the compression of the air in the compression cylinder.

3 — is the discharge from the expansion cylinder to the atmospheric heater.

3 + is the discharge from the atmospheric heater to the compression cylinder.

The author discusses each pair of operations mathematically and derives the proper formula for their expression. All the calculations are of strictly thermodynamic character and do not consider the losses by friction or actual losses in engines. But it may be said that the common objections to air as a working substance do not apply here. Air has a low specific heat which causes the cylinders to be bulky but if drying is to be effected, the dry air must be pumped or introduced in one way or another into the drying chamber even if only by inefficient diffusion, and the machine suggested acts also as a pump. The difficulty of communicating heat to air unless the direct products of combustion are brought in contact with the substances to be dried, is a strong argument in favor of the engine, for in it the air is heated evenly and to the temperature desired. Again, the heat loss can be minimized. So far as the compression cylinder is concerned there is no reason why it should not be placed inside the drying chamber which would permit of utilizing the various heat losses by friction, etc., occasioned by heating the air for drying.

The most serious objection to the plan is found in the variation of temperature in the external atmosphere, since the machine heats the air through a fixed temperature difference for a given valve setting. This may be obviated either by adjusting the valves and varying the speed of the operation at different temperature ranges or by setting a number of machines in series with each machine lifting the air through a certain temperature difference and a varying number of them used as the atmospheric temperature changes. Finally the dry air would be heated higher than necessary and adjustment made from time to time by means of adding varying quantities of cool atmospheric air. (*The Journal of Industrial and Engineering Chemistry*, vol. 7, no. 12, p. 1065, December 1915, 5 pp., 1 fig., *td.*)

Loss of Heat from Steam-Heated Surfaces

This paper was presented by Prof. Petavel, of the Manchester University, at a meeting of the Manchester Association of Engineers, October 30, 1915, and is based on the researches by the engineering staff of the Manchester University under the control of C. H. Lander.

The first part of the paper deals with problems of heat transmission and their particular bearing on heat losses sustained by steam heated surfaces. The second part deals with the efficiency of gas engines, the facts presented being based on experimental work carried out at the University of Manchester, by Prof. Asakawa, of Tokio, with the object of ascertaining by direct experiment, how near the efficiency of the commercial gas engine has approached the ideal. Finally is described a series of investigations undertaken to compare the strength of various structures as estimated by accepted methods of calculation with the actual strength determined by direct test. Within its purview is included a discussion of the strength of thick cylinders when subjected to internal pressures, and the complementary problem of the resistance of cylinders to collapse. The paper is quite voluminous and can be only briefly abstracted.

The author gives formulae for the radiation, conduction and convection in the flow of heat through a layer of gas separating two surfaces at different temperatures. The object of the research was to determine experimentally the heat flow under certain definite conditions and to estimate the relative importance of the above three modes of heat transmission. He describes the apparatus used for these tests and in several curves and tables gives a summary of the results obtained; viz., for experiments in air at atmospheric pressure; heat loss for steam pipes at various temperatures; change of loss with temperature (at habitual steam temperatures and at the entire temperature range, namely, from zero to 1500 deg. fahr.).

On the whole, the results point to the fact that the heat loss from steam heated surfaces is due mainly to convection. The loss by radiation in the case of a pipe of 1 in. external diameter is only about 15 per cent; the loss by conduction varies around 4 per cent, while convection accounts for about 81 per cent. The object attained by surrounding pipe with insulating material is to check convection currents and also reduce radiation. At the same time, all solid materials used as insulators are better conductors than air, so that the use of an insulating material really increases the loss due to conduction. Taking the case of a 1 in. pipe, a material such as slag wool or asbestos, if applied in a solid compressed block, would increase the total loss. The insulating effect obtained depends upon so arranging the substance that the least quan-

tity of material will sub-divide the space around the pipe into separate air cells as perfectly as possible. Thus the efficiency of slag wool is at maximum when the solid material occupies about one-fourteenth of the space. (Fig. 9 C.)

In a table are given values of heat lost from metal surfaces, such as bare steam pipes of various diameters under different temperature conditions, which did not, however, very materially differ from figures given by Fowler and Hiller. Another table given in the paper shows the saving of heat obtained by insulating coverings of various materials. It appears that magnesia filled rope and asbestos filled rope give the best results.

The paper proceeds then to the discussion of the effective pressure on the transmission of heat. The results of a number of experiments carried out in air at pressures up to 2500 lb. per sq. in. are given in Figs. 9A and B. It will be seen from Fig. A that as the pressure rises from atmospheric to 150 atmospheres, the loss per degree increases to nine times its original value, for a temperature of 152 deg. fahr. At high temperatures, say 2000 deg. fahr., radiation forms a large proportion of the total loss and hence the increase is relatively less. At all pressures the heat loss is very large for small diameters. It decreases rapidly as the diameter increases up to ½ in. and then becomes relatively constant for diameters above 3 in. It has further been found that conduction is important when the diameter of the hot body is small or the pressure of the air is low. Convection becomes the main factor when the air pressure is high or diameter large, and loss is principally due to radiation at very high temperatures and very low pressures. (*Proceedings, Manchester Association of Engineers*, through *The Mechanical Engineer*, vol. 36, no. 928, p. 357, November 5, 1915, 5 pp., 8 figs. *e*.)

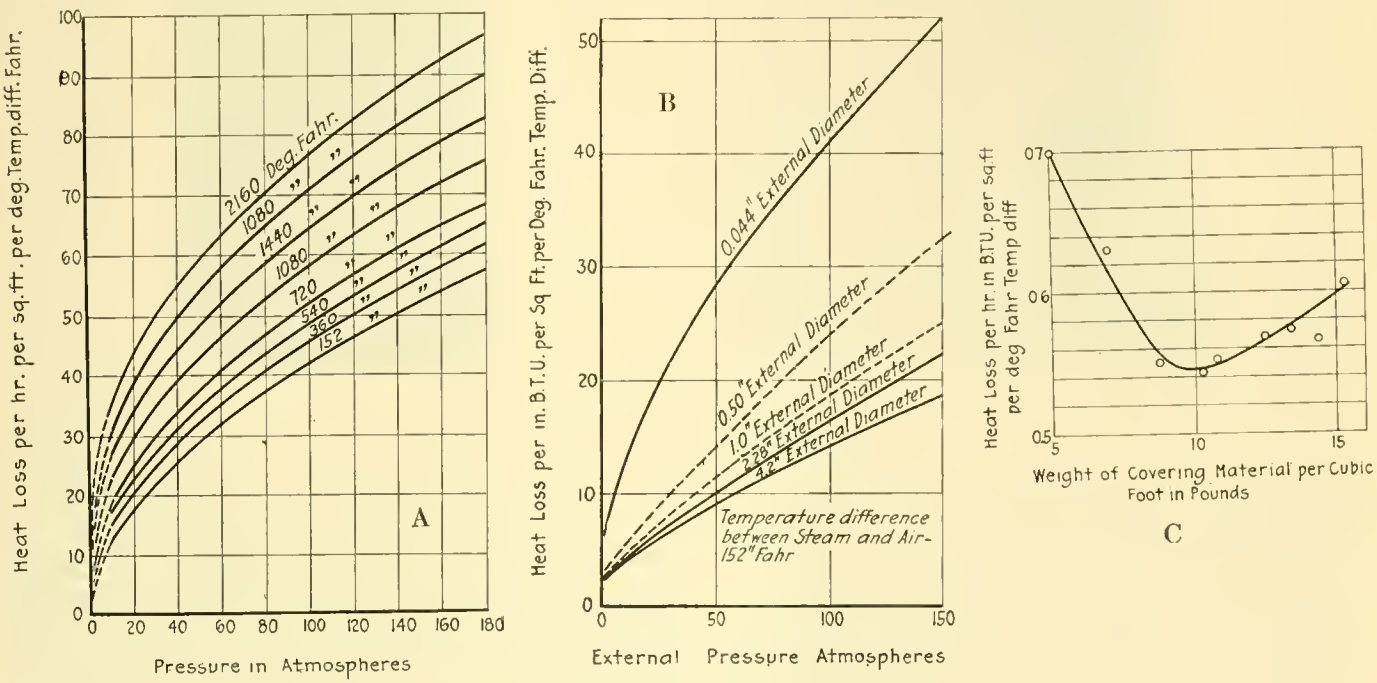

Fig. 9 Loss of Heat from Steam Heated Surfaces

Miscellanea

Some Unpublished Letters of James Watt

H. W. Dickinson

Small collection of letters representative of as many aspects as possible of Watt's activities. The letters are in chronological order and an attempt is made to indicate the purport of each and to explain the allusions in them. They are of considerable interest as an indication of the conditions under which engineers had to work in the latter part of the eighteenth century. Among other things, Watt discussed such matters as metallic piston packing, engine and pump troubles, duties performed by the atmospheric engine, boiler gages, iron cement, testing of materials, etc. Of especial interest is Watt's letter on the steam turbine, written in connection with the project introducing what was then known as Kempelen's engine. Watt pointed out that the engine was capable of improvements and in fact suggested some of them. He calculated the power developed by the turbine and found that with a velocity of 430 ft. per sec., the machine would develop 2½ h.p. and require a boiler evaporating 26 cu. ft. per hr., but with a velocity of 600 ft. per sec., the same engine might develop 11 h.p., and Watt summed up the situation as follows: "So that you see the whole success of the machine depends on the possibility of prodigious velocities. . . . In short without god makes it possible for things to move 1000 feet p^r" it can not do much harm, and by "much harm" Watt means of course, possible competition with his own machine. (*The Journal of the Institution of Mechanical Engineers*, No. 8, 1915, November 1915, 47 pp., *h*).

Artificial Arm, Kesten

Description of an artificial arm developed lately, for the use of victims of war in Germany, at the works of Siemens-Schuckert Company, in Nurnberg.

It has hitherto been the practice when replacing a part or the whole of a lost arm, to attempt to reproduce the lost member artificially. This has some times been done with great mechanical ingenuity. In fewer cases an attempt has been made to replace the lost hand by means for holding special tools which would help the injured man, more or less, to carry on some kind of work. In this case, however, like in the preceding one, the attempt is usually made to attach the new apparatus to what remained of the lost member,

which materially reduces the amount of power which could be exerted through the substitute arm because of the reduced power of the arm trunk.

The Siemens-Schukert Company, acting at the suggestion of Dr. Silberstein, adopted an entirely new method, viz., to use what remained of the arm only as an auxiliary means of guiding the tool holder, which is however suspended from the *shoulder* and held by a strap, shown in Fig. 10, against the body of the man in such a manner that the strap passes under the other arm pit. The shoulder carries two ball-bearings *b* and *c*, of large diameter, and to the outer ring *c* are attached by joints, rods *e*, made of light steel tubing. (*d* shows the journals on which these rods are connected by a cup-shaped piece *f*, which takes up the double joint to which the tool proper is attached). The ball-bearings *b* and *c*, together with the movable joint in connection with the rods *e*—*e*, permit of moving the artificial arm in the shoulder joint just as one would a natural arm. The shoulder joint is perfectly free, and in order that the stump of the arm may be able to give the desired direction to the artificial arm, there is provided in the rods *e*—*e* and slide *g* which encloses the stump of the arm. The double joint which is carried on the cup-shaped piece *f*, is arranged in such a manner that it can permit of communicating to the tool attached to it both a circular and a joint motion, or practically a complete freedom of motion in any direction desired. (*Armersatz für Kriegsbeschädigte Handwerker und Arbeiter,* Kesten, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, no. 43, p. 870, October 23, 1915, 3 pp., 5 figs, *d*).

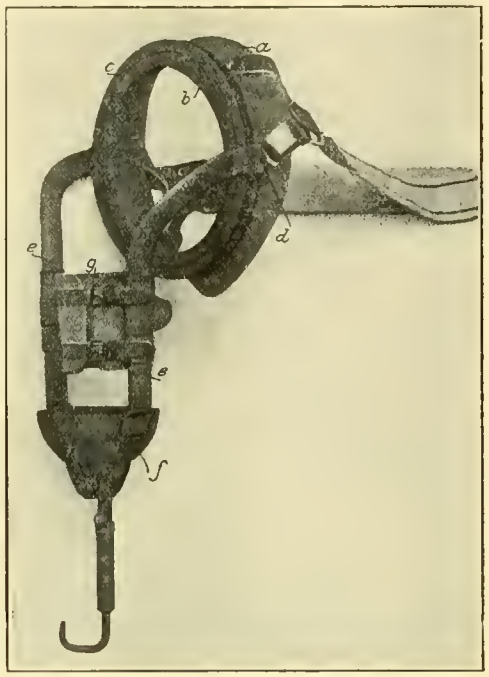

Fig. 10 Siemens-Schuckert Artificial Arm

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

CORRECTION

The article A Formula for the Comparison of Gasoline Automobile Performances (see abstract in *The Journal,* September 1915, p. 563), erroneously attributed to Theodore Douglas, is by *Cornelius T. Myers.*

SELECTED TITLES OF IMPORTANT ENGINEERING ARTICLES

AERONAUTICS

The Captured Albatros Reconnaissance Biplane. Flight, no. 361, (no. 48, vol. 7), Nov. 26, 1915. 5½ pp., 11 figs.

MACHINE SHOP

Modern Methods of Training Workmen, H. L. Gantt, Efficiency Society Journal, vol. 4, no. 9, Dec. 1915, 6 pp.

Motion Study for Crippled Soldiers, Frank B. Gilbreth. Efficiency Society Journal, vol. 4, no. 9, Dec. 1915, 1 p.

Anti-Friction Methods in Shop Management, F. C. Blanchard. Efficiency Society Journal, vol. 4, no. 9, Dec. 1915, 6 pp.

Speeding Up Metal Stampings Production, Charles C. Lynde. Steel and Iron, 49th year, no. 31, Dec. 1915, 4 pp., 9 figs.

Electric Welding Machine. Engineering, vol. 100, no. 2605, 1¼ pp., 3 figs.

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Gas Welding and Cutting, A Symposium, C. K. Bryce. Proceedings of The Engineers' Society of Western Pennsylvania, vol. 31, no. 8, Nov. 1915, 11 pp., 7 figs.

Artificial Gas for High Temperature Work, E. Raven Rosenbaum. Steel and Iron, 49th year, no. 31, Dec. 1915, 4¼ pp.

La fabrication des Obus, Ch. Dantin. Le Génie Civil, Tome 67, no. 21, Nov. 20, 1915. 8¼ pp., 42 figs.
Outline of French methods of shell manufacture.

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Holding Devices for Tapered Work, A. A. D. Machinery, vol. 7, no. 166, Dec. 2, 1915. 6½ pp., 11 figs.

Foundations for Jar-Ramming Machines, E. S. Carman. Iron Trade Review, vol. 57, no. 25, Dec. 16, 1915. 4 pp., 14 figs.

Development of Quick Acting Forging Presses—1, A. J. Capron. Canadian Machinery, vol. 14, no. 25, Dec. 16, 1915. 3 pp., 2 figs.

Lathe for Boring 6-in. Shells. The Engineer, *London*, vol. 120, no. 3124, Nov. 12, 1915. 1 p. Illustrated.

Heat Losses in Steam Transmission, W. L. Cathcart. Cassier's Engineering Monthly, vol. 48, no. 6, Dec. 1915, 15 pp., 10 tables.

MARINE ENGINEERING

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Description of Main Propelling Machinery for the U. S. S. "Maumee," Lieut. C. W. Nimitz, U.S.N. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 27 pp., 1 fig.

Description and Trials of U. S. S. Torpedo-boat Destroyer "O'Brien," Lieut. W. F. Cochrane, U.S.N. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 14 pp., 2 figs., 2 plates.

The Mystery of the Screw Propeller, Capt. C. W. Dyson, U. S. Navy. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 51 pp., 5 figs.

Description and Trials of U. S. S. "Fulton" (Sub-Marine Tender No. 1), Lieut. (J.G.) C. N. Hinkamp, U.S.N. Journal of the American Society of Naval Engineers, vol. 27, no. 4, Nov. 1915, 1 p., 3 figs.

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Refractories: Selection and Use in the Foundry, Walter H. Kelly. The Quarry, vol. 20, no. 240, Dec. 1915, 3½ pp.

Cross-Relations of Strengths of Metals, G. B. Upton. The Sibley Journal of Engineering, vol. 30, no. 3, Dec. 1915, 5 pp.

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Resistance of materials.

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Heat Treatment of Modern Steels, Robt. A. Abbott. The Iron Trade Review, Nov. 18, 1915. 6 pp., 21 figs.

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ANNUAL MEETING PAPERS

THE 36th Annual Meeting of the Society held in New York, December 7-10, 1915, like the previous Annual Meeting, was characterized by professional sessions, of which there were seven, devoted to Power Plants, Machine Shops, Railroads, Textiles, Industrial Safety, and Miscellaneous. In the January issue were published the Presidential Address and eight papers including those given at the Power Plant Session. In this issue are presented in abstract the three papers contributed by the Sub-Committee on Machine Shop Practice, one of the papers contributed by the Sub-Committee on Railroads, the paper contributed by the Sub-Committee on Industrial Building, together with the discussion which followed. There is also published the discussion which was brought out by the professional papers appearing in the January number.

AUTOMATIC MECHANICAL CONTROL OF LATHES AND SCREW MACHINES

BY L. D. BURLINGAME, PROVIDENCE, R. I.

Member of the Society

IN a general way the term "automatic control" applies to the organization of a machine so that *all* operations required to complete the work are automatically performed, and the object is to have these operations so performed as not only to secure in large measure the advantages of hand work guided by human intelligence, but also to insure a uniformity and quantity of product beyond that which can be commercially obtained by hand work.

In determining whether the employment of automatically controlled machines is warranted, the vital question is whether the product is wanted in sufficiently large quantities and whether the design is sufficiently well established to justify the investment in such special machines.

It must be determined whether the added original cost and greater cost for repairs are justified when to this must also be added the more expensive tool equipment and longer time required for setting up. In considering the cost for repairs, the conditions to be borne in mind are the greater danger of a breakdown and the greater skill required to keep the machine in running condition.

The fact that in operating automatically controlled machines the human factor is less in evidence than is the case in hand operated machines, makes it possible generally to employ less skilful workmen without lowering the quality of the work. On the other hand, the use of automatically controlled machines increases the need of skilful supervision and of skilled men for their construction and repair.

The features most prominent and essential in the automatic control of machine tools can be classified as follows:

I Spindle drives

II Means for inserting and removing the work

III Feeding mechanisms

IV Indexing mechanisms

V Controlling means for the various mechanisms

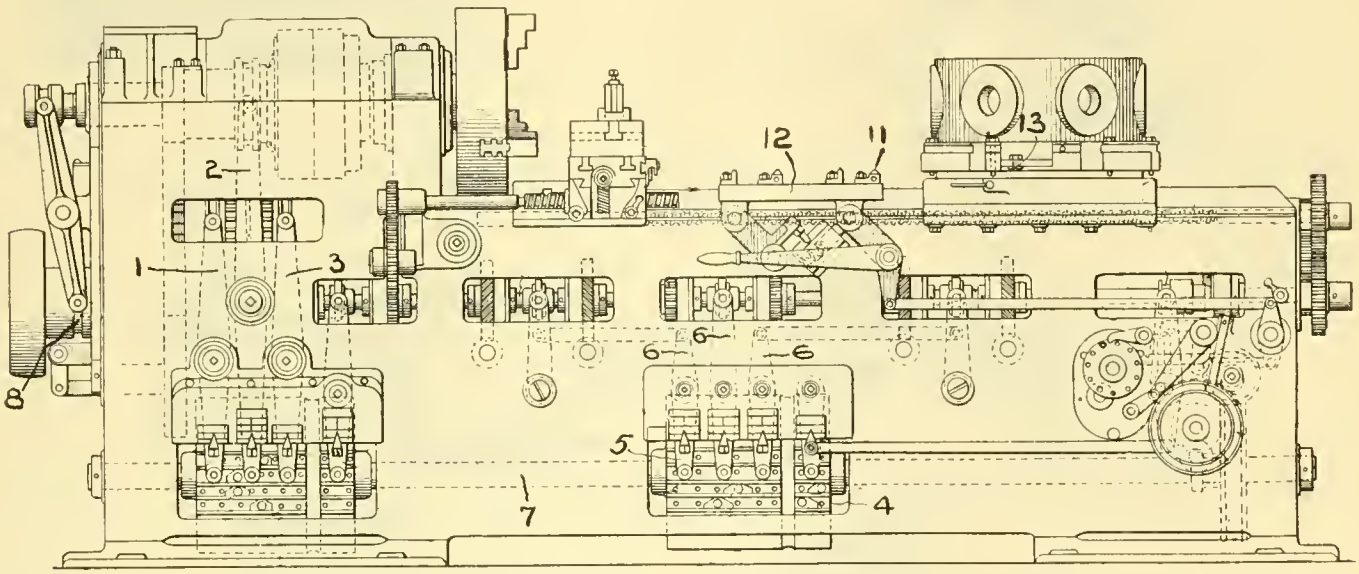

FIG. 1 AUTOMATIC LATHE WITH VARIABLE SPEEDS AND FEEDS CONTROLLED BY DOGS ON DRUMS. GISHOLT MACHINE CO.

I SPINDLE DRIVES

Features of automatically controlled spindle drives may be classified as: *a* Speed change; *b* Reversal; *c* Stopping.

Speed Change. In automatic turret machine work it is often important to have more than one spindle speed available during the operation on a given piece of work, in order that time may be most fully economized.

The automatic change of spindle speeds on machines having a constant speed motor drive is usually provided for by gearing controlled by the mechanism of the machine. Fig. 1 shows the front view of an automatic turret lathe embodying this feature. In this construction any one of eight changes of

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spindle speed can be automatically obtained, the changes being made by means of an intermittently revolving drum carrying dogs which shift levers 1, 2 and 3 as desired. Levers 1 and 3 control clutches to engage gears giving four speeds, and the number of speeds so obtained can be doubled by the operation of lever 2 which either clutches direct to the spindle for the fast range of speeds or connects through differential gearing for a slower range of speeds. The dogs on the drum may be so set as to bring the levers into idle positions, thus disconnecting the gearing.

In types of machines such as cutting-off machines or those on which squaring-up operations are largely performed, a gradual and continuous change of spindle speed is desired. A means for automatically accomplishing this is shown in Fig. 2. The automatic shifting of the belt on the tapering cones gives the desired change of spindle speed. Cam 1 is connected by gearing to the tool carriage of the machine and controls the traverse of the belt shifter 2, so that by providing the required accelerating lead to the cam, a constant cutting speed is obtained.

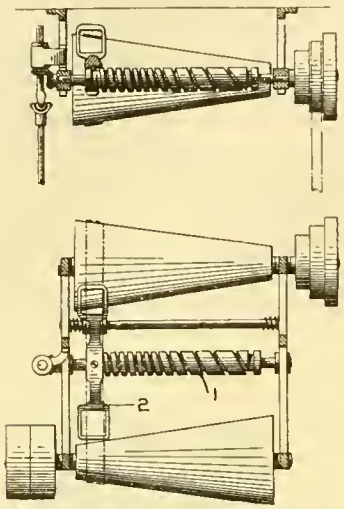

Fig. 2 Countershaft for Cutting-off Machine to Give Constant Cutting Speed

Reversal of Spindle. In designs of machines where the threading or other operations require a reversal of the spindle, this is automatically accomplished in various ways, an example being shown in Fig. 3. From the constant speed shaft 1, the spindle 2 is driven in either direction and at various speeds, the control being automatic for direction and for one change of speed. Other changes of speed are by means of change gears 4. The reverse is obtained by shifting thimble 5, engaging respectively friction clutches 6 connected by chain and sprocket with the oppositely revolving shafts 1 and 3. The shifting of the thimble is by means of a lever operated by a cam on an intermittently revolving shaft. The intermittently revolving shaft is in turn set in motion by a trip lever operated by dogs on a continuously revolving disk. The automatic change of spindle speed is by means of thimble 7 engaging respectively clutches 8 also operated by lever connection to a cam on an intermittently revolving shaft.

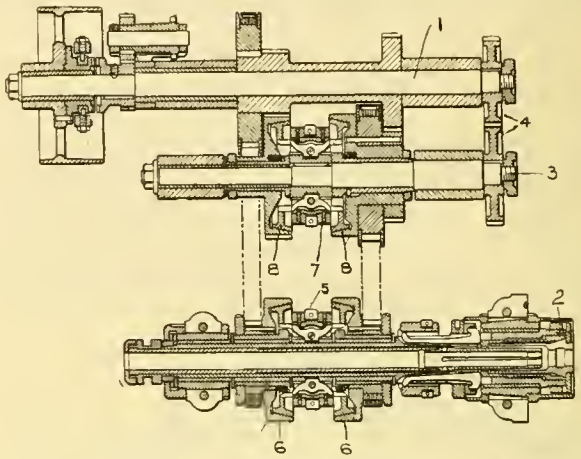

Fig. 3 Constant Speed Drive for Screw Machine Provided with Automatic Reverse and Speed Change. Brown & Sharpe Mfg. Co.

Automatic Stopping of the Spindle is required for various kinds of work. Some screw machines are so designed as to unthread the die or tap by stopping the work spindle to run the die or tap off after the threading operation. Sometimes the spindle is stopped to perform a milling, cross drilling or similar operation, and sometimes to save time in removing and replacing work when this is a hand operation.

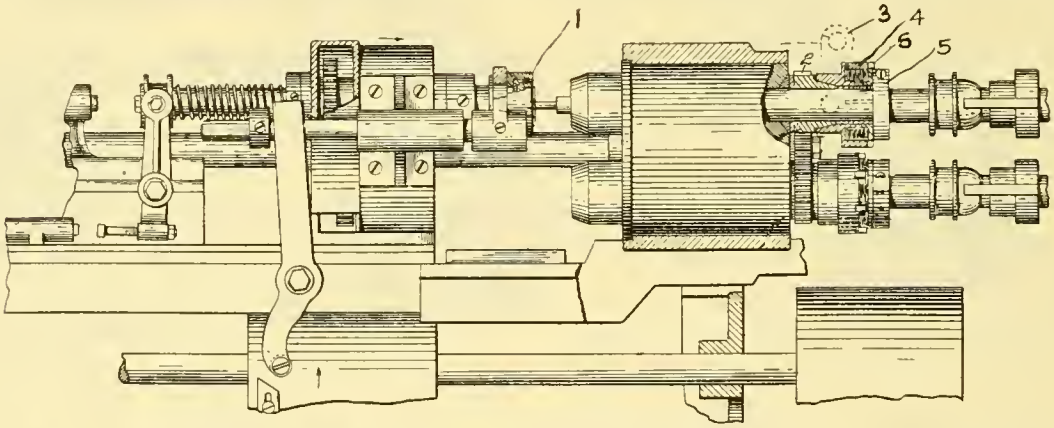

Fig. 4 Multiple Spindle Screw Machine Having Means for Automatically Stopping the Spindle. National Acme Manufacturing Company

An automatic screw machine having the feature of stopping the spindle for the purpose of threading is illustrated in Fig. 4. The revolving tap or die spindle is shown at 1, and when each successive work spindle is brought in line with it, a clutch on the constantly revolving gear 2 is disengaged by the lever 3 operated by a cam through a series of levers. This lever 3 engages a sleeve 4 which is normally in spring pressed engagement with gear 2, disengaging same from gear 2 and engaging it with collar 5 which is fast to the spindle and which constitutes a brake to stop the spindle from revolving. For heavy

work, where a positive stop is desired, a pin in collar 5 engages projections 6 on sleeve 4.

A modification of spindle-stopping means is to revolve intermittently or index the work spindle for various operations.

II MEANS FOR INSERTING AND REMOVING THE WORK

Means for Feeding and Holding Bar Stock. Bar feeding devices have in a general way followed the lines of the hand operated Parkhurst feed, brought out in the shops of the Pratt & Whitney Co. about 1871. The use of feeding fingers and roller feeds, in the latter case necessarily feeding against a positive stop, are forms of development which have since followed. In the former case graduated levers or scales determine the distance the stock is fed.

An illustration is shown in Fig. 5 of an automatic feeding device which can be adjusted so as to feed any required distance from zero to the full traverse of the machine. By means of the crank 1, the screw 2 adjusts a nut carrying a block 3, so that the motion of the lever 4 operated by a cam may give any desired feed to the slide 6 and thus to the feed tube, the setting being to a graduated scale. At the forward end of this feeding tube are feeding fingers to engage the bar of stock to feed it forward. After the stock is gripped by the chuck by means of chuck levers operated by a cam, the feeding fingers are retracted ready for the next operation.

By means of a special device, the machine can be stopped when the bar of stock becomes exhausted.

A well-known design of the roller principle for feeding the stock is shown in Fig. 6, where the rollers 1 engage the bar of stock and feed it forward against a stop. The driving means for the rollers consists of the circular rack 3, on the intermittently revolving ring 2, which, when held stationary, revolves the gear 4, which in turn revolves the worms 5 and the worm wheels 6, the latter being fast on the shafts carrying the feed rollers.

Means for Inserting and Removing Chucked Work. This may be considered through successive stages from the hand-operated method of the Fay automatic lathe, where the work, when it is to be finished on an arbor, is driven on one arbor by the workman so as to be ready to replace the piece being operated on when that is finished, the automatic feature in this case being the stopping of the spindle as already described.

Magazines for handling work to be chucked automatically have developed along many lines. Fig. 7 shows a tilting magazine attachment with the magazine 1 in position so that the conveyor 2 can advance to take a piece of work. After the piece of work is taken by the conveyor the magazine tilts up out of the way of the turret tools. The conveyor 2 then brings the piece in line with chuck 3 and deposits it in same. The conveyor is free to revolve so as to facilitate the pressing of the work into the revolving chuck. An ejector inside the spindle removes the work when completed.

A form of hopper for feeding studs into the rear end of the spindle is shown in Fig. 8. This might be called a reservoir magazine, as it has a widened upper portion to carry a large number of pieces. An agitator 1, operated by a lever 2, makes the feeding sure. The frame 3 is adjustable for different lengths of studs. The studs are fed positively into the back end of the spindle by the rod 4.

Large or irregular work presents many difficulties in automatic chucking, and hand methods are usually resorted to for such work. In some cases, however, automatic means have been devised for the chucking operation.

Even when placing the work in the chuck by hand, automatic devices can be made to assist in many ways. Fluid or pneumatic means can be employed for gripping the work, and this can be so applied as to reduce the pressure for the finishing cut, still maintaining sufficient to hold the work securely but without risk of distortion. Means for automatically ejecting the work can also be applied.

Means for Transferring Work for Secondary Operations. It is a common practice to transfer work from the main spindle to an auxiliary spindle or holder, after part of the operations have been performed, for additional operations such as milling, cross drilling, etc.

Fig. 9 shows a transfer holder in use for slotting the heads of screws. The transfer arm 1 is swung by the rock shaft 2 so that the hole 3 is in line with the work 4 in the main spindle and engages same before the work is severed from the rod. After the work is severed the arm 1 is swung to the position shown in the illustration. The rock shaft 2 is then fed longi-

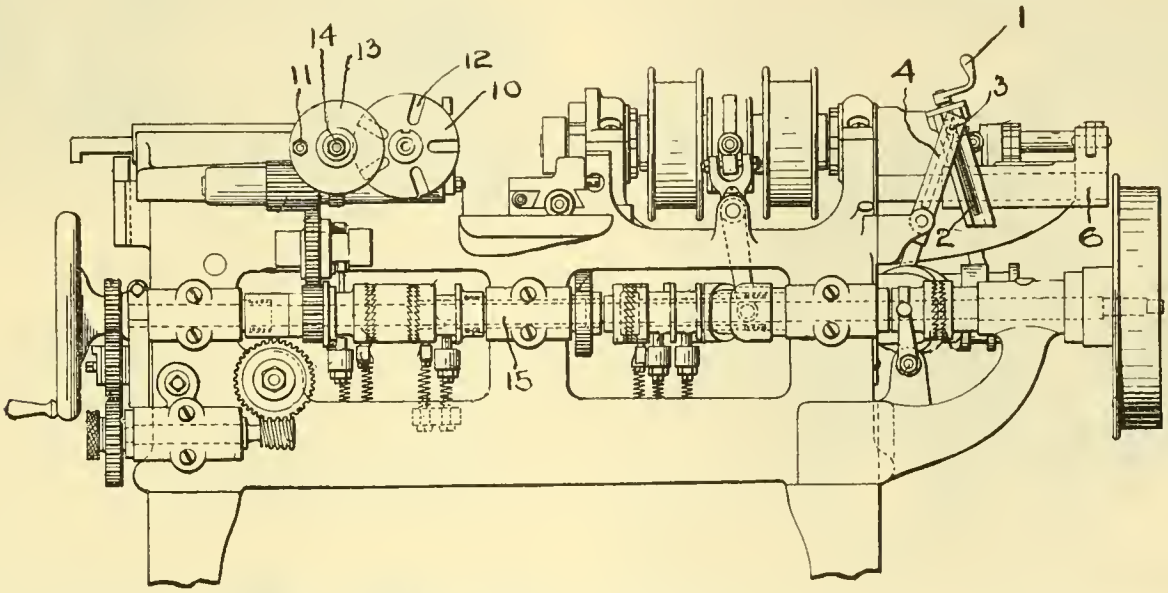

Fig. 5 Automatic Screw Machine Showing Feeding and Indexing Devices, also Use of Controlling Shaft. Brown & Sharpe Manufacturing Company

tudinally toward the saw 5, both this motion and the rocking motion being imparted by cam action.

The transfer holder can be made to turn the work end for end if desired.

III FEEDING MECHANISMS

Feeding mechanisms may be classified by the methods of controlling the movements by removable strap cams; by permanent cams, and adjustable cams and dogs; by adjustable dogs on drums; by cams specially formed for each job, and by permanently set dogs in combination with adjustable stops. The object to be attained by all these means is to save time by speeding up during the idle movements, and to provide the most efficient feed for each operation of cutting by providing a change of feed which can automatically be made effective during the operation of cutting.

Controlled by Removable Strap Cams. This type had its origin in the Spencer machines, first brought out in the early

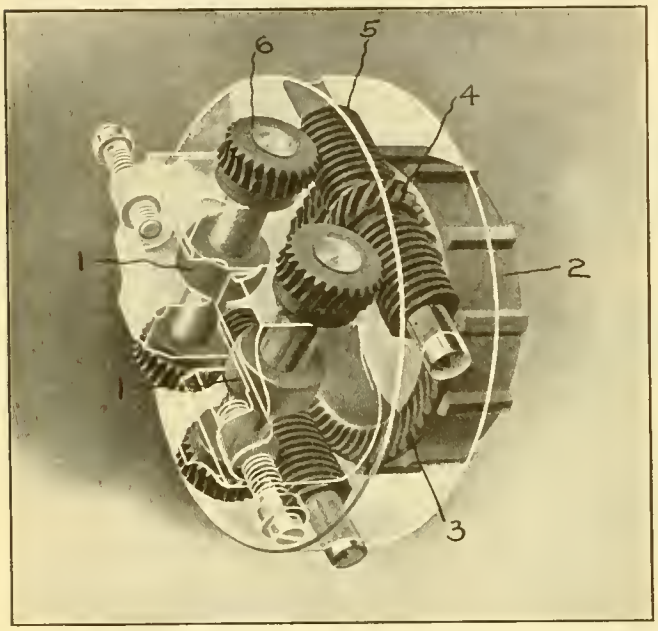

Fig. 6 Roller Feed. Jones & Lamson Machine Co.

70's. A recent development of this type of machine and one also designed by Mr. Spencer is shown in Fig. 10. In this machine the stock feeding mechanism, the tool feeding mechanism and the cross feeding mechanism are all operated by adjustable strap cams. In the case of the two former, the straps are on the periphery of drums shown at 1 for the stock feed and at 2 for the tool feeding mechanism; in the case of the last, as well as for indexing and locking the turret, they are on the faces of disks (shown at 3 for the cross slide and at 4 for the indexing).

The machines of the Hartford Automatic Screw Machine Co. in this country, and of the Alfred Herbert Co., abroad, are among the best known examples of the use of this method of camming.

Controlled by Permanent Cams and Adjustable Cams and Dogs. An example of the combined use of permanent cams with adjustable cams and dogs is shown in Fig. 11, where the feed of the individual tool holders 1 is controlled by the permanent cam 2. The rate of revolution of this cam 2 is controlled for varying the feeding movements by an adjustable cam 3 which through roll 4 governs the position of friction

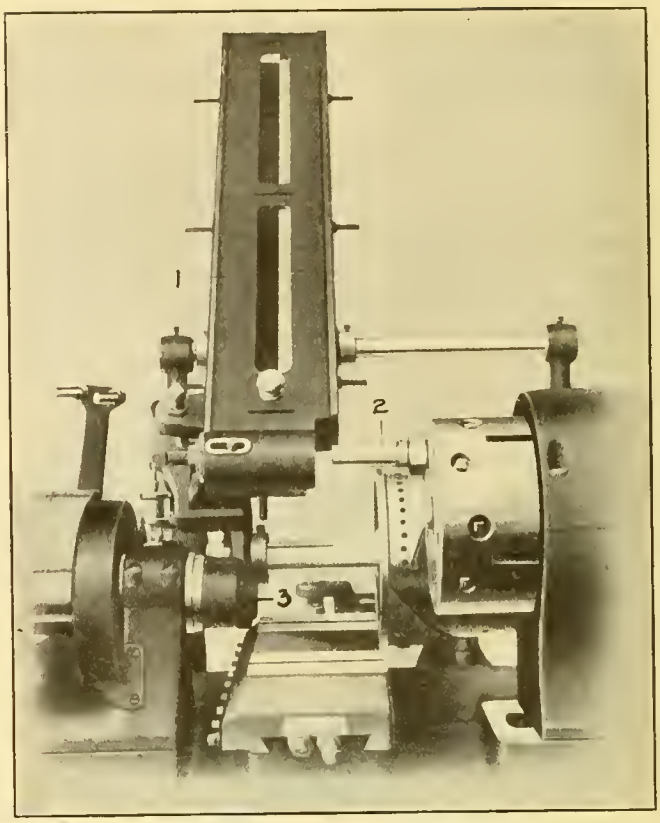

Fig. 7 Tilting Magazine Attachment. Cleveland Automatic Machine Company

wheels 5 between the disks 6. Besides this variable feeding movement, a quick movement of the cam 2 is obtained by action of the cam 7 which operates a double clutch 8 to connect either direct, giving a quick movement, or through the reduction gears 9 for the feeding movement.

The strap cam 10 regulates the cross feed, and this cam also

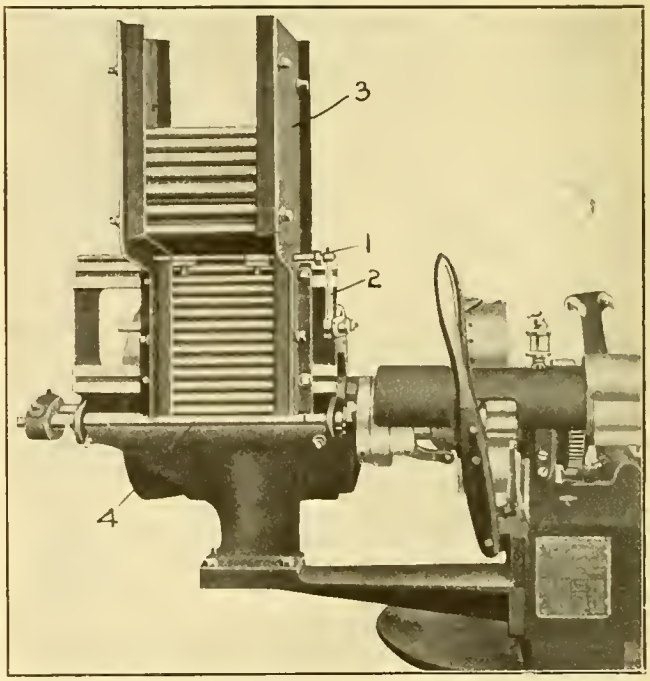

Fig. 8 Vertical Hopper Magazine. Cleveland Automatic Machine Company

partakes of the quick and slow movements controlled by clutch 8; it thus provides for moving the cross slide forward quickly to the point of cutting and then reducing to the required cutting feed, after which it may be quickly returned so as to bring the rear tool into cutting position following which the feeding movement is again engaged.

Controlled Entirely by Adjustable Dogs on Drums. The machine shown in Fig. 1 has its movements controlled entirely by dogs on intermittently revolving drums, the only exception being the back facing device which is controlled by a permanent cam 8. For the turret the feeding is controlled by means of dogs 11 on the hinged carriage 12 engaging adjustable tripping blocks 13 on the turret, providing an independent tripping point for each tool of the turret.

Controlled by Cams Specially Formed for Each Job. The advantages aimed at by this method are the securing of the ideal conditions as to rate of feed, etc., for each operation, and the minimum time for idle movements, and being able to duplicate readily these results for the same job at any future time, the cams being marked and preserved for this purpose.

The cam operated turret feed mechanism of such a machine is shown in Fig. 12. The advance feed is obtained by the cam 1 operating through the segment lever 2 to feed the turret slide 3. The return motion is accelerated by the revolution of the crank 4 bringing the turret back quickly an amount equal to the throw of the crank.

The cross feed slides, which are independent of each other, are also operated by special cams adapted to each particular job.

In a machine for high speed work it becomes important, both in securing the desired speed and in avoiding objectionable shock, to move and reverse the lightest possible parts. For this reason machines having turrets of the "revolver" or "barrel" type, in which each spindle can be fed independently, are specially adapted to high speed work. In such machines each tool carrier is connected successively with a reciprocating feed slide, and only the feed slide with one of the tool carriers connected therewith requires to be reciprocated for the feed and return movements. Fig. 11 shows a machine of this type. In order to "speed up" still further this type of machine, the use of an auxiliary slide has been resorted to, this auxiliary slide alone being moved during that part of the quick return movements required to retract each tool and even this being disconnected for the remainder of the return movement, thus avoiding the shock which would result from the rapid movement of these slides.

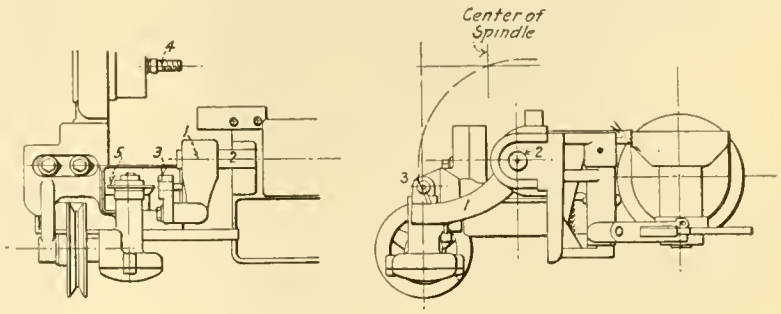

Fig. 9 Transfer Arm for Secondary Operations. Brown & Sharpe Mfg. Co.

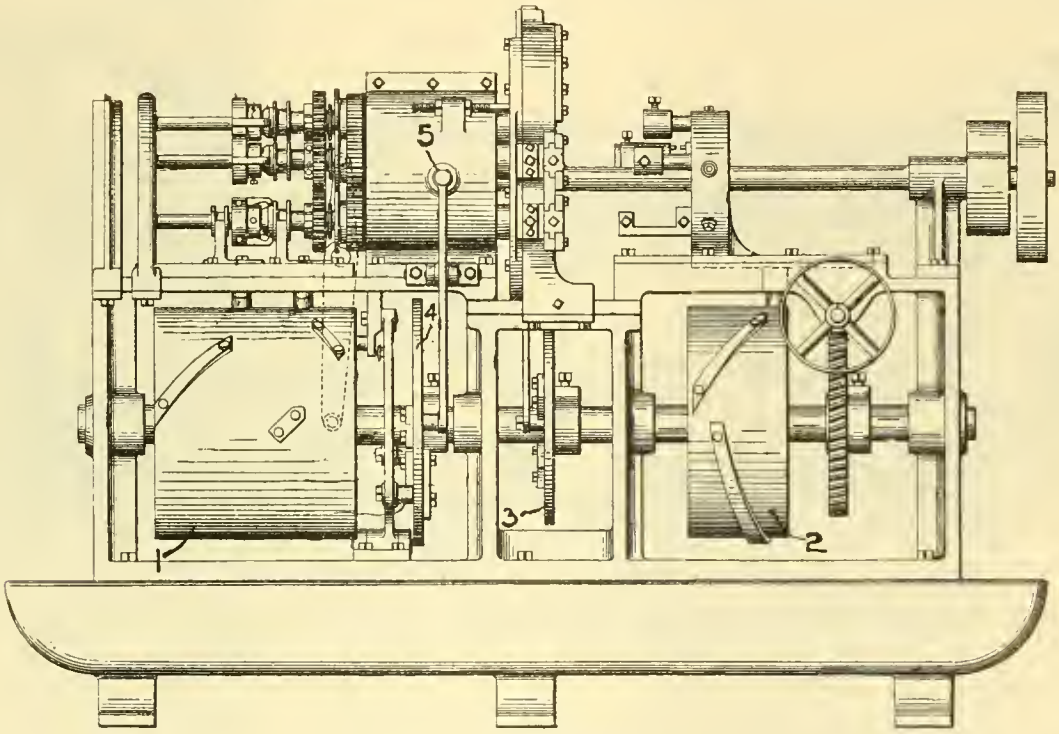

Fig. 10 Spencer Type Multiple Spindle Machine Showing Use of Strap Drum Cams. New Britain Machine Co.

Mechanism Controlled by Permanently Set Dogs in Combination with Adjustable Stops. This is a feature of the Bullard Mult-au-Matic vertical lathe, Fig. 13. This lathe has been classed by the American Machinist as a "station type machine" because the workman inserts and removes the work at one station or indexed position of the machine, while tools in the remaining positions are performing successive operations on other pieces.[1]

In this machine the rods 1 and 2 carry dogs which engage stops on the frame of the machine and trip respectively the advance and return feed movements. The quick traverse mo-

[1] For description of this machine, see American Machinist, vol 40, no. 5, p. 177.

tion, which, in addition to retracting the tools quickly, can also bring them quickly forward to the point of cutting, is operated through gears 3 and 4 controlled by clutches. The advance feed for cutting is through bevel gears 5 and change gears connecting shafts 6 and 7, the worm 8 on the shaft 7 driving worm-wheel 9. These two trains of mechanism give the desired advancing and retracting movements through connection with screw 10.

IV INDEXING MECHANISMS

Under indexing mechanisms will be treated: *a*, method of revolving turret, *b*, method of locking and clamping turret, and *c*, rectifying the indexing.

Method of Revolving Turret. A well-known method of indexing automatic turret machines is by the use of the principle of the geneva stop. This has the advantage of giving a slow starting movement gradually, accelerating and slowing down before reaching the stopping point, thus securing rapid indexing and at the same time avoiding shock. An illustration is shown in Fig. 5 where the turret 10 is indexed by the engagement of a pin 11 in the slots 12, the disk 13 carrying the pin being intermitently revolved on the shaft 14.

Methods of Locking and Clamping the Turret. It has been the general practice in turret machines to have a locking pin to automatically engage to insure the accurate alignment of the turret with the spindle and to hold the turret firmly in position while the tools are operating. Such locking pins are shown at 5, Fig. 10, and at 5, Fig. 12. In addition to the use of a locking pin, a further clamping device is often used which automatically clamps the revolving turret securely to the slide or bed and unclamps it before the next indexing.

An example is shown in Fig. 14 where the turret 1 is clamped to the turret slide 2 by the central stud 3 which is forced downward by a camming action on the projecting lugs 4. This camming action is produced by the revolving of gear 5, this gear in turn being acted on by a rack controlled by dogs acting at the desired point of the return motion of the turret slide. The locking pin for the turret is also operated from this same rack, and thus is timed with the clamping device.

Means for Rectifying the Indexing. In multiple spindle machines it is more difficult to secure accurate indexing and thus produce accurate work than in single spindle machines, because of the mechanical difficulties of constructing the machine. It is difficult to bore the spindle carrying head and mount the spindles in it so that they will be equally spaced and equidistant from the centre. To overcome such inaccuracies as are due to this cause, rectifying stops have been employed as shown in Fig. 15, one for each cross tool carrier. These consist of a series of pins 1 projecting from the disk 2, which disk is secured to the front end of the spindle head. These pins are engaged by coöperating stops 3 on the tool carriers 4 and are made so that the cutting edges of the tools carried by the tool carriers 4 will be exactly the same distance from the centre of each spindle when the pins and their coöperating stops are engaged, thus tending to counteract the inaccuracy above referred to, or any which may result from wear in the machine.

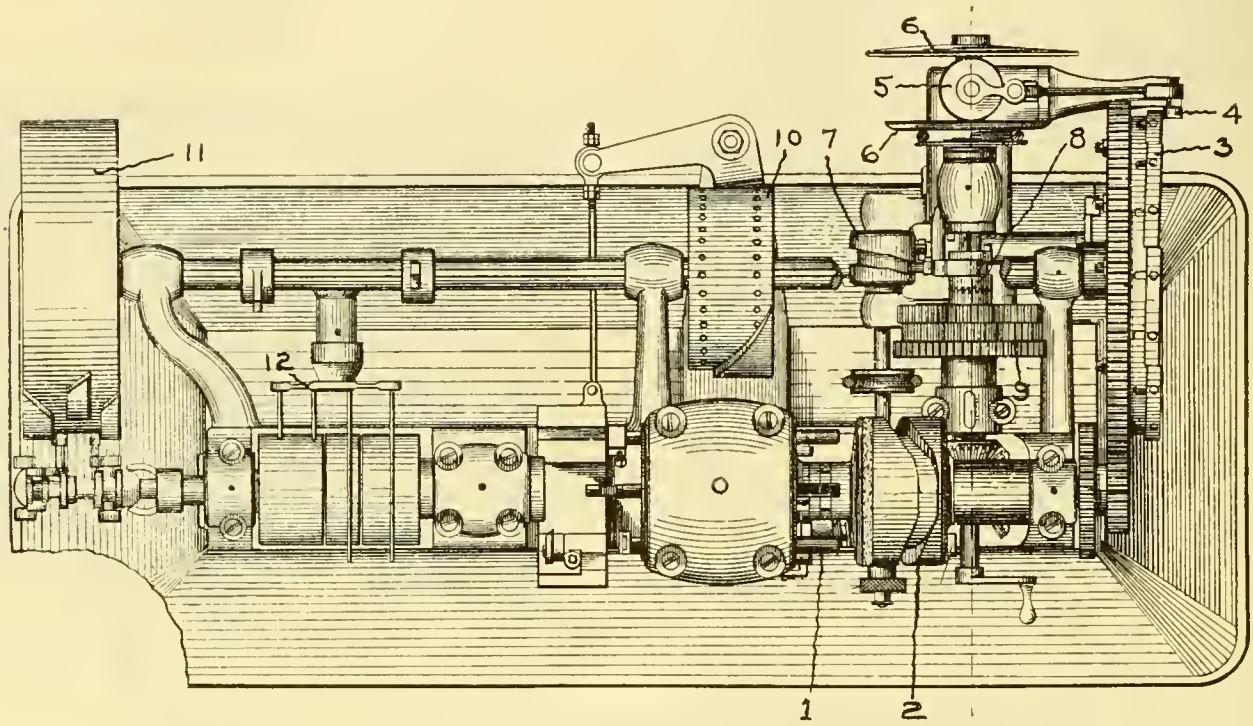

Fig. 11 Showing Control by Permanent Cams and Adjustable Cams and Dogs. Cleveland Automatic Machine Co.

V CONTROLLING MEANS FOR THE VARIOUS MECHANISMS

Aside from the ordinary practice in directly controlling the various movements of an automatic turret machine, Mr. Flanders in his paper[1] has pointed out that the use of a controlling shaft or, as he terms it, a "lay shaft," constitutes a separate type of control.

A machine with this type of control is shown in Fig. 5, where the shaft 15 drives the various mechanisms of the machine, except the spindle, and by means of clutches controls their operations.

The shaft 7 in Fig. 1 may also be said to be another type of controlling shaft, as through the interposition of dogs and levers it controls the various operations of the machine al-

[1] International Engineering Congress, 1915.

though it does not drive them. It is an application to what Mr. Flanders terms the screw feed type of machine. The Bullard machine, Fig. 13, is also of this type.

AUTHOR'S NOTE

It will be understood that in the limits of such a paper as this it is not possible to describe all machines and mechanisms devised for performing the various functions discussed. It has been necessary to select a few only and as far as possible the selections have been made of those which are typical and in the main of such as are in actual use.

DISCUSSION

C. M. Conradson[1] contributed a written discussion in which he reviewed the subject of hydraulic and pneumatic control for machine tools, citing the following as examples of the application of such control:

A device for feeding a gang drill by a direct acting hydraulic cylinder by Jesse Walrath, Supt. of the J. I. Case Threshing Machine Co., was in operation in 1889. It consisted of a multiple drill in which the table was fed up against the drills by a cylinder and piston. Pressure liquid was supplied by means of a constant discharge piston pump, the speed and stroke of the pump being such as to feed the drills correctly. A simple hand controlled valve regulated the flow of the pressure liquid to the cylinder and its escape. This machine was operated for many years and was perfectly satisfactory.

About the same time the pneumatic chuck was brought out and patented by a Chicago inventor. This patent disclosed all the essentials of the pneumatic chuck, consisting of a collet, closing tube, axial pressure cylinder with piston, retracting means, and three-way actuating valve.

F. W. Taylor, while superintendent of the Midvale Steel Co., designed and patented a hydraulic device for taking up the backlash of the forming slide used to form steel tires in the boring mill or lathe. This device merits the closest study, as it strikes at the root of the most serious trouble encountered in the use of broad cutting tools in machines. Taylor initially strained the tool holder in the same direction as it was strained by the cut, and thereby overcame chatter and "hogging in."

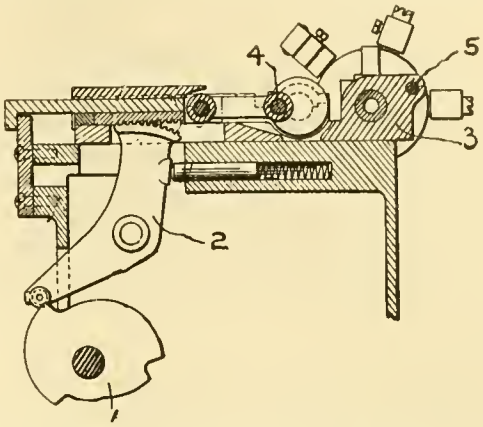

Fig. 12 Feeding of Turret Slide by Cam Specially Formed for the Job—Additional Quick Return Device. Brown & Sharpe Mfg. Co.

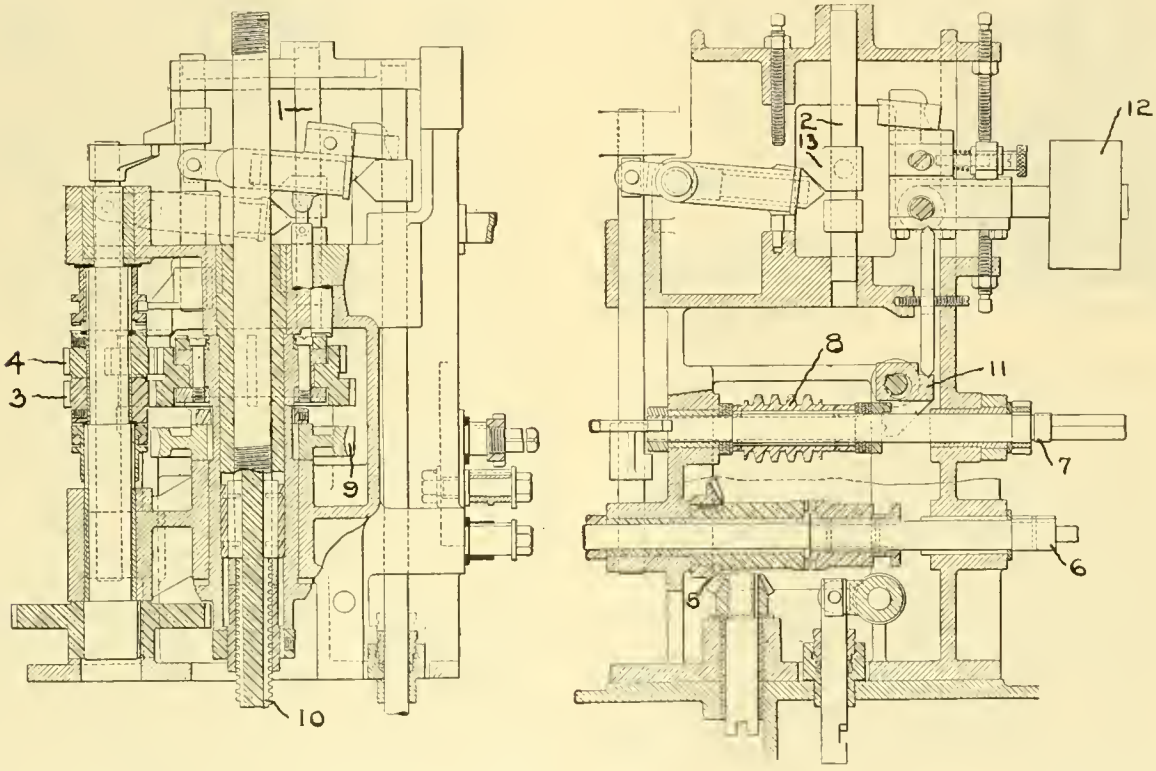

Fig. 13 Tool Device Having the Feature of Tripping the Feed if Pressure on Tool Becomes Excessive. Bullard Machine Tool Company

Taylor also invented and patented an extremely ingenious feed motion for boring machines, consisting of an axial cylinder and piston acting directly on the boring tool and restrained by means of a mechanical let-off device consisting of a threaded bar, a rotary nut, and suitable actuating mechanism, which rotated the nut at the proper rate to secure the desired feed. The hydraulic piston supplied the necessary pressure to feed the tool to the cut. By this means all backlash was eliminated, as well as the tendency to dig in.

Probably the first example of an hydraulically actuated

[1] Phoenix Mfg. Co., Eau Claire, Wis.

automatic machine tool is afforded by the writer's automatic lathe patented in 1893. In this machine a differential cylinder made integral or attached to the frame of the lathe actuated a piston attached to the turret slide. Pressure liquid was supplied to the large end of the cylinder by means of an automatically actuated valve controlled by an adjustable stop bar geared to rotate in unison with the turret. This stop bar was arranged with its axis parallel to the axis of the lathe and was carried by the turret-slide. The bar was hexagonal in general outline, and on each of its faces were arranged cam blocks for controlling the valve; as the cams came into action successively, it was possible to begin feeding at any desired point for each tool, and also to stop feeding at any point. The rapid traverse of the turret was likewise controlled by the stop bar, and was very rapid.

In a machine built in 1892, the traverse of the turret was 75 ft. per min. While this machine worked perfectly in all shop tests, further experience showed the desirability of changing the throttling control to a positive feed obtained from a variable delivery pump.

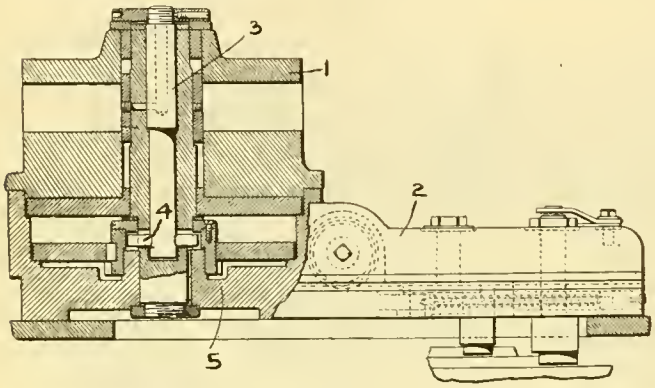

FIG. 14 CLAMPING DEVICE FOR TURRET. POTTER & JOHNSTON MACHINE COMPANY

James Hartness developed a hydraulic feed turret lathe in which the turret was actuated by a cylinder and piston; the chief novelty of this machine was in the method of obtaining the pressure liquid by means of compressed air acting on the surface of the liquid contained in a tank.

Pneumatic clamping of work in jigs was developed largely by B. M. W. Hanson, Supt. of the Pratt & Whitney Co. Such jigs are now in general use in automobile factories for holding cylinder, pistons, etc., while being operated on. Pneumatic clamps are used on plate planers to great advantage. Pneumatic vises have been in use for several years for assembling valves, fittings, etc.

Pneumatic chucks are generally used for rapidly chucking work on lathes, screw machines, etc. They are made in the original form, using collets, and also are made with radially moving jaws. This type of pneumatic chuck is especially valuable, as false jaws can be readily fitted. It can also be made to any size desired, and is in use for holding car wheels.

The writer has recently patented the application of the pneumatic chuck to multiple spindle lathes, each spindle being provided with a cylinder and piston, communicating piping, and individual valves by which the chucks can be opened and closed when the spindle is in chucking position.

B. M. W. Hanson patented in 1909 an automatic lathe operated by fluid pressure. The claims were especially directed to the indexing mechanism, all of the motions being controlled by a number of pistons.

Perhaps the most complete example of a fluid pressure controlled machine tool is found in the writer's multiple spindle automatic lathe. This was described in detail in the *American Machinist,* June 25, 1914. The power and precision of hydraulic control is strikingly examplified in these machines. In the large size, the spindle carrier weighing more than 10 tons is handled with perfect ease and is locked with perfect accuracy.

An illustration showing the exceedingly close limits attainable by the use of fluid control is the pneumatically actuated plate drilling machines employed by the Waltham Watch Company. In these machines, the watch plate is mounted on a platen arranged to move in two directions at right angles to each other. These motions are obtained by pneumatic cylinders and pistons, and are limited by rotating stop bars. The machine is automatic, and the work produced has necessarily to be practically perfect.

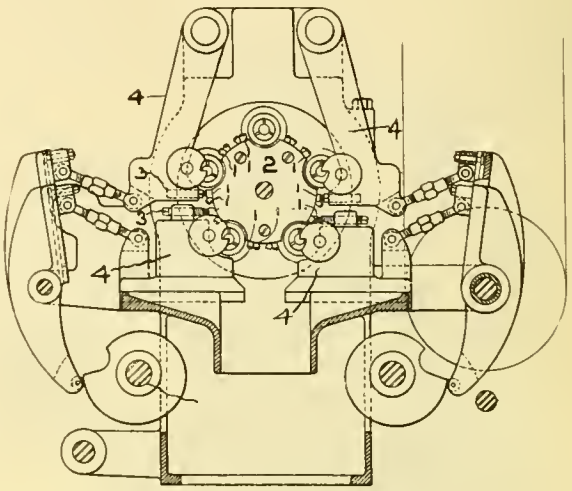

FIG. 15 MEANS FOR RECTIFYING THE INDEXING OF MULTIPLE SPINDLE MACHINE. DAVENPORT MACHINE CO.

In the hydraulically actuated shaping machine designed by the writer, the cylinder is cast integral with the frame and the piston rod is attached at the ends to the ram. The piston is in the central part of the rod, and pressure liquid is alternately admitted to the ends of the cylinder through suitable ducts. A multi-cylinder valveless pump is employed, having a shifting crank pin. The crank pin is shifted from side to side by means of an escapement tripped by tappets on the ram; the effect is to reverse the flow of the liquid and thereby cause reversal of stroke. In one particular size of this machine, the relief valves are set at 400 lb. per sq. in., giving an available pressure at the tool point of 5 tons. The ram travels up to 100 ft. per min. in either direction and without change, other than that the tool holder can be used for either push or draw out. The pressure in the cylinder rises in accordance with resistance due to cut.

A recent development in hydraulic control is the grinding lathe built by the Greenfield Machine Company; in this a stationary cylinder is employed, the piston being attached to the platen of the machine. A valve actuated by tappets operates to admit and exhaust pressure liquid to the cylinder.

A very important use of hydraulic or pneumatic pressure is for operating friction clutches for starting, stopping, or reversing moving parts. These clutches are very similar in many features to the air chuck, and are used with great success in planers, slotters, lathes, etc. Such clutches have been designed by Wm. Sellers & Co. and by John Riddell. The pneumatic clutch is easily operated, is very durable, and possesses the

great advantage that it is self-compensating for wear. Weston hydraulic clutches have been built transmitting up to 1000 h.p. At the present time, when the use of compressed air is nearly universal in machine shops, it is actually cheaper in many cases to use pneumatic clutches than mechanically actuated clutches.

There are many minor uses for compressed air in machine tool practice, such as lifting clapper boxes of planer, lifting planer tools directly out of the cut, actuating tools on automatic machines, etc.

Ralph E. Flanders. One of the things in favor of the hand machine for large work is that with it higher speeds and feeds can be used in many cases than in an automatic machine. On an automatic machine the speeds and feeds have to be kept down to such a point that nothing serious will happen while the operator is away, attending to one of his other machines. The operator running the hand machine has his eye on the work constantly, and it is safe to run at speeds and feeds which are not safe for an unattended machine.

Furthermore, at times the automatic machine has to be so set that the slow feeding movements will start at a reasonable length of time before the tool actually strikes the work, losing a little time there. This does not mean that the automatic machine will not occupy a larger field every year in certain kinds of work.

One further type of mechanism should be added to the classification of spindle drives. This is the type where a change is made in the relative movement of work spindle and tool carrier. Each one of the author's speed classifications comes under this head of change in the relative movement, strictly speaking; but the particular application I have in mind is used, if I remember correctly, on the Gridley multiple spindle. In that machine the tap or die may be run at a slower rate of speed than the work for threading on, and then at a faster rate of speed than the work for threading off, without changing the rate of speed of the spindle. Perhaps, therefore, this feature does not come in the classification of spindle drive at all, though it has the effect of some of the other methods Mr. Burlingame has mentioned under this classification.

Elmer H. Neff. Mr. Burlingame's paper would appear to use the word "control" with a different interpretation from the paper presented by Mr. Brooks. The latter has used the word "control" in the ordinary sense relating to the method of conveying to the machine tool its power for operation, while this paper covers the field of devices applied to screw machines and lathes for automatically performing the work for which they are designed. In other words it relates to the details of design of the tools. A great deal of interesting information has been collected to cover the elements of the machines as listed in the paper.

I should question the elements, *Means for Inserting and Removing the Work*, and *Feeding Mechanisms* in the analysis. The term feeding mechanism in connection with screw machines has come in actual practice to be confined to the operation of feeding out the bar by a wire feed mechanism preparatory to performing the cutting operations. Mr. Burlingame realizes this as is evident from the use of the term "is fed" later in the paper. I think, however, that the second element above should read, "Mechanism for control of operation of cutting tools." The first element above would be more properly labeled, "Feeding mechanism" or some similar title.

Referring to the paragraphs on speed change, I would suggest as a still stronger reason for having incorporated in an automatic screw machine the possibility of changing its spindle speeds automatically during the series of operations going to make up a finished piece, that the presence of this possibility enables the designer of the tools to secure a larger output from the machine. The reason for this larger output is that some pieces of work, especially in castings, will have cutting operations on diameters quite different in size from each other, so that if the small diameter has to be machined at the same rate of rotation as is demanded by the limitations of cutting speeds on the large diameter, the product of the machine is cut down to a low ebb. A further illustration is in the fact that threading must be done at a relatively slow speed as compared with turning operations.

In former years it was a common idea among those who were prospective purchasers of automatic screw machines, particularly among those who had not used such machines, that a cheaper class of labor could operate them. Experience has shown this idea to be a fallacy. As a matter of fact, if there is any difference at all, it requires a higher degree of skill to operate an automatic screw machine than it does a hand screw machine. The skilled operator attending from four to seven or more machines is sometimes assisted by a helper who can slip a bar of stock through the feeding finger, and throw the starting lever, but that is not operating the machine. These screw machine operators are not necessarily machinists by trade, but they should be highly skilled specialists in this particular work. The statement in the paper with regard to greater skill required to keep the machine in running condition is correct, and evidently is contrary to the statement that less skilled labor can be applied.

Automatic screw machines are successfully performing the work indicated by the following classification:

a Producing pieces from bar stock (bar brass, machinery steel, drill rod, etc.)

b Second end operations on pieces produced by classification *a*. In this section the work is fed into the chuck automatically from a magazine or hopper.

c Machining operations on blanks such as punchings and small castings. The work is automatically fed into the chuck in such cases usually from a chute, the only requisite being that if they are castings they shall not vary in roundness or size more than the elasticity of the chuck will allow.

d Performing the machining operations on pieces inserted by hand in the chuck. These are usually castings of such irregular shape or size that they cannot be handled or inserted from a chute automatically.

I have recommended and installed a multitude of automatic machines during the past 18 years, covering operations along the classifications suggested. I cannot agree with Mr. Flanders in his discussion of this paper that automatic machines must run at a slower speed than hand machines unless his statement should be limited in its application to castings. The machining operations on castings are liable to be considerably curtailed in speed on account of the variations in their hardness, and also on account of the liability that they may have incorporated in them slag or other hard substances that will destroy the cutting tools, and spoil considerable work, before the operator discovers the injury to the tools.

There is no direction in which the general machine tool industry is growing more rapidly than in the field to which automatic screw machines as analyzed above can be applied. The reason for this growth is readily understood by those who have used automatic screw machines because their installation, almost without exception, has shown very large savings in cases

of producing manufactured goods. At the same time it should be noted, in passing, that practically all the gears used in this country are produced on automatic gear cutting machines. Also that the cylindrical grinding machine, which has developed very rapidly, is a semi-automatic machine, that is, one which produces automatically in many cases the finished operation after the piece has been inserted in the machine by hand. Furthermore, some progress has been made in the development of completely automatic grinding machines, which insert their work automatically from a chute.

NORMAN MARSHALL inquired whether it was necessary to install automatic stopping devices on these machines to take care of accidents, and what was the state of their development.

H. K. HATHAWAY said that the contrast between what has been done in the way of automatic control in machine shops and in other lines of industry, had struck him very forcibly in the last few years.

In the textile and other allied industries, particularly, there has been much done in the way of the automatic stopping of machines when anything goes wrong, as well as other features of automatic control. In machine shops, however, the use of automatic control has, comparatively, been very limited.

THE AUTHOR. As to the differential rate of speed of spindle and work, which Mr. Flanders mentions, it is interesting to note that the patent records show that practically every imaginable combination of running forward and backward, starting and stopping, has been patented at some time, probably without the claims being of any great value. All combinations for control of spindle speeds might be classed under one heading, whether they are for stopping the spindle entirely or for slowing it down thus giving a differential speed.

There are some factors of automatic control to which study has been given but which are not included in this paper. One is the supplying of oil to the point of the drill, in a turret machine, so that the oil is shut off as soon as the turret is indexed to another position, and restarted whenever the drill is in line.

I agree with Mr. Neff that the use of automatically controlled machines increases the need of skilful supervision. In fact this statement is made in the paper. It is simply that less skilled men can be used as helpers on automatic machines; but there must be somewhere up and down the line someone with a high degree of skill for the purposes of supervision.

Men who are not fully trained mechanics can sometimes be instructed so as to become skilful in operating automatic machines. These are men adapted to this work, who become skilled in a sense, although not classed as skilled "all around mechanics." I do not wish to convey in the paper, however, any thought but that skilled supervision and skilled men are needed to operate these machines.

In reply to Mr. Marshall, it is a plan in many types of machines to have a breaking or friction point which will break or yield first and thus prevent breaking any of the important parts. The machine so constructed can be readily started up again without waiting for expensive repairs. This feature might be very aptly classed as one of automatic control, but not in the usual sense in which the mechanism for operating the machine is meant.

On the Bullard machine (Fig. 13) is a thrust for the worm which will allow it to give if the pressure is exceeded, and will trip the machine so as to stop its feeding. This illustrates in another way the point made by Mr. Marshall.

ELECTRIC OPERATION AND AUTOMATIC ELECTRIC CONTROL FOR MACHINE TOOLS

BY L. C. BROOKS, SCHENECTADY, N. Y.

Associate-Member of the Society

THE application of electric control to individual machine tools is considered to be one of the most important forward steps in the improvement of machine shop efficiency. The economies resulting from substituting electric drive (either individual or group drive) for the steam engine and long line shaft drive were very effectively outlined before this Society six years ago.[1] Prof. W. F. M. Goss too has stated: "I am convinced that the machine tool of the future is to be an individual motor driven machine, a machine in which we shall not see pulleys, belts or gears."

In the early application of electric motors to machine tools, the motors were started by hand starters, either of the dial, or drum type, the dial type usually being unprotected. However, these conditions are now entirely reversed by use of Safety First requirements and remote controlled automatic controllers.

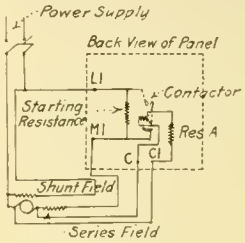

Fig. 1

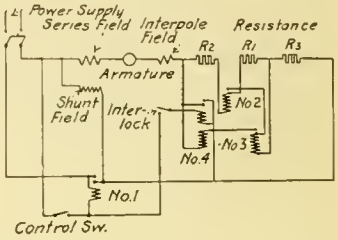

Fig. 2

FIG. 1 CONNECTIONS OF C. E. M. F. AUTOMATIC STARTER

FIG. 2 CONNECTIONS OF SERIES TYPE STARTER

During the past year, the A. I. E. E. has held a series of meetings under the auspices of the Industrial Power Committee. The subjects treated included the characteristics of electric motors; factors involved in motor applications; fields of motor application and controllers. These articles contained a vast amount of valuable data and information relative to their subjects and to present practice, and it is understood that they will be published in a special volume. All who are interested are referred thereto, as any attempt to give an abstract here would be unsatisfactory.

CONTROL APPARATUS

While there are a number of instances and special locations where dial or drum type hand starters are more applicable, we have reached the time when automatic starters, remote controlled (with the possible occasional exceptions of the reversing switch), are the most suitable. The principal advantages of automatic control are:

a The use of manually-operated controllers may cause undue stresses on the motor, especially on rapid reversing equipments

b The operating switch, or push button, is easily attached to the machine and the main panel may be located at a distant point, out of the way

[1] Trans. Am. Soc. M. E., vol. 32, p. 219; also, Proc. A. I. E. E., vol. 29, p. 621.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members; 20 cents to non-members.

c The manufacture of automatic appliances is now a well founded art and is no longer an experiment

d A considerable increase in the capacity of the machines is obtained

e The starting time is automatically regulated to suit the load conditions on the motor

f Accurate stopping points are obtained by the application of *dynamic braking*, which consists in connecting a resistance across the armature circuit in the *off* position of the starter, the stored energy of the armature being dissipated as heat in the resistance

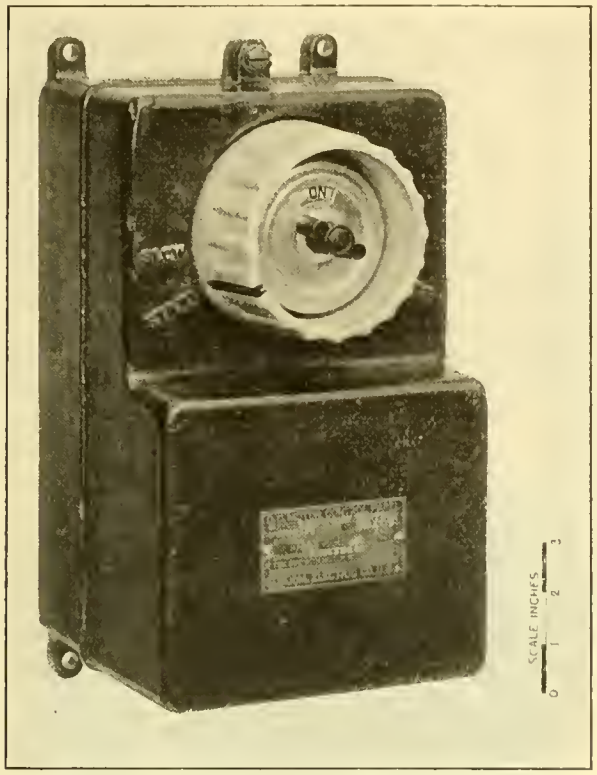

Fig. 3 Starting Panel for Small Motor

g It permits the use of operators not specially trained. It entirely removes the element of thought from the mind of the operator who has simply to operate the master switch or push button in the desired direction and does not need to think about drift points, safety features, etc.

TYPES OF STARTERS

The three general types of automatic starters are time element, counter e.m.f. and current limit. Fig. 1 shows a connection of a counter e.m.f. starter with one step of starting resistance, and line switch in motor circuit. A simplified wiring scheme of a series type of starter is shown in Fig. 2.

All panels, whether for general starting duty, or for control of special machines, should be provided with a suitable enclosing case, for the protection of the appliances on the panel against injury, also for the protection of the operator against accidental contact with current carrying parts. With starters for motors of small capacity the enclosing case should be fool-proof and meet all the applicable Safety First requirements. Under ordinary conditions, the control panels for motors of large capacity should be provided with small openings to allow for the radiation of heat from the current carrying parts. In many cases, it will be found very desirable to make the enclosing case as a part of the casting of the machine frames.

STARTER FOR CONSTANT SPEED MOTORS

A starter for small adjustable speed motors of ¾ h.p. and less, where starting resistance is not necessary, is shown in

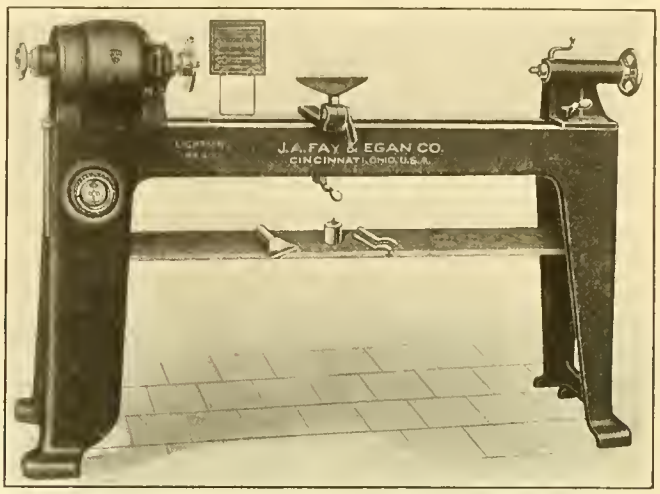

Fig. 4 Woodworking Lathe with Starter in Headstock

Fig. 3. It consists of a line contactor, an overload relay, a field rheostat and connection board, mounted on the insulating base and enclosed in a Safety First case, which is adapted for conduit wiring. This starter is arranged to always start with full field on the motor by simply turning the field rheostat handle to the extreme left, thus closing the line contactor, after which the rheostat handle may be turned to the point for the

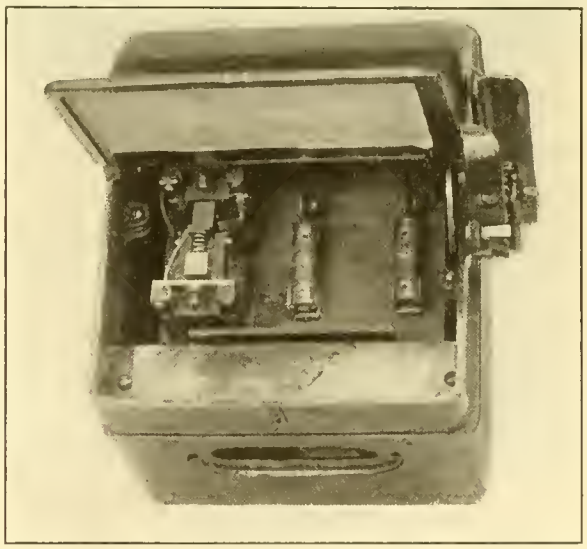

Fig. 5 D. C. Starting Panel. Max. Rating 3 H.P. at 230 Volts

desired motor speed. If desired, an "emergency stop" push button may be located at any convenient point on the machine. This starter is especially adapted for headstock motors, woodworking machines, etc. Fig. 4 shows a wood-turning lathe with the starter self-contained in the lathe frame.

A starter for motors of ¾ to 3 h.p., where one step of starting resistance is necessary, is shown in Figs. 5 and 6. The appliances on the front of the panel consist of line switch and

fuses, (1) contactor, (1) counter e.m.f. accelerating contactor, and connection board. The starting resistance is mounted on the back of the panel. The complete panel is enclosed in a Safety First case, the chief features of which are:

a The switch operating handle may be locked in position, thus preventing unauthorized operation

b A hinged door is provided for the examination of the panel and renewing the fuses

c There is an interlock between the operating handle and the cover of the enclosing case, so that the cover cannot be opened until the switch is open and the switch cannot be closed until the cover is closed, thus preventing any injury to the operator as a result of accidental short circuits. This starter is arranged for push button operation and the enclosing case may be fitted for conduit connection.

For starters of larger horsepower, arrangement *c* would be

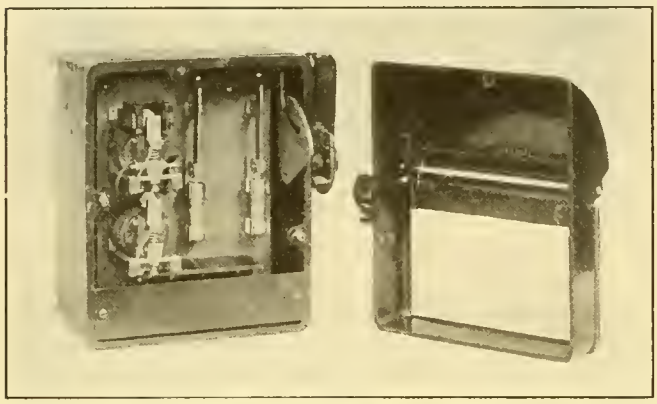

Fig. 6 D. C. Starting Panel. Max. Rating 3 H.P. at 230 Volts

somewhat modified to accommodate the additional accelerating contactors. A double pole line contactor should also be supplied. The questions of type of overload appliance and whether or not a dynamic braking contactor is necessary depend upon the application. The enclosing case should be of sheet steel, for appearance and light weight, and the interlocking features described above are not necessary.

STARTERS FOR ADJUSTABLE SPEED MOTORS

For general service, the starters for adjustable speed motors should be of the same general design as described above for constant speed service.

The starting resistance should be mounted back of the panel, except in the case of large sizes of motors when it should be separately mounted. The field rheostat should be mounted separate from the panel, with the possible exception of small sizes of motors. The method of control should be at the panel or remote, as operating conditions require.

REVERSING SERVICE

For general reversing service, the starters should be of the same general design and requirements as given above for non-reversing, with the following modifications:

a Dynamic braking at the "off" position should be supplied to protect the motor

b Two double line contactors are necessary to give the reversing. In small equipments, a double pole, double throw switch may be used for reversing.

GENERAL SERVICE

The types of starters described above are applicable for all general service, as pumps, fans, drill presses, grinders, milling machines, and boring mills, except in cases where special features are desired.

PROTECTIVE FEATURES

All automatic starters and control apparatus should be provided with protection from low voltage on the line, also from

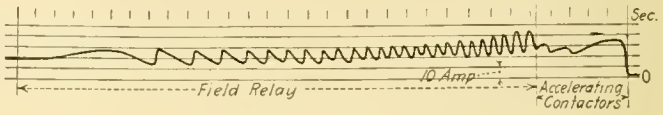

Fig. 7 5 H.P. Motor Starting Current Curve

excessive overload. In all cases, except possibly pumps and fans and similar machines, these protections should be of such a nature as to disconnect the motor from the line, and not to be restarted except by the operator at starting station. For motors of over 25 h.p., the overload protection should be preferably an overload relay, either hand or electrically reset, as operating conditions require. For motors below 25 h.p., the overload protection should be fuses, chiefly for economic reasons. The fuse capacity should conform to the requirements of the National Board of Fire Underwriters. In many cases it will be preferable to have the line switch and fuses a part of the distribution system, separate from the control panel.

With adjustable speed motors, it is desirable to set the field

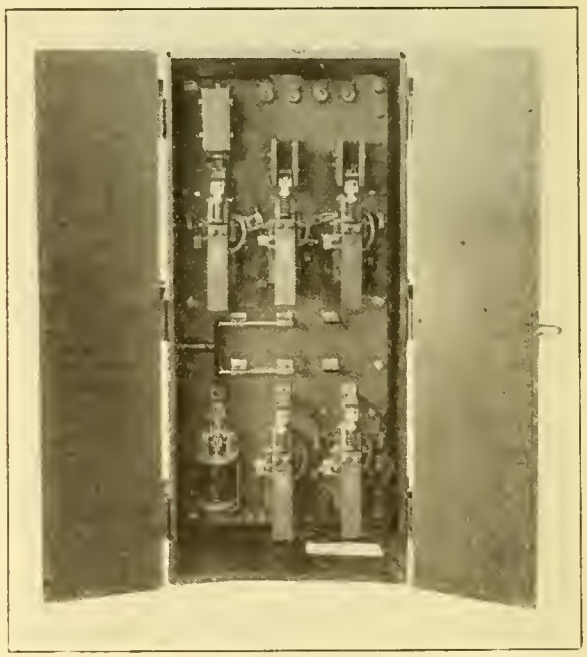

Fig. 8 Wheel Lathe Controlling Panel

rheostat so that the motor will always operate at a predetermined speed. To accomplish this, connections should be such that the field resistance is short-circuited during the accelerating period, thus permitting the motor to start under maximum torque. (This connection to be reëstablished when the motor is stopped, thereby giving maximum torque for the dynamic brake cycle). After the armature resistance is cut out, the field is then automatically weakened to the predetermined point. In order to prevent the motor from accelerating too fast, thereby drawing excessive current from the line, the field accelerating relay should be supplied. This relay is connected in the armature circuit with auxiliary contacts which, when closed, short-circuit the field rheostat and as the relay operates

alternately cut the field rheostats in and out as the motor increases from full field speed to the desired fast speed, thereby preventing the high current inrushes on the motor. This method also permits of quickly obtaining full speed and prevents severe field distortion due to high armature currents. These relays are unnecessary on motors below 5 h.p., and on motors of less than 50 h.p., with a speed range of 2:1, except in special cases where the time of bringing acceleration up to speed, with 150 per cent load, is many times that of the field constant.

Fig. 7 is a current curve when starting a 5 h.p. motor, 500/1500 r.p.m., flywheel load, showing the starting peaks, also how the field relay regulates the current.

With adjustable speed motors of a range of greater than 2 to 1, provision should also be made so that the field resistance is not cut in until the last accelerating contactor has closed, thereby cutting out the last step of starting resistance. Provision should be made so that the motor fields are not energized when the machine is not in use.

With adustable speed motors, too, especially with a range of 4 to 1, arrangements should be such as to prevent a "pump back" when stopping the motor.

On work requiring quick reversing, dynamic braking should be provided at the "off" position of the starting switch. In many cases, as on planers and boring mills, a graduated dynamic braking of two or more points is necessary.

RESISTANCES

In connection with starting apparatus, one of the most important items for consideration is the starting resistance. Except in cases of small motors, cast iron grids are very satisfactory for this service. Cast iron has a temperature coefficient of about 0.0007 and by adding a small per cent of certain alloys, a very high resistance grid is obtained which is suitable for rather small size of motors. For small motors, a high resistance wire, or ribbon, is suitable, which may be in the form of enclosed coils, flat plates or other special forms as the various manufacturers develop the material. A motor starting a load which is subject to infrequent overloads of short duration should have a resistance unit of large thermal capacity, while a motor subject to frequent overloads should have a resistance unit of small thermal capacity in order to give more rapid cooling. In all cases, the resistance units and their mounting should be of rugged construction and properly supported to be conveniently accessible.

The N.E.L.A. has proposed the following requirements for direct-current motors, as to maximum starting current, for 230 volts, which is the average factory voltage:

3 h.p., and below.....12 amperes per h.p.
Above 3 h.p..... 9 amperes per h.p.
No motor may be connected without a starting resistance where the starting current exceeds 30 amperes.

Table I gives the number of steps of starting resistance which should be required for general service. Of course, there will be instances where it will be desirable to depart from this schedule, to meet peculiar operating conditions.

TABLE 1 NUMBER OF STEPS OF STARTING RESISTANCE

Horsepower.....	Below 1 h.p.	1-3	5-25	30-50	60-100	110-200
No. of Steps.....	Direct on line	1	2	3	4	5

APPLICATIONS OF AUTOMATIC CONTROL

With the foregoing general requirements for appliances, and with the following typical special examples described, it is not hoped to have universal agreement. In fact, it is hoped that the criticisms will be wholesome and that other suggestions will be numerous with the result that the Sub-committee on Machine Shop Practice may undertake the task of formulating specifications for standard electrical equipments for machines of the various services.

The importance of standardizing cannot be too strongly emphasized. By this is not meant that the detail appliances should all be of the same design—the various electrical manufacturers can work that part out for themselves—but that the control equipment for a certain type of machine should contain a uniform set of appliances. The space required by every electrical manufacturer would thus be practically the same and the machine could be so designed to accommodate the electrical equipment, with the result that the complete installation would be much neater in appearance and more satisfactory in every way.

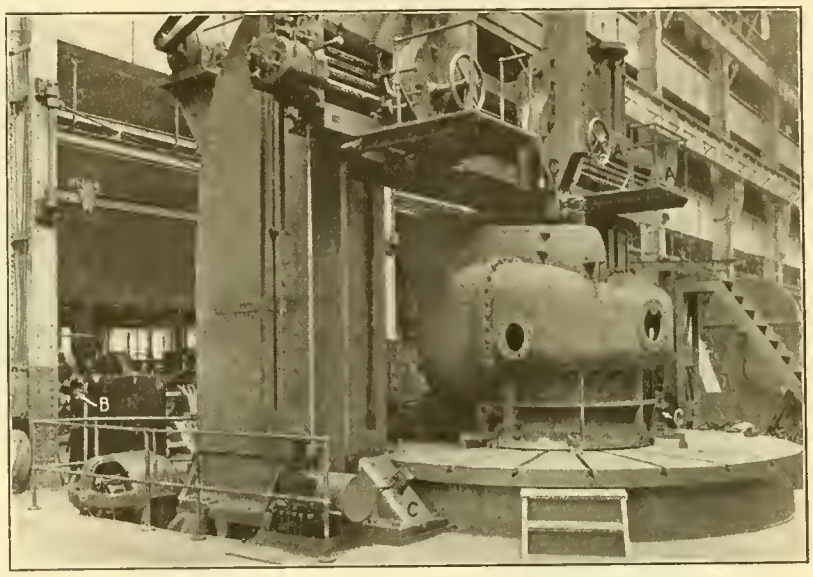

Fig. 9 Boring Mill with 7½ and 50 H.P. Motors

Lathes. At the present time the problem of *purely automatic control* for general lathes has not been entirely solved. For many uses, the drum controller has been found to fill the requirements quite satisfactorily. An automatic starting panel with a drum switch for reversing has given good results for certain applications. Lathes for a special class of work have been controlled with safety and efficiency, so that it is believed the day is not far distant when the goal for general lathes will have been reached.

Car Wheel Lathes. The functions of a car wheel lathe require that electrical equipment be designed for especially heavy service and that the control be reliable and as simple as possible. The equipment should consist of the panel and resistances, a push button station with "start," "stop" and "slow down," and a pendant or foot switch for "slow down," the "slow down" feature being necessary when a hard spot is reached in the cut, and "slow down" being to approximately 50 per cent of basic speed at 100 per cent load. After the "slow" button is pressed, it should always be necessary for

the motor to come to approximately full field speed before it is possible for slow down contactors to be closed again, to limit the "pump back."

The starting, brake, and slow down resistance should be mounted on the back of the panel, when the size will permit, the field rheostat being mounted separately. The enclosing case should be of sheet steel and provided for either wall or floor mounting. A panel for 50 h.p. is shown in Fig. 8.

Boring Mills. The control equipment for a boring mill presents many interesting problems, among which are:

a Where the mill is operating upon heavy castings, it should be accelerated slowly on starting

b Dynamic braking should always be supplied when stopping to insure efficient stops, also to prevent damage to the motor by improper manipulation of the starter

c The control scheme must be such that no possible combination of operating buttons will permit the motor to run on starting resistance when the load is decreased, or produce a "pump back" with consequent heavy sparking at the motor when stopping.

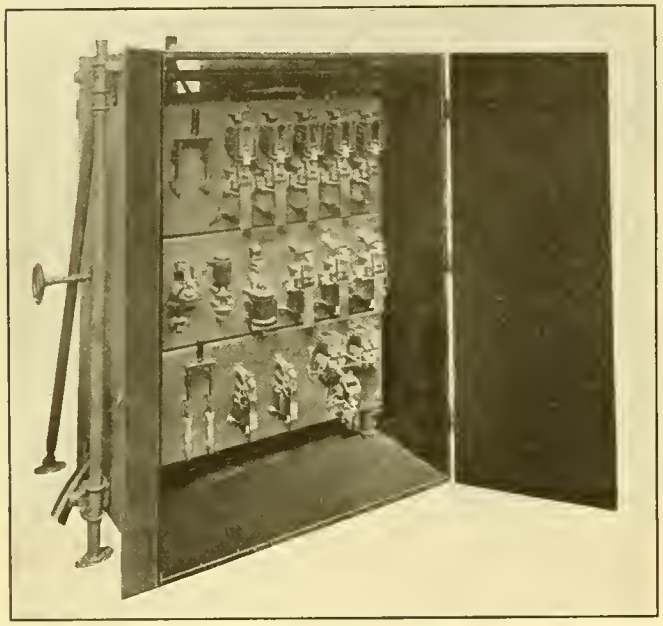

Fig. 10 Control Panel for 7½ and 50 H.P. Boring Mill Motor

Fig. 9 shows a William Sellers 18-ft. boring mill operated with 7½ and 50 h.p. motors controlled by panel. *A* is the rapid transverse and feet control station, *B* the motor panel and *C* the main motor control station. Fig. 10 shows a control panel for a 50 h.p. and 7½ h.p. combination boring mill motor.

Planers. The applications of electric motors and their control to planers, slotters, etc., is probably the most interesting, from an engineering point of view as well as that of economy in production, of all machine tool applications. The relative advantages and economics of the reversing motor drive for this purpose are now fully realized and have been set forth in bulletins issued by the various electrical manufacturers. They are also thoroughly appreciated by all machine tool men, so that a summation of them will be unnecessary. However, the main electrical points to be kept in mind are:

a Sparkless commutation of the motor

b Stability of the motor at all speeds

c Gradual dynamic braking (to prevent undue shock on the machine) in the shortest possible time

d Quick reversing

e Independent cutting and return speeds with maximum range of 4 to 1

f Provision for minimum drift when the motor is stopped or reversed, also when the power fails as a result of overload or low voltage on the line

g Auxiliary contacts on the contactors reduced to a minimum

h Provision for position operation of the main contacts

i "Time efficiency" for the complete cycle as high as possible

j All the appliances of the control equipment designed so as not to be influenced by reasonable vibration.

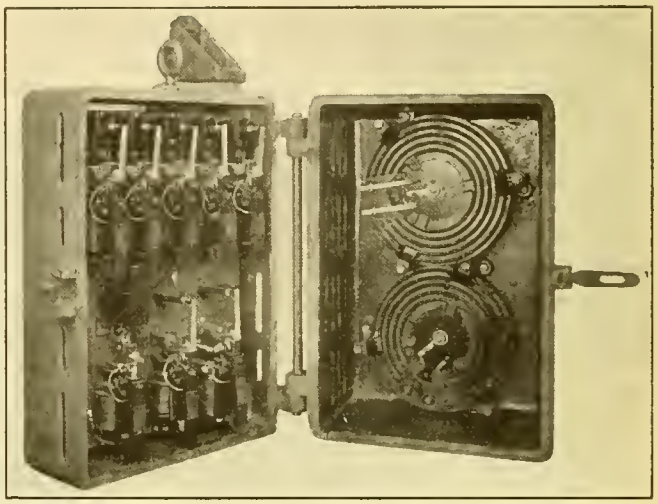

Fig. 11 Planer Control Panel

Fig. 11 shows a 25 h.p. planer control panel. Fig. 12 shows a General Electric Co. 500 h.p., 250/1000 r.p.m., 230 volt reversing motor direct-connected to a Pond 36-in. by 20-ft. heavy pattern frog and switch planer.

Fig. 13 shows a diagram of connections of a planer control equipment, 10 to 25 h.p. Contactor No. 6 is the accelerating contactor. Contactor No. 8 is 2nd point dynamic brake, operated by the field current. When contactor No. 6 is open, field current is made through an auxiliary contact which short circuits the field rheostats and half of coil on No. 8 contactor. When field current approaches full field value, No. 8 contactor is so adjusted as to close.

At full field on the motor, which is the slowest speed, No. 8 contactor will close almost instantly, while on weak field (high speed) the contactor does not operate until such time as the field current has reached a predetermined value. This gives a definite time lag between closing of 1st point dynamic contactor (No. 4) and 2nd point (No. 8), which allows the motor field to be strengthened before increasing the dynamic brake load. When motor is accelerating contactor No. 6 closes, thus opening the auxiliary contact and allowing the field current to pass through the field rheostats and both sections of coil on contactor No. 8. The two sections of this coil are wound in opposite directions and the field current passing through both sections de-energizes the contactor and it opens.

For emergency stopping, when the circuit breaker opens, an auxiliary contact on the circuit breaker connects the motor field to the armature, and the armature is connected across the resistance for dynamic braking.

To meet conditions of load where the full load cut is necessary up to the end of the stroke, a definite brake value on cutting speed is maintained independent of return speed. This is accomplished by contactor No. 7, which has two half coils, one being connected across the line and one across the armature and either coil being powerful enough to operate the contactor. When the motor is running in the cutting direction, the coil across the line is in the same direction as the coil across the armature, so that the contactor operates and short circuits a part of the dynamic brake resistance, which can be adjusted to give a definite dynamic brake value on the cutting stroke. When the motor is running in the return direction, the coil across the armature is opposed to the coil across the line, and the contactor is inoperative until such time as the armature voltage has dropped to a predetermined value and the armature has decelerated to a definite speed on dynamic braking; the coil across the line then overpowers the coil across the armature and the contactor closes, giving a 3d point dynamic braking on return stroke.

With the above arrangement, the maximum variation of cutting stroke between no-load and full load at high speed is about 1 in. and is practically zero at the slow speed.

The complete electrical equipment for planer drive consists of a reversing adjustable speed motor; a contactor panel and enclosing case with the field rheostats mounted inside of the cover, with external operating handles; the starting and dynamic braking resistance; a master controller of the drum type; a pendant switch for emergency operation, a snap switch and a special circuit breaker. A drum controller is used for controlling the cross rail motor. It is proposed to make the control equipment of the smaller horsepower sizes self-contained to economize space and reduce the external wiring to be supplied by the user. An average time efficiency of 90 per cent (depending upon the speeds and cuts employed) is obtained with these equipments.

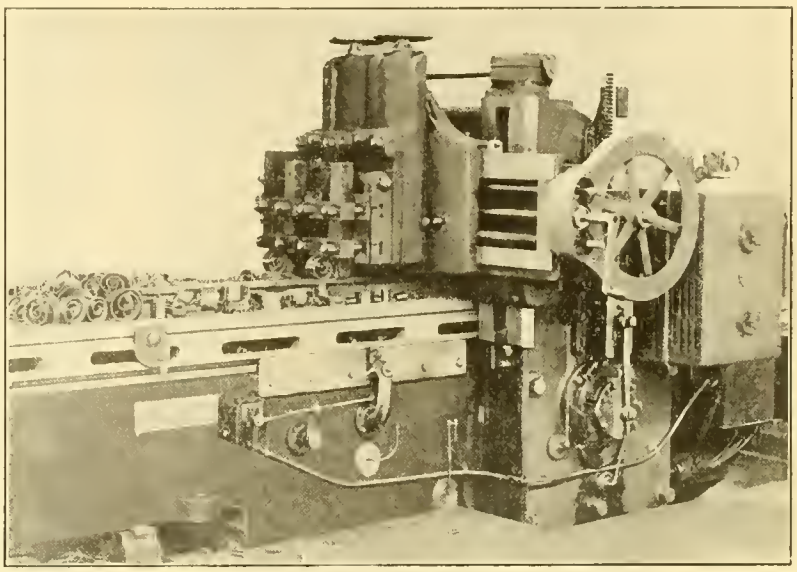

Fig. 12 Planer with Reversing Motor

MOTORS

Not the least important factor for a successfully operating electrically controlled machine is the motor.

In a shunt motor which starts under constant field excitation, the torque is directly proportional to the armature current. This type of motor is applicable for machinery where constant speed is desired, as small printing presses, ventilating fans, small machine tools, woodworking machines, etc. For adjustable speed work it is applicable to planers, boring mills, heavy lathes, etc.

In a series motor, the field excitation will vary with the load, which results in a varying speed and a very powerful torque at slow speed. This type of motor should always have a certain friction load and be geared or direct connected to the load in order to avoid the possibility of the latter being thrown off and the motor accelerating to a dangerous speed. The type is applicable to centrifugal pumps, cranes and hoists.

In a compound motor, the combination of the shunt and series field produces the heavy starting torque with small variation in speed. The working speed can also be increased by means of the shunt field. This type of motor is applicable to machinery requiring large overload capacity for short periods of time, as rock crushers, air compressors, shears, large printing presses, etc.

While the control apparatus for general use must be designed to operate with a standard motor, it is necessary that the designers of both the motor and control appliances be in thorough coöperation—especially if the customer is to obtain satisfactory results. One of the main points to bear in mind in the application of electric control to shop tools is simplicity, not only in the design of appliances but in the control schemes as well. This is especially true in the application to special and heavy duty machines. This will mean that in many instances the motor will need to be designed for the purpose and have the desired characteristics as to stability, overload, commutation, etc. The control problem will then be very much simplified. Indeed, many of the troubles and probable failures of electric control in the past may have been due to the complicated control applied in an attempt to have the motor perform functions of which its design would not permit.

DISCUSSION

H. D. James[1] (written). For starters for adjustable speed motors, the author specifies a field accelerating relay. The function of this relay is to prevent the operator from weakening the shunt field of the motor too rapidly during acceleration. The weakening of the shunt field causes the motor to take an increased current, and the relay operates in the same manner as an ammeter. When the current increases to a fixed value the relay closes the contact and increases the field strength of the motor momentarily. When the current drops the relay opens again, and this alternating closing and opening holds the field strength of the motor at the proper value during acceleration. The operation in this respect is ideal, and the relay has filled a long-felt want in many types of controllers. It has been found, however, that when the motor is operating at a high speed and the field rheostat is turned in the direction of reducing the motor speed, this increase in field strength causes the motor to act as a generator and return current to the line. This regenerative action may be very severe if the change in field strength is great. Under these circumstances the heavy current which flows causes the field relay to close the current, and still further strengthen the shunt field of the motor, causing an increased current flow. The opera-

[1] Box 3, East Pittsburgh, Pa.

tion of the relay in this respect is the opposite to what would be required for holding the current at its proper value.

The detrimental action of the field relay causes sufficient harm to more than counterbalance its good effects during acceleration, and better results can be obtained by omitting this field relay and using another device for strengthening the motor field during acceleration.

The author states that motors below 25 h.p. should have fuses for overload protection. The company with which I am connected is in favor of using overload relays on all sizes

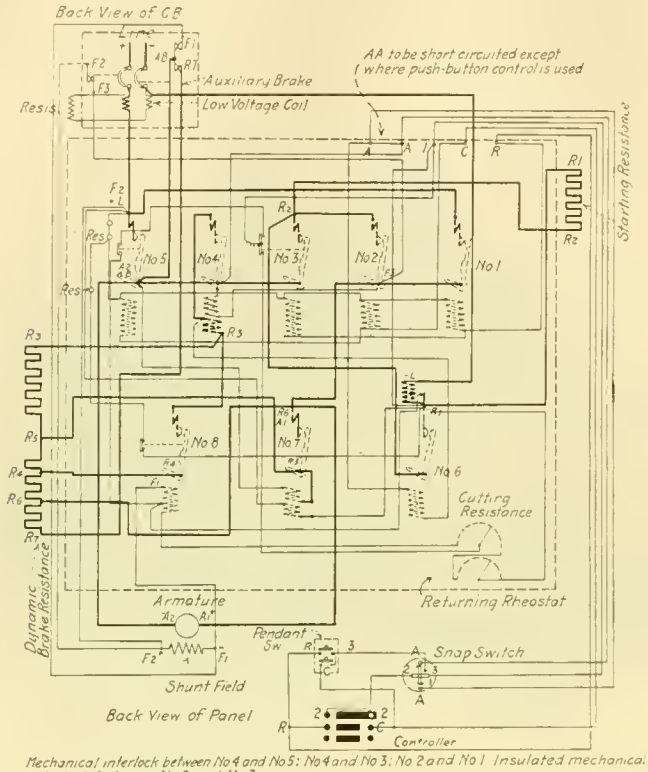

Fig. 13 Planer Control Contactor Connections

of motors, even down to 5 h.p., where such a relay can be adapted to the controller specified. The first cost of the relay is more than the fuse, but the continual replacing of fuses is a running expense and may often amount to more than the cost of the relay during the first year of operation. If fuses continue to open, there is a tendency to put in heavier ones, which is a further objection. Where an overload relay is used, it is so easy to reset the relay that very little annoyance is caused, and usually the calibration of the relay is left at a reasonable value.

The author states that a graduated dynamic breaking of two or more points is necessary on planers and boring mills. Tests made with the G. E. graphic recording ammeter on planer equipments at the William Wharton Shops, Jenkintown, Pa., showed that the retardation of the planer bed was so rapid during dynamic breaking that the ammeter recorded little or no difference between a single step dynamic braking and a graduated dynamic braking. These tests were made on Westinghouse, General Electric and Allis-Chalmers equipments; the G. E. equipment was of 50 h.p. size, and the others were 35 h.p. size.

In order to further analyze this condition we made oscillograph tests on 7½, 15 and 25 h.p. motors, both variable and constant speed, and with different maximum speeds and voltages. It was found that the graduated dynamic braking made practically no difference at the time of stopping, and merely added to the complication, the cost and the size of the control equipments. It is further found that a considerable variation can be made in the amount of resistance used in the dynamic braking circuit without affecting materially the time of stopping the motor. This investigation, which covers a period of over two years, has led us to abandon the graduated dynamic braking except in special cases where a considerable inertia load is stopped and the time of stopping is extended over a considerable period. The writer would be very glad to know of other tests made in this direction and what results they show. It is important to reduce controllers to a minimum number of parts, and no refinements which do not pay for themselves in actual results obtained should be introduced.

The safe temperature rise for any apparatus should be fixed by the materials entering into its design. The author states that the temperature rise on contacts and coils should not exceed 65 deg. under continuous operating conditions. This is high for some classes of apparatus and low for others. Recent improvements in insulation show that magnet windings can be operated at 125 deg. cent. actual temperature measured by resistance, and give good service over a long period of time. This comes under Class B insulation in the A.I.E.E. rules. The temperature of contacts is fixed by the fusing point of the material used; if a spring, by the temperature which draws the temper of the spring. The contacts subject to arcing, such as a line switch contactor, should be made of very refractory material, as the temperature set up in the contact on repeated operations is far in excess of any temperature which the contact may be subjected to by the passage of the current itself.

In criticism of Table 1, drum controllers we have had on the market for about ten years, having one step of starting resistance up to and including 15 h.p., and two steps of starting resistance above 15 h.p., and including 35 h.p., have proven very satisfactory. Further, we conducted a series of oscillograph tests extending over a period of six months on several hundred different motors, and we have adopted as our standard one step of starting resistance for motors up to and including 15 h.p. and two steps of resistance above 15 h.p. and including 25 h.p. Above that, we determine the number of steps by the motor used and the service conditions. Most machine tool motors start up light, as it is not the practice to start a machine tool with the tool cutting material. The resistance, however, is sufficient to start the motor under full load if the occasion should arise. In the above statement, by the resistance is meant that determined by dividing the volts by the amperes and adding sufficient external resistance to make the theoretical starting current of the proper value. As a matter of fact the self induction of the motor reduces the current at starting considerably below this value, particularly when the motor starts up at less than full load. This reduction in the number of starting notches reduces the size and cost of the controller, and if the control is rugged enough to stand the service it does not materially increase the wear on the resistance contactors. There are some types of control in which the switches used for short circuiting the starting resistance are light, and a larger number may be required in order to protect the switches.

In conclusion, it may be stated that the electrical equipment for both motor and controller is being reduced in complication

and gives increased durability. For the best conditions to obtain, the controller should be selected with respect to the motor used, as some designs and types of motor require more refinement in control apparatus than others. It is the business of the electrical manufacturer to offer to the machine tool builder a complete electrical equipment having a maximum durability and a minimum complication.

The writer heartily agrees with the general statements made by the author with reference to the advisability of using electric drive for machine tools. A great deal of engineering work has been done and investigations made in connection with drives of this kind, and it is now universally recognized that the individual motor represents the best practice in this respect.

A difficulty now encountered in motor application is the mechanical one of attaching the motor and controller to the machine tool so that it makes a presentable appearance. This difficulty is being overcome by the manufacturers of electrical apparatus adapting their designs to this service and by the machine tool designers obtaining a better conception of the electric drive requirements. A great deal can be done by still closer coöperation between the designers of both classes of machinery.

The writer believes in standardizing the requirements as much as possible. There is always danger that a rigid specification made may hamper development in the art. It is better to standardize first on general requirements only, and allow the manufacturers of electrical apparatus as much leeway as possible in working out the details of their part of the equipment. The apparatus described in this paper is a good representation of controllers manufactured by one of the leading companies, and in the main is representative of the art.

H. F. Stratton presented a written discussion in which he analyzed in some detail the electrical features of the paper, and in which was included the following paragraphs:

Some six or seven years ago the series accelerating switch was discovered, and its obvious cheapness and simplicity at once suggested that the time had arrived for applying, in a broad way, automatic control to motor-driven machine tools. Accordingly, about five years ago, a controller was designed and built which included a train of series accelerating switches, and an operator's switch, by means of which the motor could automatically be started, reversed, or stopped by dynamic braking. This controller, in substantially its original form, has come into extensive use, and to-day there are thousands of them operating successfully on a large variety of machine tools.

The purpose of the automatic machine tool controller is simple and important—it is to increase production. In this paper the author paints a word picture of a man manipulating a drum type or a dial type hand starter, and from this picture as a base, he passes on to the advantages of automatic control. I agree that the automatic controller possesses the advantages mentioned but am eager to put more emphasis on the main issue. What we are after is to keep the machine going the maximum amount of time and at maximum speed. Other seeming advantages are so in reality only when they yield tribute to this principle of increased capacity. It is true that automatic control protects the motor, but that is important chiefly because it saves delays; automatic control provides stopping by dynamic braking, but that too is important chiefly because unproductive time is transmuted into productive effort; it is true that the workman is relieved of much mental and physical effort, but that is important chiefly because he does more work. The problem is a matter of manufacturing economics rather than engineering technique.

Mr. Brooks intimates that the automatic controller is not satisfactory for lathes and he states that for many uses the drum controller has been found to fill the requirements quite satisfactorily. I think there are more automatic controllers on lathes than on all other machine tools combined. Several of the fastest working machine shops in this country are using several hundred such controllers. As long ago as 1913, the R. K. LeBlonde Machine Tool Co. wrote a letter containing this statement: "From recent tests made in our shop on one of our heavy duty lathes, equipped with your controlling devices, we find that we are able to produce 20 per cent more work than can be done on an ordinary motor driven lathe. These results are directly due to the automatic stopping, starting, and drift positions, and dynamic braking obtained by the use of your controlling devices."

I think the old style drum controller for lathes is unsatisfactory. In a recent paper by D. M. Petty, Electrical Engineer of the Bethlehem Steel Company, are described comparative tests made on duplicate engine lathes doing the same work and driven by duplicate controllers, the difference being an automatic controller in one case and a drum type controller in the other. Among other features is mentioned that the stopping time with the automatic controller using dynamic braking in the off point, was 8 sec. as against 40 sec. with the drum type controller. Mr. Petty draws the following conclusions:

First. The automatic controller protects the motor from not only excessive currents in starting, but excessive voltages in stopping.

Second. It decreases the starting and stopping time, which would amount to a considerable item when the operation requires frequent stopping.

Note. The possible exceptions to this conclusion would be that a drum type controller might equal the automatic on applications using speed adjustments of 1 to 1½ or under.

To Mr. Petty's conclusion I would add the following points: First, the drum type controller has the damaging "pump back" characteristic which Mr. Brooks condemns, and second, with the drum type controller it is necessary to hunt for the desired speed each time the motor is stopped and started, whereas with an automatic controller this best cutting speed is maintained regardless of stopping and starting, until it is purposely changed to suit the changing requirements of the work. The only advantage which the drum controller enjoys over the automatic controller as applied to lathes, is that it requires but one spline shaft for apron control, whereas two are required for automatic control on very long bed lathes.

Under the subject of car wheel lathes it is stated that the controller panel should include in addition to accelerating contactors, two dynamic braking contactors. Why not use the same contactors for acceleration and dynamic braking, as this is easily accomplished?

Mr. Brooks says a reversing planer controller should incorporate dynamic braking. It is my belief that the planer motor should be reversed by the reverse power method instead of being first stopped by dynamic braking and then reversed. The point is to reverse the motor in the quickest safe time. The quickest reversal is accomplished by having field strength at its maximum, armature current of its highest safe value, and a minimum number of movements of magnetically operated switches. To first stop the motor by dynamic braking,

means that dynamic braking switches must close and open, and in addition the reversing switches must function.

C. D. Knight. The trend of the discussion seems to be regarding the relative merits of the drum controller vs. the automatic, and also the use of automatic control on lathes.

The drum controller has been in successful use for a great many years, and by many is considered an exceedingly efficient piece of apparatus. Mr. Brooks in specifying the advantage of automatic control states that a considerable increase in the output of the machine is obtained, and there is no doubt but what in a great number of cases this is so. It stands to reason that a man cannot operate the drum controller throughout the whole day as rapidly as he can the automatic.

Furthermore, with automatic control the motor comes up to the same predetermined speed each time. With the drum controller, especially with adjustable speed motors, the operator is liable to obtain various speeds at different times on the same class of work, due to his not bringing the drum controller handle to the same point on each cycle of operation. With automatic control, including field relays, once the field rheostat is set for a certain speed it is absolutely certain that the motor will accelerate to that speed each time.

Another great advantage of automatic control is the question of insuring safety to the operator. By placing push buttons or small enclosed master switches on the machine, the main part of the controller can be mounted away from the machine, and whether open or enclosed, it will be out of the reach of the operator. I certainly believe that in following the lines of Safety First, we will in time have totally enclosed motor controlling apparatus.

Regarding the question of lathe control, there is no doubt but what a great many machines have been successfully equipped with automatic devices. Where the lathe is small and the speed regulating device can be placed on the headstock of the lathe within the reach of the operator, it is safe to say the problem can and has been fairly well solved. The problems I have in mind are on big lathes where the operator may be 10 or 15 feet away from the headstock of the lathe. In this case it is necessary to have the speed regulating device controlled from the apron of the lathe. There have been many proposed methods of doing this, but I have yet to see anything which looks like a successful solution of the problem.

H. K. Hathaway. The discussion of the possibilities of electrical control on milling machines, drill presses and machines of that character, which are not in the class of automatic machines in the same sense that automatic screw machines are, should open up a very fertile field. There is much to be done in the way of developing mechanism for the starting and reversing of milling machines after the cutting has been done, for the releasing of clamping devices, etc. This is a subject which our Local Sections might very well discuss further.

H. J. Eberhardt. A few years ago, at the Newark Gear Cutting Machine Company, we adapted a standard motor and starting device to one of our standard machines. The problem came up of how to stop the motor when the function of the machine had reached its limit. One way was to put a switch breaking mechanism, operated by a heavy spring, against the main switch and throw it out bodily, with the danger of an arc forming; but what we did was to utilize the overload switch, by putting a small bell crank up against the overload armature, and the pressure exerted by a fibre button, on the end of the bell crank, threw the overload switch and stopped the motor.

Ralph E. Flanders. Regarding the statement of Professor Goss, included in the paper, that in the machine tool of the future we shall not see belts, I am aware that up-to-date electrical controlling apparatus is provided with current overload, coils and switches; but there is nothing like a slipping belt for telling a shop man that there is something wrong with the machine. The very best safety device that I know of between the lineshaft or motor and the machine is a properly proportioned belt, and I wish to put in a word for the belt as a prominent feature of modern design.

Elmer H. Neff. My attention has been attracted to the quotation from Professor Goss' address. I fear the interpretation placed on the quotation is hardly correct because a machine in which there should be no pulleys, belts or gears would surely be something of a problem for a machine designer to produce. Mr. Flanders has spoken a word for the pulleys and belts, and I wish to put in a word for the gears. I am in favor of all machine tool transmission having absolutely positive connections for the main drive and for the feed, and of tying up the feed drive with the main drive so that it cannot work unless the main drive is in satisfactory operation.

At the Milwaukee meeting of this Society in 1901, one session was devoted to the subject of electrically driven machine tools. At that time an enthusiastic electrical advocate stated that in a short time practically all machine tools would be driven by electric motors. Nearly fifteen years have passed and yet today the proportion of machine tools sold fitted up with motors is relatively small. I am inclined to think that such extravagant statements as the above, and other similar statements which have been made by the advocates of electric drive, have done as much as anything else to hinder progress in that direction.

When electrically driven machine tools were first sold, the application of motors was made on machines that had not been designed with their use in view, consequently the arrangements were clumsy and cumbersome. The variations in speed had to be obtained by varying the speed of the motor or by adding to the machines themselves, between the work spindle and the motor, additional apparatus for obtaining the speed variations. This made the motor drive a very expensive one to obtain for two reasons. If the variable speed was obtained by varying the speed of the motor, the motor had to be much too large for ordinary purposes because at the slowest speed the maximum power was required. If mechanical means for changing the speed were supplied, a relatively large expense was involved.

A very fine thing has come out of this agitation for motor driven machines in that machine tools have been redesigned so that it is relatively easy to substitute a motor with sprockets and chains for the belt connection, all the speed changes being regularly incorporated in the machines themselves. These machines which are called single belt drive machines, or constant speed drive machines, furnish the best solution of the motor drive problem. A constant speed motor should be used, and by varying the speed mechanically within the machines you have the maximum rotative effect at the slow spindle speed which is the time at which you want it most. A further advantage has been that, by driving the feed works of the machine from the constant speed main drive shaft, it is possible to vary the spindle speed without changing the rate of feed, consequently any feed can be obtained with any spindle speed, and the most advantageous spindle speeds and the most advantageous feeds can be used on the work in hand. The machine thus designed, which as I have stated especially lends

itself to the application of a motor, has equally great advantage when it is used as regularly intended, with a belt drive from the overhead works. With a friction pulley on the machine for the application of power, and when the machines are designed, as they are in many cases, with the possibility of reversing the direction of rotation of the spindle by the mechanism in the machine itself, it is possible to drive these machines without the use of a countershaft, by belting directly from the line shaft to the machine.

For light machine tools I am an advocate of the group drive system rather than the individual drive. By light machine tools I refer to those requiring a 3 h.p. motor or smaller. A great multiplicity of motors such as involved by the individual motor drive involves too much expense for installation; too much expense for up-keep and attention; too much lost power. The group drive system in which a motor can be applied to a line shaft or to the machines in a particular room furnishes, I believe, the ideal electrical arrangement for light machine tools. In such cases the motors can be of sufficient size to run economically and all of the objections which I have stated with regard to the individual drive are eliminated. For large machines, or for isolated machines whether large or small, the individual motor drive furnishes a neat and desirable arrangement.

The Author. It will be noted that the paper contemplates the permanent short circuit of the field rheostat during acceleration, and, as Mr. James states, the operation of the field accelerating relay, with proper rheostat connections, is ideal for adjustable speed motors.

Referring to the use of overload relay vs. fuses, there are, of course, personal opinions as to where the dividing line should be. This point, of course, comes up in connection with the operation of a single step starting resistance which was advocated up to 15 h.p., as the peak current during acceleration under these conditions would be considerably over 200 per cent normal current, and unless the overload relay were fitted with a time limit device, there would not be sufficient protection to the motor during normal working conditions. It will also be noted that the oscillograph tests which our company have made indicate that there is no difference in the peak current, whether the motor starts with a no-load or full-load, the main question being whether or not the motor will stand the service.

In connection with the question of dynamic braking, the opinion seems to be universal as to the necessity for this, the difference being in the method in which it is applied, and it would appear that planers and boring mills especially, where graduated dynamic braking is recommended, would come under Mr. James' classification of heavy inertia loads. The question also arises that if graduated braking is required on heavy inertia loads, why is it not also desirable in other cases? It is very easily proven mathematically that increased torque obtained by dynamic braking of necessity gives decreased stopping time, assuming that the dynamic brake resistance is properly adjusted to the operating conditions of load.

The 65 deg. temperature rise recommended on contactor coils is in accordance with A.I.E.E. rules and U. S. Government standards for this type of appliance. At the present time the use of Class B insulation for contactor coils is not general practice, although it is a probability for the near future.

In the paper and by various members in the discussion, the necessity for coöperation between the machine tool builders and the electrical manufacturers is very forcibly emphasized.

SAFETY CODE FOR THE USE AND CARE OF ABRASIVE WHEELS

This Code was originally prepared by the Abrasive Wheel Manufacturers. It was presented to the Society, who referred it to the Committee on Machine Shop Practice. This committee carefully reviewed it, made some suggestions involving slight modifications and approved it.

SAFETY DEVICES

Three general types of safety devices to be used for grinding wheels, namely: protection flanges, protection hoods and protection chucks, are recommended.

ARTICLE A: PROTECTION FLANGES

A1 Protection flanges of the double or single concave type, used in conjunction with wheels having double or single convex tapered sides or side, are recommended.

A2 Flanges of the sizes shown opposite wheel diameters in column C, article A9, shall be used. As wheels wear, size of flanges, as indicated in column C, article A9, shall be maintained.

A3 New installations of protection flanges for double tapered wheels shall have a taper of not less than three-quarters (¾) of an inch to the foot for each flange, and the center of flange shall conform with the dimensions shown in column B, article A9. Such flanges shall be of a thickness not less than is shown in column D, article A9.

A4 New installations of protection flanges for single tapered wheels shall have a taper of not less than three-quarters (¾) of an inch to the foot, and the center of flange shall conform with dimensions shown in column B, article A9. Thickness of such flanges shall be as shown in column F, article A9.

A5 Each flange, whether straight or tapered, shall be relieved or recessed at the center at least one-sixteenth ($^1/_{16}$) of an inch on the side next to the wheel for a distance as specified in column E, article A9.

A6 All tapered flanges over six (6) inches in diameter shall be of steel, or other material of equal strength. Tapered flanges six (6) inches and smaller in diameter may be made of cast iron.

A7 All flanges shall be accurately turned, correct to dimensions and in balance, except flanges which are purposely made out of balance. Two such are known as balancing flanges and are sometimes used to counteract out-of-balance condition in an abrasive wheel.

A8 Both flanges in contact with the wheels shall be of the same diameter.

A9 Dimensions in inches of tapered flanges and tapered wheels where hoods are not used in conjunction therewith, are given in Table 1.

ARTICLE B: PROTECTION HOODS

B1 Protection hoods shall always be used where practical with wheels not provided with protection flanges. Hoods shall be designed and constructed of a material sufficiently strong to retain all pieces of a broken grinding wheel.

B2 Hoods shall conform as nearly as possible to the periphery of the wheel, and shall be so designed as to leave exposed the least portion of the wheel compatible with the work, and shall be of the adjustable type or provided with a sliding tongue or similar device, or a method of contract-

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ing the rim, for the purpose of closing the opening in the hood as the wheel is reduced in diameter, to afford maximum protection at all times.

B3 Protection hoods must be securely fastened to the grinding machine. If advisable, hoods may also be fastened to the floor.

ARTICLE C: CUPS, CYLINDERS AND SECTIONAL RING WHEELS

C1 Cups, cylinders and sectional ring wheels shall be either protected with hoods, or enclosed in protection chucks, or surrounded with protection bands. Not more than one-quarter (¼) of the height of such grinding wheels shall protrude beyond the provided protection.

ARTICLE D: GENERAL SAFETY REQUIREMENTS

D1 Competent men shall be assigned to the mounting, care and inspection of grinding wheels and machines.

D2 Before mounting, all wheels shall be closely inspected to make sure that they have not been injured in transit, storage or otherwise. For added precaution, wheels other than of the elastic and vulcanite type should be tapped lightly with a hammer; if they do not ring with a clear tone they should not be used. Damp wheels when tapped with a hammer may not give a clear tone. Wheels must be dry and free from sawdust when applying this test.

TABLE 1 DIMENSIONS OF TAPERED FLANGES AND WHEELS

a Maximum flat spot at center of flange.
b Flat spot at center of wheel.
c Minimum diameter of flange.
d Minimum thickness of flange at bore.
e Minimum diameter of recess in taper flanges.
f Minimum thickness of each flange for single taper at bore.

Diam. of Wheel in In.	a	b	c	d	e	f
6	0	1	3	⅜	2	⅜
8	0	1	5	⅜	3½	⅜
10	0	2	6	½	4	½
12	4	4½	6	⅝	4	⅝
14	4	4½	8	⅝	5½	¾
16	4	6	10	⅝	7	⅞
18	4	6	12	¾	8	1
20	4	6	14	¾	9	1
22	4	6	16	¾	10½	1⅛
24	4	6	18	¾	12	1⅛
26	4	6	20	¾	13½	1⅛
28	4	6	22	⅞	14½	1¼
30	4	6	24	⅞	16	1¼

Note:—Where hoods are used in conjunction with tapered wheels and tapered flanges the specifications given in article D 12 may be followed.

D3 Grinding wheels shall fit freely on the spindles; they shall not be forced on, nor shall they be too loose.

D4 Wheel arbor holes shall be made 0.005 inches larger than the machine arbor.

D5 The soft metal bushing shall not extend beyond the sides of the wheel at the center.

D6 Minimum sizes of machine spindles in inches for various diameters and thicknesses of grinding wheels are given in Table 2.

D7 Ends of spindles shall be threaded left and right, so that the nuts on both ends will tend to tighten as the spindles revolve. Care should be taken in setting up machines that the spindles are arranged to revolve in the proper direction, else the nuts on the ends will loosen.

D8 Wheel spindles shall be of sufficient length to permit of the nut being drawn up at least flush with the end of the spindle, thus providing a bearing for the entire length of nut.

D8a Protruding ends of the wheel arbors and their nuts shall be guarded.

D9 The surfaces of wheels in contact with straight or tapered flanges, the surfaces of the flanges in contact with the wheels and the wheel washers between the flanges and wheel shall be clean, smooth and free from foreign material.

D10 Size of straight flanges for straight wheels shall not be less than shown by column B, section D12.

D11 All straight flanges shall be relieved or recessed at the center at least one-sixteenth (1/16) of an inch on the inside surface of flange for a diameter as specified in column C, article D12.

D12 Dimensions of straight flanges and straight wheels used with protection hoods are given in Table 3.

D13 Wheels shall never be run without flanges.

D14 Both flanges in contact with the wheels shall be of the same diameter whether straight or tapered.

D15 Wheel washers of compressible material, such as blotting paper, rubber or leather, not thicker than approximately 0.025 inches, shall be fitted between the wheel and its flanges. It is recommended that the wheel washers be slightly larger than the diameter of the flanges used.

D16 When tightening clamping nuts, care shall be taken to tighten same only enough to hold the wheel firmly, otherwise the clamping strain is apt to crack the wheels.

TABLE 2 MINIMUM SIZES OF MACHINE SPINDLES

Diam. in In.	Thickness of Wheel in In.																		
	¼	⅜	½	⅝	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	4	4½	5
6	½	½	½	½	½	½	⅝	⅝	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1
7	½	½	½	½	⅝	⅝	⅝	¾	¾	¾	¾	¾	¾	1	1	1	1	1	1
8	⅝	⅝	⅝	⅝	⅝	⅝	¾	¾	¾	1	1	1	1	1	1	1	1¼	1¼	1¼
9	⅝	⅝	⅝	⅝	¾	¾	¾	¾	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼
10	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½
12	¾	¾	¾	¾	¾	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼	1½	1½	1½
14	⅞	⅞	⅞	⅞	1	1	1¼	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½
16	..	..	..	..	1¼	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	1½	1¾	1¾	1¾	1¾
18	..	..	..	..	1¼	1¼	1¼	1½	1½	1½	1½	1½	1½	1½	1¾	1¾	1¾	1⅞	1⅞
20	..	..	..	..	..	1½	1½	1½	1½	1½	1½	1½	1¾	1¾	1¾	1⅞	1⅞	1⅞	1⅞
24	..	..	..	..	..	1½	1½	1½	1¾	1¾	1¾	1¾	1¾	1¾	2	2	2	2	2
26	..	..	..	..	..	..	1½	1½	1¾	1¾	1¾	1¾	2	2	2	2	2¼	2¼	2¼
30	..	..	..	..	..	..	..	1¾	1¾	2	2	2	2	2	2¼	2¼	2½	2½	2½
36	..	..	..	..	..	..	..	..	2	2¼	2¼	2¼	2½	2½	2½	2¾	2¾	3	3

D17 Flanges, whether straight or tapered, must be frequently inspected to guard against the use of flanges which have become bent or sprung out of true, or out of balance. If a tapered wheel has broken, the tapered flanges must be carefully inspected for truth before using with a new wheel. Clamping nuts shall also be inspected.

D18 The work rest must be kept adjusted close to the wheel to prevent the work from being caught. Work rests must be rigid and always securely clamped after each adjustment.

D19 (1) A speed of 5000 peripheral feet per minute is recommended as the standard operating speed for vitrified and silicate straight wheels, tapered wheels and shapes other than those known as cup and cylinder wheels, which are used on bench, floor, swing frame and other machines for rough grinding. Speeds exceeding 5000 feet may be used upon recommendation of the wheel manufacturer but in no case shall a speed of 6500 peripheral feet per minute be exceeded. (2) A speed of 4500 peripheral feet per minute is recommended as standard operating speed for vitrified and silicate wheels of the cup and cylinder shape, used on bench, floor, swing frame and other machines for rough grinding. Speeds exceeding 4500 peripheral feet per minute may be used upon recommendation of the wheel manufacturer, but in no case shall 5500 peripheral feet per minute be exceeded.

D20 For elastic, vulcanite and wheels of other organic bonds, the recommendation of individual wheel manufacturers shall be followed.

D21 For precision grinding an operating speed of 6500 peripheral feet per minute may be recommended. Speeds higher than 6500 peripheral feet per minute can be used only upon recommendation of the wheel manufacturer.

D22 Table 4 gives revolutions per minute for various sizes of wheels for the peripheral velocities in feet per minute at the head of each column.

D23 Machine spindle speeds shall be tested and determined correct for size of wheel to be operated before wheel is mounted, and shall never be changed as a wheel is reduced in diameter, except by men assigned for such duties.

D24 If a wheel spindle is driven by a variable speed motor, speed control of the motor shall be enclosed in a locked case, or some device shall be used which prevents motor from being run at too high speeds.

D25 Grinding machines shall be sufficiently heavy and rigid to prevent vibration, and they should be securely mounted on substantial foundations.

TABLE 3 DIMENSIONS OF STRAIGHT FLANGES AND WHEELS

A	B	C	D
Diam. of Wheel in In.	Minimum Outside Diam. of Flange	Minimum Diam. of Recess	Minimum Thickness of Flange at Bore
6	2	1	⅜
8	3	2	⅜
10	3½	2¼	⅜
12	4	2¾	½
14	4½	3	½
16	5½	3½	½
18	6	4	⅝
20	7	4½	⅝
22	7½	5	⅝
24	8	5½	⅝
26	8½	6	⅝
28	10	7	¾
30	10	7	¾

D26 No user of wheels shall use on any given machine a wheel of larger diameter or greater thickness than specified by the machine builder.

D27 Wheels which wear out of round shall be trued by a man assigned to that duty. If wheels, not provided with balancing flanges, become out of balance through wear and cannot be balanced by truing or dressing, they should be removed from the machine.

D28 A wheel used in wet grinding shall not be allowed to stand partly immersed in the water. Water-soaked portion may throw the wheel dangerously out of balance.

D29 Wheel dressers should be equipped with rigid sheet metal or other guards over the tops of the cutters to protect operator from flying pieces of broken cutters.

D30 Goggles shall be provided for use of grinding wheel operators where there is danger of eye injury. They should be readily accessible, or better, should be the individual property of the operator.

D31 The space about the machine shall be kept dry, clean and as free as possible from castings or other obstructions.

D32 Grinding rooms shall not only be well ventilated and well lighted, but kept warm and dry. Machines used continuously for dry grinding shall be attached to a dust-exhausting system. Besides protection to the workmen, the dust-exhausting system prevents wear and tear on machinery and belts.

D33 Care shall be exercised in the storage of wheels. They shall be stored in dry places and should be well supported on edge in racks. Work shall not be forced against a cold wheel, but the work applied gradually, giving the wheel an opportunity to warm and thereby eliminate possible breakage. This applies to starting work in the morning in grinding rooms which are not heated in winter, and new wheels which have been stored in a cold place.

ARTICLE E: PRECAUTIONARY SUGGESTIONS

E1 Cone pulleys determining the speed of a wheel should never be used unless belt locking devices are provided.

E2 The maximum size of wheel which should be used with given operating speeds should be indicated on each machine.

TABLE 4 R.P.M. FOR VARIOUS SIZES OF GRINDING WHEELS

Diam. of Wheel in In.	Peripheral Speed					
	4,000	4,500	5,000	5,500	6,000	6,500
1	15,279	17,200	19,099	21,000	22,918	24,850
2	7,639	8,590	9,549	10,500	11,459	12,420
3	5,093	5,725	6,366	7,000	7,639	8,270
4	3,820	4,295	4,775	5,250	5,730	6,205
5	3,056	3,440	3,820	4,200	4,584	4,970
6	2,546	2,856	3,183	3,500	3,820	4,140
7	2,183	2,455	2,728	3,000	3,274	3,550
8	1,910	2,150	2,387	2,635	2,865	3,100
10	1,528	1,720	1,910	2,100	2,292	2,485
12	1,273	1,453	1,592	1,750	1,910	2,070
14	1,091	1,228	1,364	1,500	1,637	1,773
16	955	1,075	1,194	1,314	1,432	1,552
18	849	957	1,061	1,167	1,273	1,380
20	764	860	955	1,050	1,146	1,241
22	694	782	868	952	1,042	1,128
24	637	716	796	876	955	1,035
26	586	661	733	809	879	955
28	546	614	683	749	819	887
30	509	573	637	700	764	827
32	477	537	596	657	716	776
34	449	506	561	618	674	730
36	424	477	531	534	637	689
38	402	453	503	553	603	653
40	382	430	478	525	573	621
42	364	409	455	500	546	591
44	347	391	434	477	521	564
46	332	374	415	456	498	539
48	318	358	397	438	477	517
50	306	344	383	420	459	497
52	294	331	369	404	441	487
54	283	318	354	389	425	459
56	273	307	341	366	410	443
58	264	296	330	354	396	428
60	255	277	319	350	383	414

E3 Grinding machines should be provided with a stop or some method of fixing the maximum size of wheel which may be used, at the speed at which the wheel spindle is running.

E4 Boxes must be of proper length to provide an ample bearing surface, and prevent heating or rapid wear. It is important that the bearings be kept well lubricated and properly adjusted. Ring oiling devices are recommended, amply protected from dust and grit, and box caps should be adjustable for take-up.

E5 For protection against flying chips, etc., plate glass in metal frames can be placed just above the grinding spaces of the wheels.

E6 Where it is impracticable or undesirable to use a glass shield, a leather flap may be attached to the hood and adjusted so as to interrupt sparks and dust.

E7 Table 5 of causes of grinding wheel accidents has been prepared by the Independence Inspection Bureau, and by their courtesy it is published with this report.

TABLE 5 CAUSES OF GRINDING-WHEEL ACCIDENTS. (Prepared by the Independence Inspection Bureau of Philadelphia for general distribution.)

- **Broken wheels (caused by)**
  - Cracked wheel (caused by)
    - Improper inspection of wheel
      - Before issued to operator.
      - When being mounted.
    - Dropping or striking against some object while not being operated
      - During storage — Carelessness. Horseplay.
      - While being mounted — Carelessness. Horseplay.
      - While standing — Carelessness. Horseplay.
    - Being forced on improper sized spindle
      - Too small bushing.
      - Too large spindle.
    - Heated spindle
      - Tight bearings
        - Lack of oil.
        - Improper spindle size.
      - Inner flange not fixed on spindle.
    - Only one flange
      - Careless mounting.
      - Ignorance.
    - Uneven bearing of flanges
      - Bent or broken flange or flanges — Improper specifications. Ignorance.
      - Bushings projecting beyond sides of wheels — Improper specifications. Ignorance.
      - High spots on flanges — Improper specifications. Ignorance.
      - High spots on wheels — Improper specifications. Ignorance.
    - Flanges of different diameters
      - Careless Mounting.
      - Ignorance.
    - Flanges not properly relieved
      - Entirely without relief
        - Improper specifications.
        - Ignorance.
      - Diameter of relief too small
        - Improper specifications.
        - Ignorance.
    - Compressible washers
      - Missing — Carelessness. Ignorance.
      - Too thin — Carelessness. Ignorance.
      - Too small diameter — Carelessness. Ignorance.
    - Tightening of nut
      - Carelessness.
      - Ignorance of mounter.
    - Hacking of wheel
      - Desire for increased cutting.
      - No restriction on use of wheel.
    - Screwing wheel on taper arbor
      - Ignorance.
  - Too high rim speed caused by
    - Spindle overspeeded
      - Overspeed when first set up.
      - Speed increased
        - Desire for increased cutting.
        - Thoughtlessly increasing speed of line shaft.
      - Use of cone pulley
        - Shifting to small pulley.
          - Desire for increased cutting.
          - Loose shifter.
          - Carelessness.
      - Wheel initially too large
        - Carelessness.
        - Ignorance.
    - Use of too large wheel for spindle speed
      - Too large wheel substituted
        - Desire for increased cutting.
        - Ignorance or indifference.
      - Wheel of different grain and lower recommended speed substituted — Ignorance or indifference.
      - Wheel of different shape substituted — Ignorance or indifference.
      - Wet wheel substituted — Ignorance or indifference.
  - Catching work between rest and wheel (caused by)
    - Improper adjustment of rest
      - Lack of attention.
      - Ignorance.
    - Improper handling of work
      - Side grinding when rest not designed for it.
      - Pushing work under rest — Ignorance.
  - Out of true (caused by)
    - Loose bearings
      - Lack of attention.
      - Ignorance.
    - Bent spindle
      - Lack of attention.
      - Ignorance.
    - Loose frame
      - Lack of attention.
      - Ignorance.
    - Rough or improper use
      - Inexperienced men.
      - Responsibility of foreman.
- **Broken wheels (caused by)**
  - Unbalanced wheel (caused by)
    - Wheel standing in water (see under "cracked wheel").
    - Side grinding (see below).
    - Wheel untrue.
  - Weakened wheel (caused by)
    - Wheel standing in water (see above).
    - Side grinding (see below).
    - Hacking wheel (see above).
  - Too small spindle (caused by)
    - Bushing too small in wheel — Ignorance or indifference.
    - Wrong spindle used for size of wheel — Ignorance or indifference.
  - Side grinding on improper wheel (caused by)
    - Lack of proper equipment.
    - Inexperience of men.
    - Indifference.
- **Flying wheel unbroken (caused by)**
  - Mounted so that nut works loose (caused by)
    - Spindle threaded in wrong direction — Improper specifications.
    - Belt twisted so that machine runs opposite to initial direction — Equipment incorrectly erected.
    - Motor reversed — Ignorance.
    - Spindle turned end for end — Ignorance.
- **Work or dresser hurled out of workman's hand (caused by)**
  - Caught between rest and wheel
    - See above.
- **Flying particles of emery, inhaled or in eye (caused by)**
  - Exhauster defective (caused by)
    - Entire lack of exhauster
      - Exhauster not provided.
      - Exhauster disconnected.
    - Exhauster line not proper size
      - Ignorance.
      - Desire for saving expense.
    - Exhauster line stopped up
      - Not often cleaned.
      - Poorly designed or constructed.
  - Eye protection insufficient (caused by)
    - No goggles provided.
    - Improper goggles provided.
    - Goggles not used
      - Prejudice.
      - Carelessness.
      - Fear of infection.
  - Chip guard defective (caused by)
    - No chip guard.
    - Chip guard not in use
      - Broken and not replaced.
      - Prejudice of workmen.
- **Flying pieces of broken revolving type of dresser (caused by)**
  - No guard for dresser.

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OPERATION OF PARALLEL AND RADIAL AXLES OF A LOCOMOTIVE BY A SINGLE SET OF CYLINDERS

BY ANATOLE MALLET, PARIS, FRANCE

Honorary Member of the Society

An examination of the principal arrangements proposed for transmitting power to convergent axles without, however, increasing the number of steam cylinders, forms the subject of the present paper. These various systems of transmission may be divided into two classes: *First,* those which involve elements having rotary motion; *second,* those which involve elements having reciprocating motion.

TRANSMISSION BY ROTARY MOTION

This class includes gear transmission, transmission by endless chain and transmission by universal joints.

Gear Transmissions. Although the first use of gear transmissions dates back to the very origin of locomotives, they appear to have been first utilized for operating locomotive axles having freedom of radial movement in 1838, in a locomotive built at Heath Abbey for the Rhymney foundry in Wales. This locomotive was carried on two trucks with two axles each. The two trucks could turn so that they were at an angle with each other without throwing the driving gears out of mesh.

In 1841, the Baldwin Locomotive Works built a locomotive in which the rear axles were driven by means of a countershaft and connecting rods, and the axles of the front truck were operated by a gear transmission located on the longitudinal axis of the machine. This locomotive weighed 13½ tons and was designed for use on a quarry railroad, but the type was afterward abandoned.

The French engineer, Tourasse, presented at the Competition of Semmering in 1851 a design of locomotive with six axles, similar to the Rhymney locomotive. It may be seen from Fig. 1 that from the cylinders is operated a countershaft carrying a toothed gear which engages with toothed wheels carried on the nearest axle of each track, these axles in turn being coupled to the other axles by outside connecting rods. This locomotive was to weigh 60 tons with the water carried in a saddle tank on the boiler. The cylinders were 0.50 m. (1.64 ft.) in diameter with a 0.60 m. (1.97 ft.) stroke; the wheels were 1.20 m. (3.93 ft.) in diameter and the heating surface, 250 sq. m. (2590 sq. ft.). The power developed would have been extraordinarily large for that time, since, according to the author of the design, the locomotive was to be able to start with a load of 250 tons over a grade of 2½ per cent, although a capacity of only 140 tons was required.

The Locomotive Works of Winterthur, Switzerland, built in 1883, for an industrial railroad in the south of France, a locomotive similar to the one just described. It was supported on two trucks of two axles each, and weighed 22 tons. It appears that this type was unsuccessful.

The famous Engerth locomotive (Fig. 2), built after the Semmering Competition from which no practical results were obtained, was at first characterized by the use of gear transmission for connecting the last axle of the locomotive to the forward axle of the tender. The intermediate shaft, carrying the middle toothed gear, is arranged to slide longitudinally in its bearings if necessary, to cut out the connection with the wheels of the tender.

Quite a large number of Engerth locomotives were built. As a rule, they had six driving wheels under the locomotive proper and four under the tender, or a total of ten in all. As the gears did not give satisfactory results in actual practice, however, they were eliminated and the machine reduced to the type of locomotive and tender with six coupled wheels. The complicated gear transmission type has long since entirely disappeared from practice.

Within recent years, a locomotive builder in Lyons has built some small narrow gage locomotives which are supported on four axles—all driving. The three rear axles are coupled by external connecting rods, while the front axle, which has radial freedom of motion, is connected with the axle next to it by a train of gear wheels located in the longitudinal axis of the machine, just as in the Engerth type. It does not appear, however, that this system has found an extensive application.

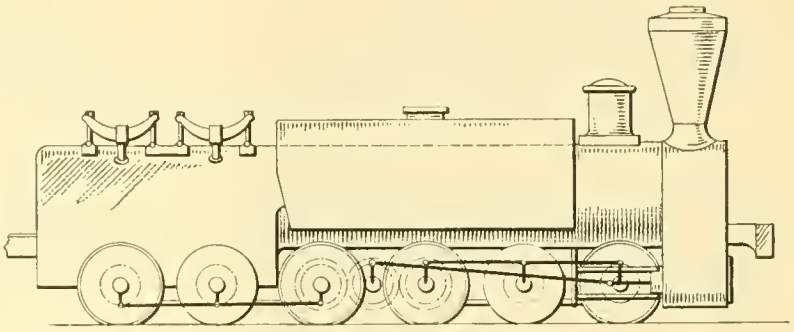

Fig. 1 Six-Axle Gear Transmission Locomotive by Tourasse

Before 1830, W. N. James, of Birmingham, proposed to connect not only the axles of the locomotive and tender but also those of the cars by means of gear wheels operated by a longitudinal shaft running the length of the train and provided with ball and socket joints to give them the flexibility necessary for making the curves. By this arrangement the inventor proposed to obtain sufficient adhesion to handle the train on grades without recourse to the Blenkinsop rack, and he stated that experiments made on a small scale showed that he could make grades of three inches in a yard, or 1 in 12.

There are, in actual use in the United States, locomotives in which the axles of the engine and of the tender are coupled together by gears and a longitudinal shaft fitted with ball sockets. These locomotives are of the Climax, Shay and Heisler systems, which differ from one another in the arrangement of the details of transmission and the location of the steam cylinders. These systems are too well known to necessitate their description here, but it may be of interest to state that they have been used even for very large units. Thus, the Climax and Heisler locomotives have actually been built in sizes of 75 to 80 tons and the Shay locomotives, up to 135 tons.

Transmission by Endless Chain. The use of endless chain for coupling axles which may be thrown out of parallelism appears to have been adopted for the first time in 1851, by S. A. Maffei, of Munich, in the construction of the locomotive Bavaria, presented by him at the Semmering Competition. This machine (Fig. 3) had seven axles, driven by two cylinders The axles were divided into three groups and the wheels of each group were coupled by external connecting rods, while

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members; 20 cents to non-members.

the groups were connected by endless chains made of links and studs. The engine weighed 68,000 kg. (74.8 tons) with its equipment and it was given the first prize at the Competition after having satisfactorily passed all the tests. It was said that the victory was due only to the very brief duration of the tests, and that this locomotive could be maintained in good operating condition only by constant repairs to the chain transmissions. As a matter of fact, the Bavaria has never been reproduced in full or in part.

The Locomotive Works of Winterthur built a locomotive with three axles, the middle one rigid and the two others with radial displacement. The two non-rigid axles were connected by Galle chains[1] engaging with rim gear sprockets attached to the axle by ball sockets. The cylinders were located forward, were vertical and drove a countershaft which was coupled with the axles by the Galle chains. The locomotives of standard gage were 16.5 tons and could handle curves of 11 m. (36.08 ft.) radius. This type was not built again.

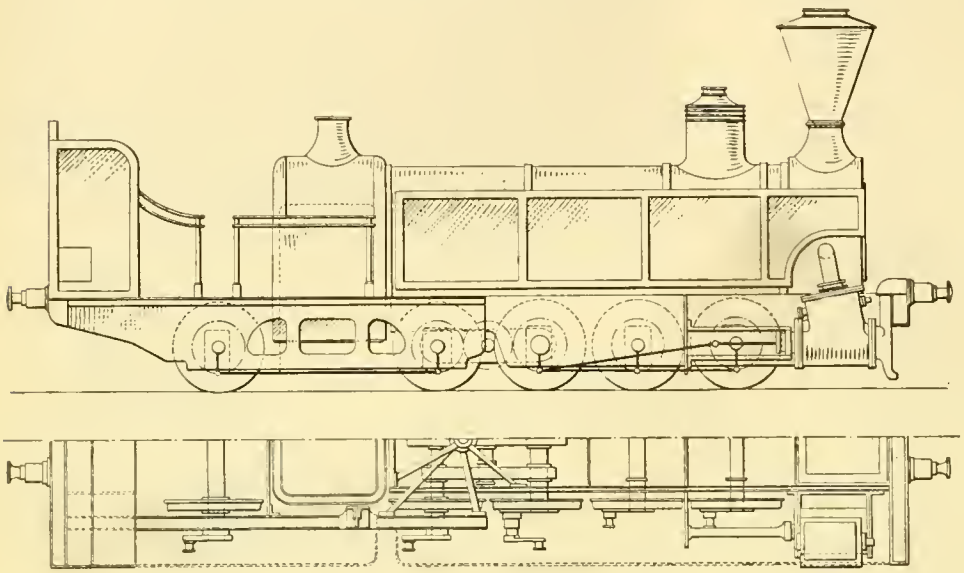

Fig. 2 Original Engerth Locomotive

In the United States a type of small locomotive designed to operate over roads made of logs placed end to end is sometimes used in lumbering operations. This locomotive is set on two trucks and its axles are driven by means of Galle chains from a countershaft operated by the cylinder. The wheel treads are groove-shaped, fitting over the log rails on which they run. It is generally known that Galle chains are used on road locomotives, rollers, gasoline locomotives and certain electric locomotives.

Transmission by Universal Joints. In this category can be placed all transmissions by ball joints. The term ball joint applies here to any device involving wheels mounted on a hollow axle, in the interior of which is a shaft that receives the power from the steam cylinders and transmits it by means of a ball joint, or universal joint, to the hollow axle. On curves the hollow axles take the radial displacement while the interior shafts remain parallel. The interior shafts are coupled by external rods in such a manner as to make the converging movements of the outer axles and the movement of the transverse displacement of the central axle correspond. This ingenious device appears to have been invented by Percival Haywood, who made use of it about 1880 on a small locomotive weighing approximately 2.5 tons and running on a 15-in. gage railroad having curves of 16-ft. radius. (Fig. 4.) The three axles are connected.

E. P. Cowles applied the same principle, but a different arrangement, to a locomotive on a quarry railroad in Kentucky as shown in Fig. 5 (only one-half of the machine is shown, the other half being exactly similar). From the figure it may be seen that only the central carrying axle of each truck is hollow, containing a rigid shaft *a* acted upon by the steam cylinders. The other axles are coupled by external connecting rods, in the middle of each of which is provided a slot in which slides the crank pin of the shaft *a*. The shaft *a* is carried on external supports and is connected with the hollow axle by a central universal joint.

The inventor utilized the peculiar idea of operating both trucks from the same cylinders in order to simplify the general construction of the machine. To accomplish this, each piston rod was arranged to pass through both covers of its cylinder and to engage at each end with a connecting rod. Due to the obliquity of these connecting rods, however, their midpoints of stroke did not correspond to each other, and a sliding of the wheels on the rails twice in each revolution resulted. This difficulty could have been avoided by the use of two pistons in each cylinder, one for the forward truck and the other for the rear truck, but that would have complicated the machine.

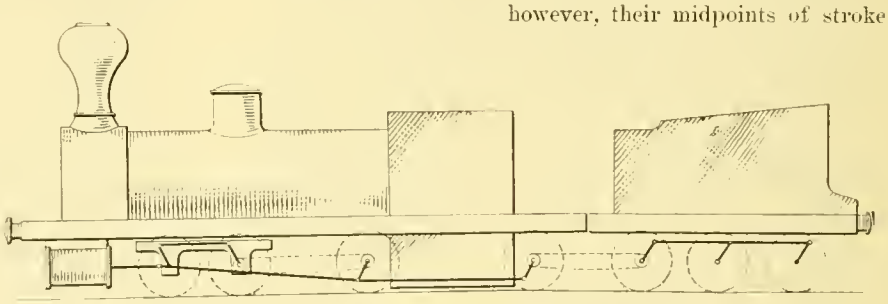

Fig. 3 Locomotive "Bavaria" by Maffei

TRANSMISSION BY RECIPROCATING MOTION

This class includes such systems as make use of connecting rods, equalizers, etc., for connection of the convergent axles. The author considers it advisable to call attention in a general manner, however, to the fact that this classification cannot be very rigorous because certain arrangements might belong to two classes at the same time, owing to the multiplicity of parts entering into their construction.

The mechanisms of this class may be divided in the following manner: Coupling of convergent axles by connecting rods located in the longitudinal axis of the engine, these connecting rods being either simple or double, rectilinear or triangular; coupling by oscillating levers or equalizers; use of a free axle

[1] Straight-link roller chain.

coupled by connecting rods to the converging axles, and coupling of axles by means of external connecting rods of which the length varies with the radial displacement of the axles.

Coupling by Connecting Rods Located in the Longitudinal Axis of the Engine. The use of central connecting rods acting on spherical crank pins located in two contiguous axles is a very simple idea, but there is serious difficulty in passing the dead center. This can be remedied in several ways. In designs presented for the Semmering Competition, Maffei proposed to locate, side by side and in the center of the axles, two connecting rods acting at right angles on cranked portions of the axles. It is easy to see that this solution of the problem was not a rigorous one, since the connecting rods are not on the axis of the engine, although they are very close to it. A certain amount of play had to be allowed between the pins of the cranks and the brasses of the connecting rods, which would finally result in causing a breakdown of the transmission.

Thouvenot took up this idea of locating rods on the axis of the engine about 1860. He deflected the connecting rods so as to bring them back into the axis of the engine, as shown in Fig. 6. This arrangement does not appear to possess sufficient strength.

C. Aliges, former engineer of the Cail factory in Paris, developed a design for a four-axle locomotive (Fig. 7), in which one of the two axles forming the truck was connected with the driving shaft by a central connecting rod and the other with the third axle by a like arrangement.

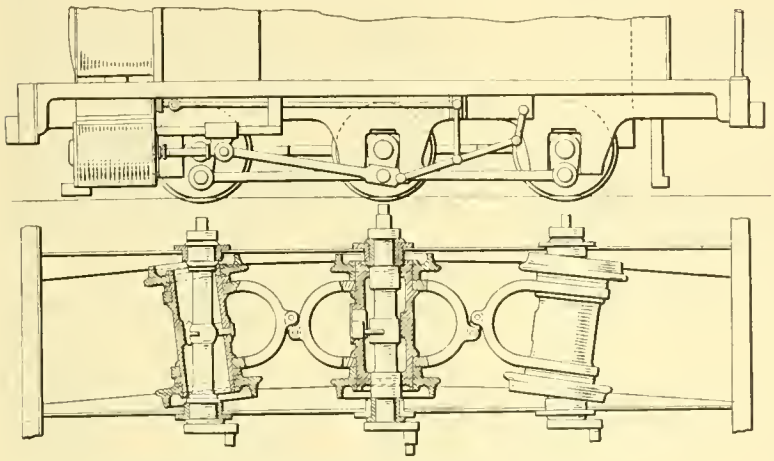

Fig. 4 Haywood's Hollow-Axle Locomotive

De Bergues, of Manchester, proposed an arrangement for inter-connecting the axles of a locomotive and its tender by means of central coupling rods acting on cranks in these axles, the coupling rods being driven by vertical oscillating levers. This arrangement embodied two similar systems located very close to the longitudinal axis, with cranks at right angles to the axles.

Coupling by Oscillating Levers or Equalizers. The idea of using oscillating levers for coupling convergent axles was first disclosed about 1855 in an invention by Lucien Rarchaert, who tried very persistently to realize it. This system has been very favorably reported on, but has never been actually used. A German engineer, Christian Hagans, of Erfurt, invented an arrangement which he applied at first to small locomotives and after, with some modifications, to large five-axle locomotives with three fixed axles and two axles forming a truck, as shown in Fig. 8. The axles of the truck were acted upon by a vertical lever, *a*, oscillated through the intermediary of a longitudinal rod by lever *a'*, oscillated by the piston rod. The upper end of the lever *a* is connected to the top of an equalizer, *b*, articulated in the middle and having its lower extremity attached by a distance rod to the rear axle, *e*, of the truck. The result of this arrangement is that if, on curves, the axles of the truck are displaced, the lower part of the lever *a* has a displacement in the same direction and to the same amount, so taking care of the convergence of the axles.

The Hagans system was at first considered quite a success on the Prussian State Railroads on five-axle coupled locomotives weighing 72 tons in service, but it has since been entirely abandoned. As a reason for this was given the fact that the introduction of locomotives with five axles, parallel and coupled by ordinary side rods, has made the complication and expensive maintenance of the Hagans machine unnecessary. However this may be, we may say that this system has probably been supplanted by the Engerth system, no doubt one of the most widely applied arrangements for operating converging axles.

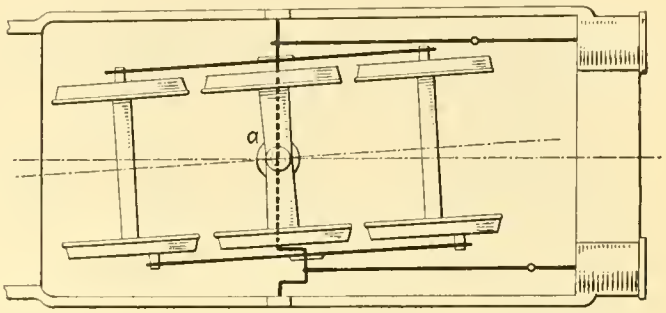

Fig. 5 Cowles' Hollow-Axle Locomotive

The Johnstone system, which has been applied on several large duplex locomotives built in the United States for the Central Mexican Railroads, has also some resemblance to the preceding type. Fig. 9 shows one-half of this locomotive, and the other half is entirely similar. The piston rod (or rather rods, since there are three of them, there being two cylinders placed side by side) acts on the middle of a lever *a*, which is vertical when in its normal position. The main connecting rod is attached to the lower extremity of this lever, while from the upper extremity a short coupling rod connects to the top of equalizer *b*. This equalizer oscillates about its middle and operates from its lower end a connecting rod to a crank pin set at 180 deg. from the working pin of the counter-crank. From the figure it is seen that the lever *a*, to which the piston rods are attached, moves always parallel to itself, vertically on straight track and at a slight incline on curves.

Use of Free Axles. The use of a free axle coupled by connecting rods with radial axles appears to date back to the Semmering Competition. Maffei there presented several designs in which the axles of locomotives and their tenders were coupled by inclined or triangular connecting rods. A similar design (Fig. 10), submitted at the same Competition by a Hannoverian engineer, Kirchweger, shows a locomotive carried on two trucks having two axles each, the coupling of the trucks being effected by an arrangement of this kind. It may be seen that there is a connection between the journal boxes of the wheel axles and of the free axle.

The Austrian engineer, Pius Fink, tried to retain in the Engerth machine its original property of total adhesive weight by substituting for the gear train an articulated device. He

built three locomotives, which were in service for several years, but they are not built now. The locomotive had three axles and the tender two, as in the Engerth machine. Dredge and Stein in England resorted to the use of a free axle and a central triangular connecting rod for coupling the axles of a locomotive with those of the tender.

The inventor, Rarchaert, to whom reference was made above, after having abandoned the system of oscillating levers, designed an arrangement coming under the present category (Fig. 11). This was applied on a locomotive with two trucks

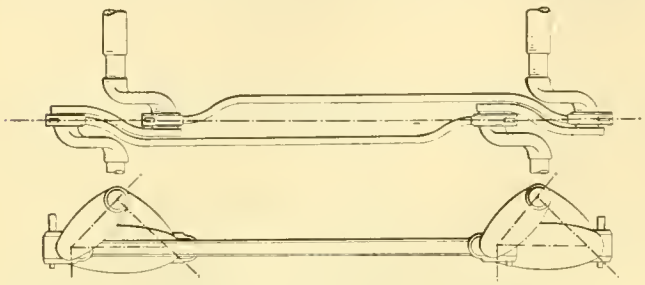

Fig. 6 Thouvenot's Locomotive with Rods on Axis

having two axles each. The cylinders operated a free axle coupled with the carrying axles by a triangular central connecting rod. The pins of the cranks had spherical heads. The locomotive was in service on the railroad between Fougères and Vitré and from Orleans to Chalons. It gave good results, but at the death of the inventor experiments with it were discontinued.

The use of a loose axle may be combined with that of external coupling rods in which are provided slots, and in these slots, again, glide the coupling pins of the radial axles. An arrangement of coupling rods of this type was used in the Cowles system, mentioned above (compare Fig. 5). The Köchy system (Fig. 12) also furnishes an example of this arrangement. A third example is found in the design presented by the engineer Gouin, author of the system employing oscillating levers similar to the first system of Rarchaert. This model represents a combined locomotive and tender with five axles, of which the two rear ones form a pivoted truck. These axles are coupled by connecting rods having an open or slotted link in which slides the pin of a crank forming the terminal of a free axle. This cranked free axle is in turn coupled with the third axle of the machine.

Finally, the well-known designer, Krauss, of Munich, proposed, in 1893, an arrangement permitting of the operation of the axles of a truck by steam cylinders carried on the main frame of the engine, as shown in Fig. 13. To accomplish this, the crank pins on the driving shaft carry pin blocks working in slots in the trussed connecting rods. It may be seen that the use of such connecting rods with slots is subject to serious objections. Stress is exerted on the crank pin in a vertical direction only and, moreover, the pin blocks have on curves a periodic displacement in a direction transverse to the axis of the connecting rod. As a result of this, friction and considerable wear is likely to ensue, rapidly producing play, shocks and dislocation of parts. None of these systems appear to have been utilized practically.

External Connecting Rods, the Lengths of Which Vary with the Convergence of the Axle. In this connection reference will be made first to the Klose system, which has been fairly widely applied. Fig. 14 gives an idea of this system. It may be seen from this figure that the crank pin of the working axle carries a kind of rocker lever to two points of which are connected the coupling rods of the other axles. The other two points are connected to the extreme axles by a system of connecting rods and triangles in such a manner that the convergence of the axles corresponds to the variation in length of the coupling rods. This system has been employed in locomotives having a gage of 1.76 m. (5.77 ft.) on the Bosnian-Herzegovinian Railroads and on large five-axle locomotives of the Würtemberg State Railroads.

An arrangement proposed by a Brazilian engineer, G. Fretl, might also be cited. In this a double horizontal box engages with the crank pin of the middle axle and, by bearing on the coupling rods of the two other axles, increases or decreases the length of these coupling rods when the middle axle is transversely displaced on a curve.

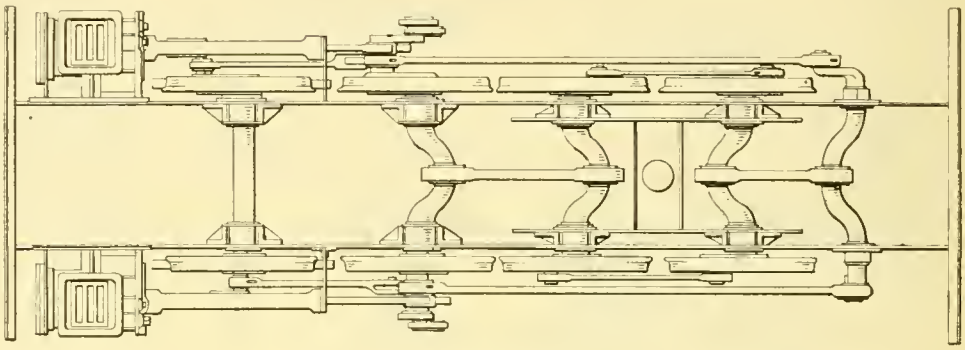

Fig. 7 Aliges' Four-Axle Locomotive

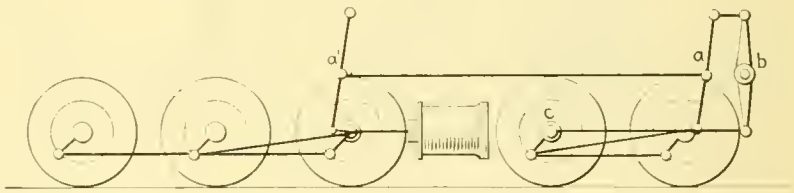

Fig. 8 Hagan's Five-Axle Locomotive

CONCLUSION

In this paper the author has indicated the most interesting arrangements, so far as he knows, which have been proposed for operating the converging and parallel axes on a locomotive by a single pair of steam cylinders. If he has failed to mention any, especially those of American origin, it has been done unintentionally and he apologizes for it in advance.

An examination of these devices gives the impression that all of them involve a serious inconvenience, and that all of them can operate in a satisfactory manner only when they are in vertical play, parallel to the longitudinal axis of the engine, *i.e.*, when the latter runs along straight sections of track. But such is not the condition on curves where the transmission element acquires a certain amount of obliquity, which necessitates the use of pins or spherical parts more difficult to lubricate.

This obliquity introduces differences in length and further play between the parts, and this, in turn, leads to shocks and rapid wear of parts. Hence the maintenance of mechanisms of this kind becomes necessarily more costly than that of the ordinary locomotive transmissions.

Notwithstanding these difficulties, the author believes that in view of the ingenuity which has developed in the study of this question during so many years and by so many inventors,

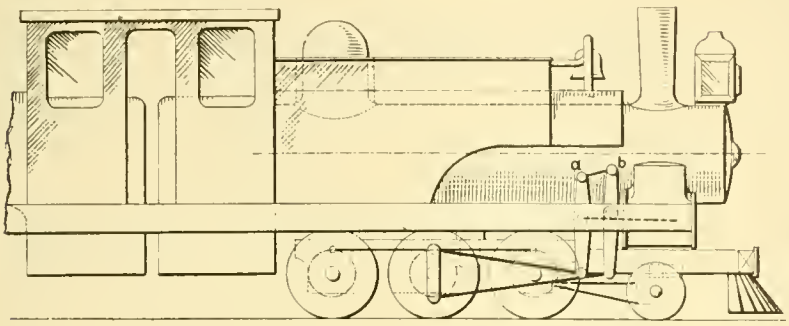

Fig. 9 One-Half of Johnstone System Locomotive

it would be hard to predict that a system may not finally be found combining all the conditions essential to the practical operation of such a device. On the other hand, however, can it not be questioned whether researches in this direction are of any actual utility to-day when there is no hesitation with regard to coupling directly the largest number of parallel axles by external connecting rods and when there are other perfectly satisfactory solutions of the problem based on a different order of ideas?

As a matter of fact, since 1861 and more than fifty years ago, J. J. Meyer, an eminent engineer and author of the first system of articulated locomotives which has given practically satisfactory results, wrote the following:

In the systems proposed for coupling in a rigid manner in whatsoever way it may be, the several axles belonging to two diverging trains, the addition of coupling mechanism introduces a greater complication than the addition of two extra steam cylinders, and the maintenance of these mechanisms, as well as keeping the drive wheels rigidly to the same diameter, will be of greater cost than that of the two extra cylinders and the two mechanisms, without taking into consideration the loss in efficiency.

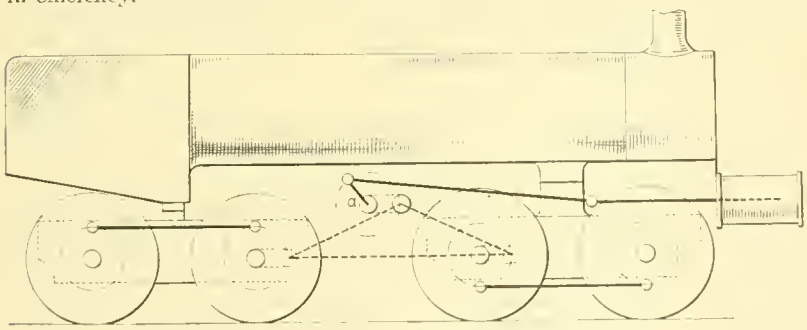

Fig. 11 Rachaert's Free-Axle Design

What has been said above is all the more true to-day, since, in addition to the Meyer machine, we now have the Fairlie system and the author's system, which was the last to come and which has received in recent years such important and remarkable application in the United States, thanks to the energy and skill of American engineers and builders.

DISCUSSION

E. A. Averill. It is impossible in a two-cylinder locomotive to obtain a tractive effort of 100,000 lb., as far as the cylinder is concerned. In view of the limitations of the satisfactory factor of adhesion and safe weight on each driving axle, such tractive effort would necessitate the use of six-coupled drivers. Six-coupled drivers of 60 in. diameter means a driving wheel base of approximately 21.5 feet, which would be impossible for ordinary use, and almost impossible in any case. In this country we have not quite reached 100,000 lb. tractive effort, but we have reached 84,700 lb., and we have also reached the 22 ft. wheel base; and the step to 100,000 lb. tractive effort is one that is desired and probably will be taken. There is an important problem to solve in connection with the very long wheel base required, however, and this paper is particularly timely and should receive very close attention.

The paper itself is mainly historical and contains largely negative information, because the constructions shown are mostly those of failures. They certainly show how the problem cannot be solved, and that is very frequently the most important information that we have.

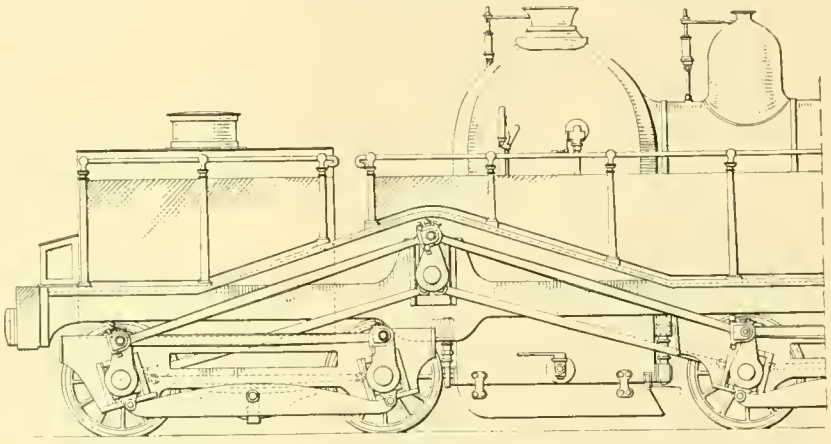

Fig. 10 Free-Axle Locomotive by Kirchweger

Carl J. Mellin (written). The excellent paper by Mr. Mallet is a valuable addition to the history of the development of the locomotive, and one from which references are readily obtained as to what has been done toward the solution of adapting driving axles to curves. This problem has been under constant consideration from the beginning of the locomotive era to the present day and has occupied many minds.

Various forms of gearing were among the first means sought to transmit motion from one set or group of axles to another, each set of axles to be capable of independently adjusting itself to the curvature of the road. This has probably been the most successful principle, through the range of the numerous designs made for this purpose, within the size and weight of the engine where one set of cylinders could supply the power.

The first application of chain transmission was also made at an early date, but probably owing to defective or insufficient strength of the chain this method was abandoned at the outset, although reintroduced at a comparatively recent time. With a more suitable design of chain, a number of log engines have

been built and are reported doing satisfactory service. In a rougher roadbed they permit greater freedom of the axles than do coupling rods.

Theoretically the most correct method for self-adaptation of individual axles to curves, is probably the Haywood idea. It does not appear, however, that this can be applied to any but light engines, due to the unfavorable manner of carrying the weight on the crank axle on the ball connection between the frames. It is also a question whether the wheels will run steady on a straight track, not being confined by any more

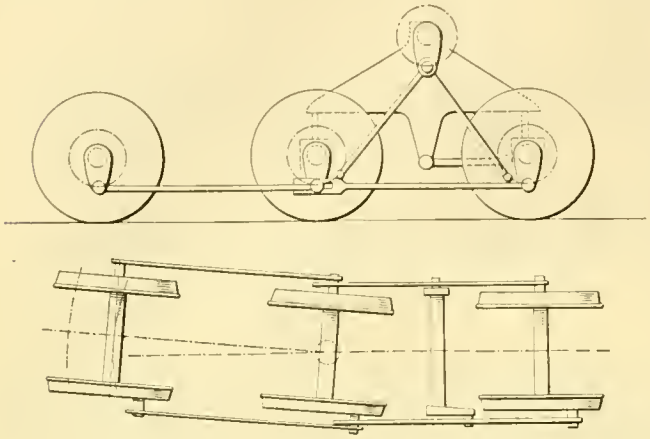

Fig. 12 Köchy Free-Axle System

rigid bearings than the single ball in the hollow axle. This remark holds good also for the hollow axle designs of Cowles, and Klinn and Lindner.

The various other designs are not applicable to modern sizes of locomotives, but have nevertheless served as stepping stones for further progress to meet modern demands of simple and practical applications; and by the introduction of the four cylinders, followed by the Fairlie designs of double swivelling bogies and further by the application of the compound principle, the Meyer and Mallet systems, were brought into existence.

W. F. Kiesel, Jr. (written). Mr. Mallet has given us a most interesting historical presentation of attempts to provide a flexible drive for coupled wheels on driving axles which are permitted to assume a radial position. Apparently few of these designs have reached the experimental stage and none have come into general use. This is sufficient indication that the probability of the schemes are doubtful. The further fact that other solutions to the problem, less expansion and complicated, have been found would lead to the conclusion that such schemes, as illustrated in this paper, will likely never be adopted, as their only advantage would be that all the axles can be driven from a single set of cylinders.

The weight and size of modern locomotives are so great that the cylinder diameters are now as large as road clearances will permit. If larger locomotives are built, and some have been built, the application of two or more sets of cylinders will probably be obligatory. If the number of sets of cylinders is increased, the Mallet type of locomotive is the logical type to use, as with that type no change in customary construction of side rods, pins, etc., is necessary. In the Mallet locomotive, all necessary flexibility that may be required on account of track curvature can readily be obtained, making it unnecessary to consider further the flexible drive. For the reasons given, it is extremely questionable whether further research on the subject of flexible drive would be anything more than an interesting intellectual pastime.

Another reason why such types are not likely to come into practical use is that the loss in efficiency would be greater than the loss engendered by carrying 10 to 15 per cent of the weight of the locomotive on truck axles.

The Mallet type answers the same purpose, is more efficient and less expensive, and has deservedly established itself as a permanent standard on railroads in general.

G. R. Henderson (written). To the writer, the most interesting clause of the able paper by Mr. Mallet is that in which he quotes Mr. Meyer as considering that the extra complication of the various methods of connecting different trains of axles is less desirable than additional cylinders, with articulated pipes. It seems that there are other points in favor of the additional cylinders, more important than the cost or efficiency, thermally considered.

When a large number of axles are operated by one pair of cylinders, we have the following objectional features: *a* Large and unwieldly cylinder proportions and parts, *b* great loads on rods, crossheads, guides and main crank pins, *c* heavy rods

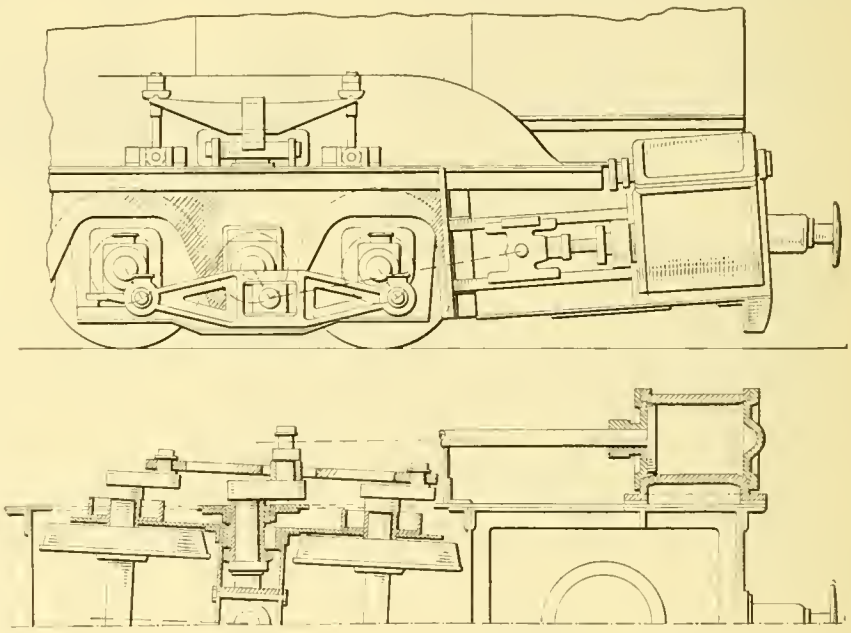

Fig. 13 Krauss' Slotted Rod Arrangement

and reciprocating parts, *d* increased difficulty in lubricating the bearings and rubbing surfaces, *e* greater labor in making round house repairs and adjustments.

When operating on the road, the most objectionable feature is found in the loss of headway due to slipping of the drivers practically stalling the train on heavy grades, whereas, in the Mallet type of locomotive, it is a well known fact that the drivers of both high and low pressure cylinders practically never slip at the same time.

Thus, should the high pressure unit slip the wheels, the receiver pressure at once rises, stopping the slippage and causing the low pressure unit to increase its work momentarily,

thereby retaining at least half of the tractive force (as the throttle need not be closed as in single expansion locomotives) and utilizing the steam exhausted from the high pressure cylinders with little if any waste. Should the low pressure unit slip, then the receiver pressure is reduced, throwing more work on the high pressure unit; and the result is the same as before, only reduced pressure steam being wasted, and the tractive effort is still one half or more as the throttle need not be closed.

The writer considers this one of the most valuable features of the Mallet type of locomotive, and believes that this point is not given sufficient consideration in ordinarily selecting locomotives for heavy drags.

W. E. Woodard[1] (written). It is opportune that the presentation of this paper coincides with the introduction, into this country, of an arrangement which accomplishes in a somewhat different way the purpose of the various schemes described.

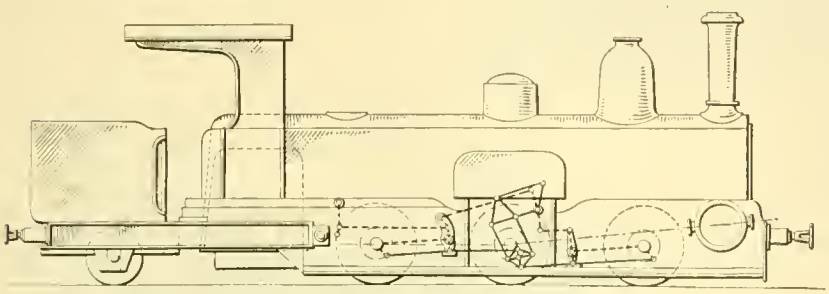

Fig. 14 Klose Variable Length Rod System

From the standpoint of tracking, the problem of operating a long coupled wheel base with a single pair of cylinders could undoubtedly best be solved by arranging certain of the wheels so that they could deflect radially. However, as clearly shown in the paper, this involves mechanical difficulties which so far have appeared to be hard to solve or complicated in application, at least for heavy locomotives. A practical solution would seem to be a compromise construction which permits of lateral motion of certain of the coupled wheels in a plane parallel with the other coupled axles. A comparatively simple side rod construction can be used which will readily take care of the side motion required. The Zara and other similar truck constructions, which have been used abroad, are based on this general principle.

Floating coupled axles, in which an abnormal amount of lateral play is allowed to accommodate the curving of the wheel base, have also been used abroad and to a limited extent in this country. Floating axles with lateral play will certainly allow long wheel base engines to pass sharp curves easily, but their use is open to the objection that they do not contribute any guiding effort to lead the mass of the locomotive around curves, or to steady it on tangent track until the full lateral play is taken up. Moreover, on account of such axles being free to move laterally, almost all the flange wear comes on those coupled wheels which have normal lateral play. The ruling of the Interstate Commerce Commission covering allowable lateral play between driving wheel hubs and driving boxes, lately made, is also an objection to this construction.

It is evident that the design of lateral motion coupled axles which will best meet the conditions of the case should be capable of application to any or several pairs of the coupled wheels. Thus it may be desirable to equip the first and last coupled axle with a lateral motion device, or possibly even the first, last and middle pairs of wheels.

There has recently been placed in service an arrangement of lateral motion coupled axle which meets these requirements. It provides sufficient flexibility to admit of a locomotive having a long driving wheel base curving easily and at the same time affords a definite resistance against lateral motion. This design is in successful operation on a number of heavy ten-coupled locomotives on the New York, Ontario & Western R. R. and has also been used on a similar class of locomotives of unusual weight and power just going into service on the Erie Railroad.

Briefly, the design consists of an arrangement which permits of about two inches total side play of the leading coupled wheels and boxes. This lateral motion is resisted and controlled by a constant side resistance which is obtained through the action of the load carried on the boxes. In this way, a positive gravity control is obtained against an initial side motion of the wheels and throughout the entire range of this motion up to its limit. The side rods connecting this pair of driving wheels with the second pair of wheels are arranged with ball knuckle joint pins and a special design of spherical crank pin.

The principle of applying a yielding resistance to control the motion of the driving axle having lateral play appears to be fully justified by the results of operation so far obtained. Observations of the engines in service show that there is no lateral motion of these wheels on tangent track and on ordinary line curves even when the engine is working very hard at moderate speeds. The tire wear also appears to be about evenly divided between the first and the second driving wheels.

The construction is also applicable to Mallet locomotives, thus increasing the number of pairs of coupled wheels in each unit with a corresponding increase in tractive power.

George L. Fowler said that all the designs illustrated in this paper are intended for easement of wheel pressures on curves, and he had made a few investigations of this subject, with apparently astonishing results.

A seeming fact was that the truck leading a locomotive has a very material effect upon distributing the lateral thrust. For example, in the case of a Consolidation locomotive, it was found that on curves the leading truck exerts the greatest amount of pressure on the rail, then the second driver, followed by the first driver, and third driver and fourth driver, in the order named. Running the engine backwards, the rear wheel strikes a tremendous blow and the remainder travel around the curve without much pressure on the track at all.

The same thing was manifest in connection with the Pennsylvania R. R. electric locomotive, that is, that the leading driver on the rear unit was the one that put most of the pressure on the rail.

The distribution of the lateral thrust depends, of course, entirely upon the type of engine. The easiest riding engine he knew of was the old-fashioned American 8-wheel engine, followed possibly by the Pacific, if weight was eliminated, although in a Pacific engine with trailing wheel, the pressure put on the track by the trailing wheel was invariably much higher than that by the rear driver. In this connection, too, the pressure of the tender on the track was found to be very

[1] Schenectady, N. Y.

light, but strange enough in the case of the sleeping cars it was two or three times that of the locomotive.

On a Pacific engine maximum single wheel pressures of from 13,000 to 14,000 lb. were obtained, while a sleeping car would give a pressure of 32,000 to 36,000 lb. He had obtained as high as 32,000 lb. on a freight car, but this was running on an 8-deg. curve at fifty miles an hour.

He thought the speed of Consolidation engines running backward and switch engines should be limited to certainly not more than 20 or 25 miles an hour. Switch engines hauled over his apparatus, running dead in the train, had a marked effect on the track.

He said it was of no use attempting to make a mathematical

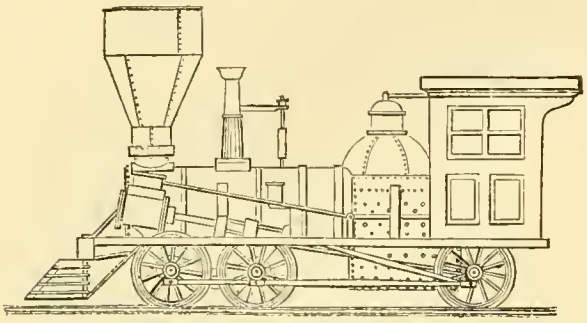

Fig. 15 Baldwin Six-Wheel Connected Locomotive

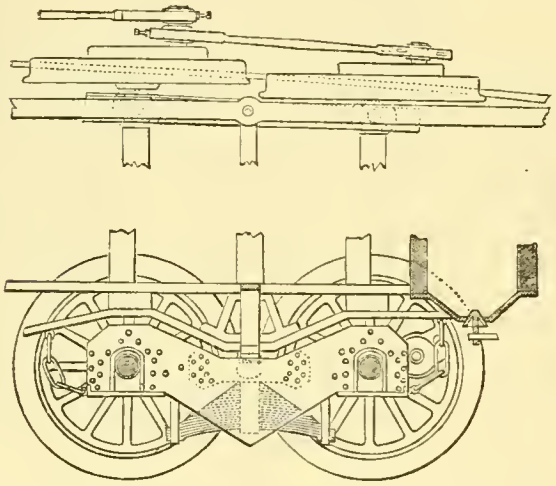

Fig. 16 Truck for Locomotive (Fig. 15)

analysis of what happens on curves. The distribution of the wheel loads on the lateral thrust is quite different from anything in connection with the center of gravity. For example, in the case of the Pacific Locomotive the greatest thrust is by the front truck wheel or main driving wheel, sometimes one, and sometimes the other, but the rear driving wheel thrust is low, while that of the trailing wheel is very high.

In regard to the limitation of side motion in the driving axle, mentioned by Mr. Woodard, he did not feel that there was any difference in a large number of engines, in lateral motion on curves, where the engine is apparently laying over against the outer rail and all the thrust is put there. Side motion on tangent track was apparently a very important element, and an old locomotive with from 1½ to 1¾ in. side motion in the journals slides over a tangent track with an ease that is perfectly surprising.

He thought most of the blow caused by a tuned-up engine was due more to the track. His own experience coincided with that of the Pennsylvania Railroad on the New Jersey & Sea Shore Line, to the effect that if you got a heavy blow at a certain point on the track, at any speed, or in any one particular type of engine, you were apt to get it every time an engine passed over that point. Distortion of the track, too, is a serious matter.

If there is any limitation in regard to the side play in an engine, it should be very liberal. A worn engine does not put any greater stress on the track on a curve than one freshly out of the shop, and it puts remarkably less stress on the tangent track.

E. B. Katte. Some experience derived from the development of the earlier high speed electric locomotives does not conform with Mr. Fowler's in regard to lateral motion. It was found that in the early electric locomotives equipped with two wheel guiding trucks considerable lateral motion produced a hard knock against the track rails when running into

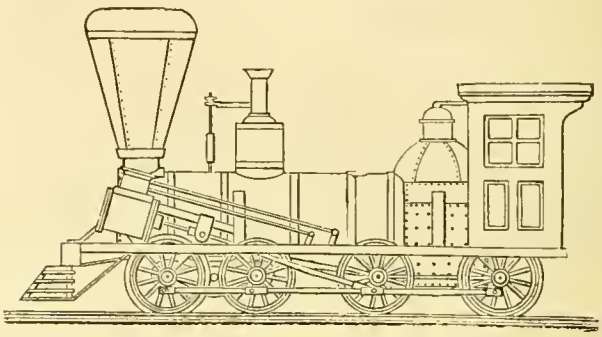

Fig. 17 Baldwin Eight-Wheel Connected Locomotive

or leaving a curve. The low center of gravity accentuated the blow and at 70 or 75 miles an hour the cumulative shock was considerable, while the same locomotive with the lateral motion reduced by hub shims was run up to 85 miles per hour without producing a blow against the rails. Unfortunately, the locomotive had to be shimmed up so tightly that it would not take the short radius yard curves, and other means to prevent the lateral rail thrust had to be found.

Roy V. Wright asked whether it were possible to provide a large enough cylinder on a locomotive to take care of six-coupled axles, and C. D. Young asked what were the limitations to one design. What was the maximum play that could be given the front and rear axles?

W. E. Woodard replied that he thought this was possible. Such a locomotive would probably take a 32 or 33 in. cylinder, well under the size of those used on the Mallet engines. He did not see any obstacle in the way of our proceeding up to a 100,000 lb. tractive effort simple locomotive. With a larger cylinder the centers would have to be thrown out further, and to prevent side vibration the wheel base would have to be made considerably longer.

In reply to Mr. Young, at present we have only one 1⅛ in. play on each side, but we could probably arrange for one 1½ in., or possibly more.

C. D. Young said that he could see no particular difficulty in reaching 100,000 lb. tractive effort in a locomotive other than of the Mallet type, but did not believe that the use of two cylinders was the only way to do it. It should be done with two pairs of simple cylinders, or with three simple cylinders, or if two cylinders are designed to keep within the clearance

diagram of the right of way, by increasing the boiler pressure and limiting the cut-off. In that way the long overhang of the main pin which results from the wide spread of cylinders would be overcome, as well as cylinder clearance.

If the cylinders were made large enough to limit the full gear position to a reasonable cut-off, he thought that a boiler could be made which would develop the possibilities of 100,000 lb. tractive effort with two or three cylinders. He saw no use, however, for such a locomotive if the boiler could not supply enough steam.

There should be three or four cylinders large enough to permit the valve gear to be so arranged that the maximum cut-off would not be over 65 or 70 per cent, thus making it possible to develop full tractive effort at a reasonable water rate.

The water rate of the two-cylinder engine, working in full gear at seven or eight miles per hour, is about 31 lb. per i.h.p. hour with 125 deg. of superheat. If the cut-off is reduced to 50 per cent the water rate drops to 18.5 lb. The difference in boiler requirements between these two valve gear positions is evident. Likewise, if two cylinders are used and the boiler pressure is increased a sufficient amount to limit the cut-off to 50 per cent, corresponding results would be obtained, so far as the water rate is concerned, but with such an arrangement, some special provision should be made in the valve, or by a special starting valve with the two-cylinder locomotive.

Fig. 19 Motor Car with Pivoted Trucks

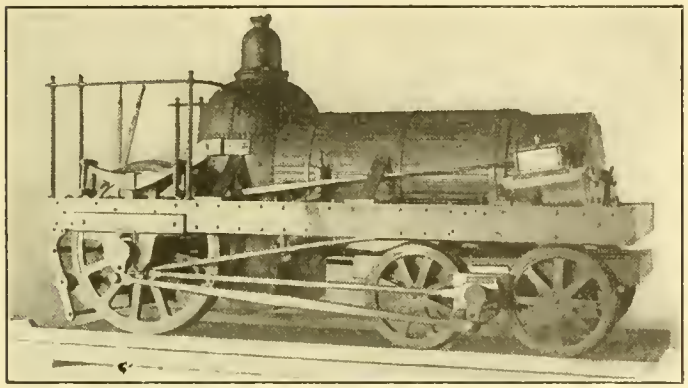

Fig. 18 Gear-Driven Truck Locomotive

S. M. Vauclain (written). I have read with great interest the author's historical account of the development of the different systems of radial axles on locomotives operated by a single set of cylinders.

Mr. Mallet's paper covers only the use of transmission adapted to curving when such a transmission is driven by steam cylinders. Electric drive lends itself to the use of radial trucks without serious complications, and the various systems employed both in this country and abroad have been described so frequently that a further description will be of no special interest.

In 1842, Mr. Baldwin took out a patent on his 6-wheel connected locomotive in which the four front drivers were combined in a flexible truck. This locomotive was especially adapted to use on American roads then existing, which had extremely sharp curves, and a large number of locomotives of this type were built and were very successful. The original engine of this type, as shown in Fig. 15, had six wheels, all connected as drivers. The rear wheels were placed rigidly in the frame and had inside bearings. The four remaining wheels had inside journals running in boxes held by two wide and wrought iron beams. These beams were entirely independent of each other and the pedestals formed in them were bored out cylindrically for the reception of cylindrical boxes. The engine frame on each side was directly over the beam, and a spherical pin from the frame bore in the socket between the beam, midway between the two axles, so that the operation of the beam was similar to the parallel ruler. A half plan of this truck is shown in Fig. 16. The coupling rods were also made with cylindrical brasses.

This design was subsequently modified into an 8-wheel connected locomotive, shown in Fig. 17. In this arrangement both pairs of drivers are rigid and connected to the boiler and steam machinery. The wheels of the front truck are connected by side rods to the drivers and the truck frames are pivoted under the engine frame to obtain a parallel movement to the axle when on curves. This lateral movement is possible since the axle journals and the rod brasses are cylindrical in their boxes.

Fig. 18 shows a design in which one driving wheel is coupled to a shaft driving a gear, which in turn drives truck wheels of smaller diameter. The truck is adapted to curves in the same manner as that previously described.

Fig. 19 shows a motor car with a compound engine in which the driving trucks are pivoted and steam is admitted to the cylinders through the carrying bearings. The boiler rotates in the body of the motor car as the driving truck accommodates itself to the curve. The rear truck in this arrangement is simply a carrying truck and is not driven. This locomotive was built in 1897.

The foregoing are by no means all of the American designs of locomotives with radial axles, but they serve to show different solutions of the problem, all of which have been in successful operation.

F. J. Cole (written). This paper makes readily available the information contained in technical literature extending over many years regarding the most interesting arrangements which have been used or proposed for parallel driving mechanism arranged for operation by two cylinders, having all the weight available for adhesion, with the advantages of radial axles for traversing sharp curvature.

It is probable that such designs, with the exception of geared locomotives, similar to Shay, Climax, etc., attract much more serious consideration abroad than in this country. It is significant, however, that few, if any, of these locomotives are now in operation, the inherent difficulties and complications probably being so great that they more than offset the advantages gained. They have also been superseded by designs having more than two cylinders and in which the necessary radial action is obtained by swiveling trucks, such as the Fairlie and Pechot. Usually such engines are built for slow service on roads with heavy grades and sharp curvature. The use of four cylinders is often more economical, all things considered, than the complication incident to special forms of radial axles.

The author, in the invention of the locomotive which bears his name, has done more to render unnecessary such designs (except geared) than probably any other man. These Mallet or articulated locomotives, as is well known, are adapted to the widest possible range of service. Originally they were intended for military use for very narrow gauges and extremely sharp curvature, the track following the natural undulations of the ground with but little grading. At the present time in this country, we see their very highest form of development in hauling the heaviest tonnage trains in the world, such for instance, as the 2-8-8-2 type for the Virginian Railway, having a tractive power of 115,000 lb. when working compound and 135,000 lb. when working simple for short distances; it has a weight of 481,500 lb. on drivers and 542,500 lb. total in working order. It is probable that even these figures will be exceeded in the near future.

We see again modifications of this design in the Triplex, which is a triple articulated compound, with the weight of the tender utilized for adhesion. Such locomotives are suitable only for very slow service because of their boiler or steaming limitations.

Engines of this kind operate with the axles of the front engine substantially radial to the track. They can be built in all designs from 0-4-4-0 to 0-10-0 or 2-10-10-0 and many other intermediate modifications of arrangement of trucks and driving wheels carrying either all the weight on the drivers or provided with leading and radial trailing trucks suitable for the road conditions under which they operate. I agree, therefore, with the author that it seems unnecessary to consider seriously many of the designs shown in the paper.

Five-coupled engines, having leading and sometimes trailing radial trucks with lateral play in the front and occasionally in the rear driving axles, can be operated successfully on sharp curves. It is better practice to use some form of gravity or spring resistance in axles having much lateral play in order to distribute the flange wear. Whether for safety these axles actually require centering devices or control, depends upon the speed and other conditions under which the engines are operated. Such devices are now available in simple form, which operate successfully. It is only in heavy grade service that locomotives having all the weight on the drivers can be operated satisfactorily. The horsepower in such service is relatively small, therefore the steam requirements are not so exacting. For fast service, in order to get sufficient boiler capacity for conventional types of locomotives it has been found necessary to carry a certain portion of the engine on leading and sometimes on trailing axles, not only to provide for the guiding of the locomotive on curves, and therefore to make the operation safe, but to permit the construction of a boiler of sufficient size to provide the steam required.

W. F. M. Goss said that from our study, experience and understanding of the general problem, it would appear that the developments described in the paper are not of great practical value. Our experience seems to have passed the stage of development with which Mr. Mallet deals. The fact is, however, that we can never tell what the next step will be, because we can not predict the conditions that are to govern it. It is perfectly clear, for example, that the chain transmissions shown in these designs were destined to failure at the time they were employed, for in that day chain drives were crude things; but it is equally clear that if for any reason we should desire to-day to couple up locomotives with chains, we could do it successfully because practice in chain gearing has passed from an experimental stage to one of great refinement. Changing conditions, therefore, emphasize the profit to be derived from study involving the historic development of mechanisms. I regard the masterful presentation of Mr. Mallet as a contribution to our Proceedings of high value.

The Author was unable to present his paper in person, but it was presented by E. A. Averill, Mem.Am.Soc.M.E., who also contributed to the discussion. A letter written by Monsieur Mallet and received subsequent to his manuscript included the following paragraph which, he said, established a very clear case of priority in favor of an American designer:

The author wishes to recall here that probably the first case of transmission by convergent axles on a locomotive from a fixed steam cylinder by means of a connecting rod located in the longitudinal axis of the engine, is to be found in the locomotives built in 1832 by Horatio Allen for the South Carolina R. R. In this engine the main rod had a vertical jointing with a small stub end and large head spherical journal, so that, on curves, it lent itself to an oblique action on the central arm of the axle.

FOUNDATIONS

BY CHAS. T. MAIN, BOSTON, MASS.

Member of the Society

After the location of a plant has been decided upon, and the site selected, a sufficient number of borings should be made or test pits sunk to determine the character of the soil and its bearing capacity. Such exploration will reveal whether the site is suitable or whether the cost of foundations would be excessive. If the site is found suitable, the knowledge of the underlying soil or rock is necessary for the proper and economical design of the foundations.

The borings are made for the purpose of determining at what level firm soil is to be reached, if at all; the thickness of any stratum of firm soil: the character of the underlying material; the level of the ground water; whether piles will be required and the probable length of the same.

It is of great importance to support all structures on a stratum of soil below silt or peat. If the structure is to be a heavy or an important one and it is found necessary to use piles, some of the borings should be carried to bed rock, if possible, and dry samples of the soil should be taken every few feet in depth. The samples should be examined as soon as taken, as the moisture in them evaporates and their character changes rapidly. If uniform conditions are found a few widely scattered borings will be sufficient, but where the conditions vary a greater number should be made. A description of the processes and values of borings is given later.

If it is found necessary to drive piles, test piles should be driven and careful records kept. Piles should be tested by loading until marked settlement takes place and careful readings should be made before and after each increment of load. If possible loads should be allowed to rest at least 24 hr. after each increment, except the final load which should remain on at least 48 hr. unless a failure of pile or testing platform prevents. All test piles should be pulled, whether load-tested or not, to determine their condition and suitability for the work.

From the accumulated data obtained from borings, test pits, test piles and from pile loading tests, it will be possible to select working loads for the piles suited to the building to be supported. In general the working pile values should have a factor of safety of not less than 2½ based on a load producing ⅜ in. total settlement by test. However, it may be desirable to select a working load based on allowable settlements such as $\frac{1}{16}$ in. to ⅛ in. The values of the factor of safety and working or ultimate settlement are all to be fixed to suit the class of structure to be supported.

Buildings which are to contain moving machinery or delicate instruments would naturally require piles with fairly large factors of safety, while in cheap one-story structures for storage purposes the safety factors could be much lower. Where piles are not load-tested, the values given by the Engineering News formulæ can safely be used. These formulæ are:

For a pile driven with a drop hammer

$$P = \frac{2\,W\,H}{S + 1}$$

For a pile driven with a steam hammer

$$P = \frac{2\,W\,H}{S + 0.1}$$

in which

P = safe load in lb.
W = weight of hammer in lb.
H = fall of hammer in ft.
S = penetration or sinking in in. under the last blow

Test pits should be sunk for determining the level of the ground water and for making a study of the soil for a reasonable depth more accurately than can be done with borings. Both the maximum and minimum levels of the ground water should be determined, the maximum for obtaining the hydrostatic head on waterproof basements and the minimum for finding the safe level for cutting off wood piles or to determine if it will be better or cheaper to use concrete piles.

When the structures are of any considerable magnitude and piling is unnecessary, tests should be made to determine the bearing capacity of the soil to insure the maximum economy in design. Having ascertained the condition of the soil and decided that piles are not necessary, and having also decided upon the maximum pressure to which the soil is to be subjected, the widths of foundations can be determined from the estimated loads.

Solid ledge forms the securest support for foundations, providing it goes all round the building. Part earth and part ledge are apt to cause unequal settlements. The ledge, if uneven, should be leveled off and, if on a slope, cut to form steps to give an approximately horizontal surface. In going from rock to earth, the footing courses of the foundation should be spread out to a greater width on the soil next to the ledge, gradually narrowing into the regular width for earth foundations. If there should be any unequal settlement, it will be spread over a greater length of the superstructure and probably save cracks in the walls which might otherwise occur at the junction of earth and rock.

Hard gravel or hard pan is quite as desirable as ledge. Gravel and sand are also good when kept dry. A stratum of 6 to 8 ft. of hard-compacted and well-cemented material, even if underlaid by softer material, is usually safe. With dry sand, this stratum should be double the thickness.

Clayey soils are somewhat treacherous. Upon exposure to the air they dry and crack, and exposed to rain they become semifluid or expand. With this soil it is best to open only a small portion of the trench at a time and quickly fill in behind.

With buildings used for industrial purposes, there is usually more or less vibration caused by machinery in motion, and the loads carried by the foundations should be less per square foot of bearing material, or less per pile, than in buildings which are not subject to such vibration. On soft clay or running sand confined, the pressure should not exceed ½ to 1 ton per sq. ft.; medium blue clay, whether or not mixed with fine sand, 1 to 2 tons; hard clay, 2 tons; compact sand and gravel, 2 to 3 tons; hard pan, 5 to 6 tons per sq. ft. Under favorable conditions of soil and use of building, these loads may be exceeded.

In any building with a uniform firmness of earth under it, the area of foundations for walls, towers, piers, and other portions of the building should be in proportion to the pressure. The loads on the outside walls may be a little lighter than those on the piers. In case the soil should vary considerably in one portion from another, the areas supporting equal weights should be changed to correspond with the soil. In this way unequal settlements are avoided and the most economical structures of approximate uniform strength obtained.

Where there is unreliable soil, piling must be resorted to. If firm earth cannot be reached by the bottom of the piles, the

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supporting force is friction alone. If there should be an underlying firm stratum, even at such a depth that excavation would be too expensive and sometimes impossible, but still within the reach of piles, then piling can be used with good success.

Where wood piles are properly driven, that is, not broomed or broken, the bearing capacity of the piles, when driven into sand, usually shows under the test loads a slight increase over that indicated by the Engineering News formula; but those which have brought up hard and have been crippled will show a much less capacity under the test load than was indicated by the formula.

From tests recently made on wood piles embedded in medium and stiff clay on the site of the new buildings for the Massachusetts Institute of Technology, it was found that for about each 5 ft. of embedment of the pile in clay, 1 ton value could be added to that given by the Engineering News formula for drop hammers.

Spruce or similar soft wood piles without iron points, driven with drop hammer, should be used cautiously where there is a hard crust of gravel or sand overlying clay. Oak piles without iron points will usually penetrate the hard ground and come practically to a standstill without material injury. Any wood pile which is to depend largely upon point bearing for its value should be of oak or southern pine.

When piles are driven through a hard fill and an intervening layer of peat, silt or mud, to the hard sub-soil it will be necessary to reduce the value given by the formula as it contains the values of the hard fill above the intervening peat. This value can be approximately corrected by subtracting the value shown when driving in the fill or a conservative value assumed after comparing with other piles passing through no complication of strata.

Unless Batter piles are used, it is necessary to drive far enough into the solid material to give stiffness to the structure against vibration, especially where the fill above is soft.

Concrete piles should be used where the distance to good bearing material is great, where wood is scarce or the ground water low. Considerable expense may be saved in the foundations under the latter condition.

The three kinds of material commonly used in foundations are dry rubble masonry, rubble masonry laid in mortar and concrete. Dry work is unsuitable for industrial buildings. Stone laid in cement mortar with bedded joints is very satisfactory and should be used where there is an ample supply of stone at a low price. Concrete is most commonly used and is usually the most convenient material to handle, and under ordinary conditions it can be used at the lowest cost.

A foundation for a chimney and other isolated structure having a small base and heavy pressure should be carried to the lowest depth to which it would be necessary to go with any other work reasonably near it, since if it is on sand there is a liability of undermining it.

The preceding is a very general consideration of the subject only, and the second part of the paper is devoted to more extended descriptions and data regarding testing soil, excavations, structures, stability of foundation walls, specifications for concrete, mixing concrete, placing concrete, forms, surface finish and foundations for piers. The following paragraphs are taken from this part.

TESTING SOIL

Wash Borings. These are made with the aid of a tripod, iron or steel casing, drill rod, hose, force pump, bucket, etc. The tripod used to support the casing and drill rod usually stands 12 to 15 ft. high. The casing is usually made of heavy pipe, 2 to 2½ in. internal diameter, and inside it works a heavy hollow drill tube or rod, 1½ in. to 1¾ in. outside diameter. This drill rod is fitted at the bottom with a chopping bit having openings in it for the water jet, while the top is connected with a water hose and force pump, the latter usually double-acting. In action, the water is forced down through the drill rod, jetting through the holes at the chopping bit and carrying up the loosened material in the annular space between the rod and case.

Test Pits. Test pits furnish the opportunity of observing the character of soil, its degree of compactness, amount of moisture, etc., but to be of full value they should be carried well below the level of the bottom of the foundations. In cases where the strata change with the depth, a test pit gives no sure indication of the soil below the foundations unless carried deeper than the level of the footings.

Test Rods. Testing soil with a rod is an unsatisfactory method and cannot be relied upon to give accurate information except in a limited number of cases. In a homogeneous material, not too hard, the method is valuable in determining the constancy of varying density and resistance.

EXCAVATION

Work on foundations consists of excavation of earth or rock, including shoring, sheet piling, or coffer dams, and a structure of stone, concrete, brick or timber at the bottom of the excavation, including bearing piles. In nearly all cases the expense of excavation will increase with the hardness of soil and inconvenience for working; but if the excavation is in sand or soft earth, with considerable water to contend with, the cost is largely increased by the necessary structures for inclosing the excavations and sustaining the banks.

Earth is hard in proportion to the amount of cementing material which it contains and its temporary stability also depends on the amount of this material, while its permanent stability depends upon the friction of the particles on each other. The disadvantage of hardness for excavation is offset in many cases by the advantage of the self-sustaining power of the vertical cut for a time sufficient for the work on the foundation to be completed. If a vertical cut is exposed for a long time to the weather, it may become dangerous. The effect of an excess of moisture, freezing and thawing, or drying out is to crack off the bank and gradually to approach the natural slope of permanent stability. If the time required to lay the foundation be very long, or the weather unfavorable, it may become necessary to shore up even in firm earths, but in a much less expensive manner than in material which has a tendency to flow.

Usually, in working in clean sand or gravel below a depth of 5 to 6 ft., shoring may be done by laying in planks horizontally along the sides of the banks, putting in vertical timbers or planks at short intervals and opposite each other, and bracing between them. Even with this sort of shoring, it is well to make it secure, so that no braces or other pieces may drop out and injure any person or perhaps cause a slide.

When sand containing water, or soft clay with running water, is encountered, the saving of soft excavation is entirely absorbed by the expense incurred in sustaining the banks and preventing damage to any adjacent buildings. Sheet piling must be used here, which consists of planks or timbers driven closely together and of a thickness varying from 2-in. plank to large timbers, according to the depth, pressure, and soil. Four-in. plank is about the thickest used in ordinary work. Three to 6-in. plank should be grooved on edges, the grooves to be filled with splines.

Coffer dams are built for the exclusion of water while work is being done. The kind employed depends upon the nature and extent of the work and the strength should be somewhat in proportion to the amount of damage or delay from failure. As the space and amount of puddling material are usually limited, the best and usual form will be a bank of puddle inclosed and supported by a row of sheet piling on each side. Experience has shown that 4 to 6 ft. is sufficient for the puddle to exclude the water; but unless the dam is supported independently, its width must be in proportion to the depth of water, so that it will not be overturned. Good timber should be used here as in ordinary sheet piling and for the same reasons. Where there is room, a bank of sand against the inside sheeting will assist in supporting the dam.

Bag Dams. Where the depth of water is not great, bag dams can be used to advantage. They can be cheaply and quickly constructed and in some cases are almost indispensable. They can be used for shear dams for turning water away from foundations, especially where sheet piling cannot be driven, for repairing breaks in banks and for many other purposes. They are made from strong empty cement bags or gunny sacks filled with sand or other suitable material and securely tied and deposited in the place where they are to be used.

Piling. Where the depth of good bottom is too great to be reached economically by the foundations, approximately 10 ft. or more, it becomes necessary to use piles. The determination of the type of piles depends upon local conditions. If it is necessary to spread the load over as much area of the underlying land stratum as possible, wood piles should probably be used. If it is not necessary to spread the load, a fewer number of concrete piles with higher bearing value can be used. If the ground water is comparatively low down, it may be much more economical to use concrete piles and carry the foundations down to the ground water level, than it would be to use wood piles.

STRUCTURES

Of the structures at the bottom of the excavation there are many forms and kinds. Those most commonly used are concrete stone laid in cement mortar or bedded rock, stone laid with outside joints pointed and then grouted full, and stones laid dry.

Dry rubble work is unfit for industrial buildings. As there is a constant vibration, the few bearing points of the stone, when laid dry, will get worn off and thus cause slight settlements, which, though perhaps not unsafe, might lead to annoying cracks.

The cheapness of suitable building stone in some localities will sometimes made it desirable to use stone for the foundations. Stone laid in cement mortar, with bedded joints, is the surest kind of stonework. With grouted work there is not that surety of filling all the joints. Grout, when made thin enough to run freely, takes a very long time to set and strengthen, and never attains the strength of cement mortar. The sand is liable to settle away from the cement, thus making the final strength variable. Old foundations laid dry may be greatly strengthened by pouring in grout, and pinning them up. The more recent method of forcing grout into old work is used with great satisfaction in many cases.

Concrete, plain and reinforced, is now used almost exclusively for all kinds of foundations owing to its economy, availability, suitability, ease of handling and rapidity of construction and strength. It should be made according to proper specifications, and be properly mixed and laid.

FOUNDATIONS FOR PIERS

Foundations for piers which support columns are subject to more shock than foundations for the side walls, and the footings in buildings which contain machinery which causes much vibration should be ample, so that there will be no settlement. In some cases the footing course is made continuous for the full length of the building. If built of concrete the location of the joints should be predetermined; they should be about half way between column centers and not over 20 ft. apart. Where the bays are large, reinforced footings can be used. It is probably safer and more convenient for construction to design independent piers of liberal area and low soil pressure suited to the load and soil.

The piers above the footings may be of concrete or brick, usually now of concrete. If of brick they should be good hard burned brick laid in cement mortar and capped with stone or cast iron. The pressure should not exceed 15 tons per sq. ft., and as the height increases the area should be increased for stiffness.

With piers or other footings of concrete, if built in steps, the horizontal lap should not exceed $1\frac{1}{2}$ the thickness of the step.

DISCUSSION

M. M. Upson presented a written discussion in which he stated that, in his experience, on most sites where the problem of foundation is serious, it is difficult to use the information from either wash or dry borings unless they disclose a substantial bearing stratum. The reasons for this are many, but in general are due to the inability of the average engineer to determine from a physical examination of a small sample of the soil what safe bearing strength it has, or what friction per square foot of pile surface may safely be imposed upon it. Many engineers of wide experience are reluctant to place heavy structures on a site where rock, hardpan, or stiff clay cannot be reached, and frequently valuable real estate remains undeveloped because engineers have not been able to find a good bearing soil within economical reach of the surface.

The idea of carrying heavy monumental buildings or costly steel structures on the friction of piling has not until recently been accepted as good engineering practice, and there is at the present time a large school as yet unwilling to subscribe to the assumptions on which the principle is based. Piling is usually conceived of as a means of carrying the loads from the surface of the excavation through a soft material to a substantial underlying base. It is therefore frequently a shock to be told that the piles supporting certain structures have their points in a material of no greater density and frequently of less density than the material which surrounds their butts.

The engineering prejudice against all friction pile foundations is more or less justifiable, since little information is available in engineering literature on the allowable friction per square foot of pile, and unless the individual has had a wide experience in driving various kinds of piles in all characters of soil, it is quite impossible to safely predetermine the length or the proper pile for the work.

A large percentage of piling work is done in ground which does not have any substantial lower stratum to which the point of the pile can reach. This means that the pile must support its load by friction. The amount of friction per square foot of the surface of the pile is dependent upon two variables, namely, the taper of the pile and the character of the soil surrounding it. Given the same soil, the surface friction increases as the taper increases. This is due to two causes:

a The greater the taper, the greater the tendency to compress and increase the density of the surrounding earth, since a tapered pile subjects the surface of the ground to the maximum initial pressure and thereby overcomes the tendency of the earth to heave around the pile. The density of the underlying material is thus greatly increased. It is obvious that a heaving of the soil releases the interior compression, which in turn reduces the surface friction.

b A unit area on the surface of a tapered pile naturally has a greater vertical component than the same unit on the surface of a straight pile. In the latter instance the vertical strength can be no more than the shear of the earth, while in the former the compression strength of the earth becomes a material factor.

The above statements are based on the assumption that the type of pile used conforms to the essentials of a frictional piling member, and may be tersely expressed as follows:

(1) The form which acts as a penetrating element or the pile itself must not be so cushioned that the major part of the energy of the stroke of the driving hammer is absorbed in the cushion, and must be of sufficient strength to withstand severe abuse.

(2) The compression of the earth secured by driving the form must be maintained while the latter is being removed and concrete put in place. In other words, the substitution of soft plastic and unset cement in a hole made by the driving form will not hold the compression of the soil which has been obtained in the driving.

From the above it may be observed that a lineal foot of piling may represent a supporting power of ½ ton or 3 tons, all depending upon the resistances to which the pile is driven, and on whether the conditions which obtained while the pile is being driven are continued throughout the entire process of placing the pile.

Much thought and money has been expended in experimenting on a simple and inexpensive method to quickly predetermine the probable length and carrying capacity of piles in a given soil. The most feasible method thus far developed is the driving of a series of ¾-in. rods joined together by large cast iron screw couplings. This driving is accomplished by the use of a heavy sledge of given weight and swung through a definitely determined arc. A record is carefully kept of the number of blows required for the penetration of every foot, and the test is considered complete when the resistance of the rods has attained a certain number of blows to the last inch. The extending shoulders of the couplings are analagous to the taper of the pile and test the resistance of the various strata of soil penetrated. By carefully comparing these tests with the actual results of driving piles on the same site, a very interesting analogy is formed, making it possible to predetermine with a fair degree of accuracy the length and the loading.

Charles H. Bigelow said that in a good many cases sufficient attention is not given to foundations, and he had seen quite a number of cases in which there had been practically no foundations put in at all. The reason is probably that foundation work is covered up.

He recalled a case in which a building was put up directly over a 24-in. water pipe, but the owner desired a cheap building and was satisfied.

He thought the matter of foundations required a good deal of attention and care, and that the paper would be of service to anyone requiring to take up the facts of the subject on any occasion.

A. G. Monks (written). It may be worth while to point to the interesting complication that arises when buildings are constructed on land so valuable that the outside walls or columns must be placed on the lot line and the foundations must be kept entirely within the lot, a condition frequently met with in cities. It becomes necessary then to place a column on the edge of a foundation, the effect of which is similar to that of a heavy-weight swimmer standing on the edge of a raft. Two courses are open to the designer. He may either construct the foundation large enough and strong enough to carry the column, notwithstanding its eccentric position, or he may combine the foundation with one or more others in such a way that the center of the combined column loads coincides with the center of uniformly distributed pressure on the soil under the combined foundations.

Either of these types is, of course, much more expensive than the ordinary concentric foundation, and they are for that reason to be avoided when possible. The first method was more prevalent some years ago when heavy stone masonry was chiefly used for foundations, and still meets some favor when the soil is particularly firm or the loads light. Concrete reinforced with steel bars, which has come so extensively into use in recent years, both for foundations and for the superstructure of buildings, is particularly adapted to the combination type of foundation, and this type has consequently grown in favor along with concrete.

The design of a combination foundation is often intricate, particularly at the corner of a building adjacent to two sides, both of which are on the lot lines. Four columns have then to be carried on one foundation. In some cities the space below the surface of the street is regarded so valuable for present or future subway purposes that by the building law foundations are not allowed to project beyond the street line, and the combination foundation is more frequently required for that reason.

The facility with which reinforced concrete can be handled by the experienced designer, and its adaptability to a wide variation of conditions in the design of foundations, have made possible the easy solution of many problems formerly exceedingly expensive and intricate.

Sanford E. Thompson (written). Almost as important as the bearing power of the soil is the structural part of the foundations. Where the construction rests on columns, a thorough study of the conditions must be made to determine whether single or combined footings are best. In combined footings, that is, footings upon which more than one column rests, the problem of obtaining uniform distribution of the column loads on soil or piles is frequently so complicated, especially where column loads are unequal, as to call for the application of principles which the engineer seldom meets elsewhere. The arrangement of steel and the computation of stresses also present many difficulties.

In general, where piles or unstable soil require a large distribution of area the combined footing is preferable. This also applies in general to a line of columns under the conditions indicated. The footing of course must be designed for the upward reaction between columns. In a floor the distributed loads are resisted by concentrated reactions of the columns. In footings the concentrated loads of the columns are resisted by the disturbed reactions of the soil. It simplifies the problem for the designer who is inexperienced in this type of work to think of the footings as upside down and to consider the supports to be the columns and the loads to be the upward pressure of the soil or the piles. The reinforcement

of the combined footing must be placed in just the reverse position from that in the ordinary beam or slab. It must be in the top of the footing between the columns and at the bottom of the footing below the columns. In simple cases the computations then are similar to those required for floor design. Unequal column loads and especially the arrangement of three unequal columns on the same footing may further complicate the problem.

A retaining wall, as indicated by Mr. Main, is frequently a part of the foundation. A reinforced concrete retaining wall must be designed to resist not simply the stresses due to the pressure of earth, but also the stresses due to shrinkage in concrete and changes in temperature must be taken into account. This is particularly necessary where the foundation wall projects above ground and the building is placed directly upon it. Of course, if a structure permits, definite joints may be placed between different sections. In building construction, however, it is frequently necessary to avoid joints or any noticeable cracks. By placing reinforcement to the amount of 0.3 per cent, or better still 0.4 per cent of the cross section of the wall, it may be built monolithic and noticeable cracking may be avoided even in long walls.

The greatest difficulty is in providing for a bond between sections of the wall laid on different days. Positive adhesion cannot always be assured, but by running full or better still excess reinforcement through the end forms and then spreading a bonding layer of neat cement upon the vertical surface of the old concrete, just before the fresh concrete is placed it is usually possible to prevent separation.

Of special importance in the design is the reinforcement above and below openings in a long retaining wall. As much, or preferably a little more, cross sectional area of longitudinal steel must be used in the sections above and below the opening as in the total section of the blank wall. The forces caused by shrinkage and temperature, which are proportional to the cross-sectional area of the solid wall, are just as powerful at the openings as in the solid wall, so that the section is weaker unless as much steel (which means a larger percentage) is used there as elsewhere. In fact an excess in quantity may be needed because the area, and therefore the strength, of the concrete itself is reduced by the opening in the wall. In addition it is advisable to put diagonal bars across the corners of openings to assist in preventing the starting of any cracks at these points.

F. A. Waldron (written). The use of the Engineering News formula is dangerous unless full knowledge of the character and action of the underlying strata is at hand. Buildings erected on pile foundations in peat or silt have been known to go down two or three feet; in fact, piles have sunk away from the building from their own weight and weight of soil, when driven to the requirements of this formula.

Special care should be taken to avoid driving taper concrete piles in peat formation, as it is like driving a taper nail into a rubber heel and demands too much punishment of the driving mandrel; and these piles will settle if given double the amount required by the Engineering News formula, unless driven to hard pan, which is next to impossible in thick strata of peat.

Piles driven in peat or silt or other formation of varying thickness, where the mass is liable to change by fill and slide or exert a force sidewise, should be tied together, where driven singly on each side of the building, or the groups so arranged or designed to resist the unbalanced lateral pressure.

Particular care should be taken, where soil is filled, in analyzing and counteracting forces tending to spread or force out of position by lateral pressures on the piles, due to weight of fill on strata above hard pan.

ANNUAL MEETING DISCUSSION

IN the January issue of The Journal were published the papers by F. W. Dean on fire tube boilers; L. B. McMillan on steam pipe coverings; Paul A. Bancel on circulation in water tube boilers; Geo. H. Gibson and Paul A. Bancel on surface condenser performance and design; Robert Cramer on higher steam pressures, A. L. Menzin on proportioning chimneys; Mark A. Replogle on the turbine discharge accelerator and Louis Illmer on oil engine vaporizers, all presented at the Annual Meeting, December, 1915. The discussion of these papers, both written and oral, indicated an appreciation of the work of the authors in the preparation of the papers, and testified to the value of the data contributed, as well as brought out a number of points of particular interest. These discussions are printed in their complete form below.

DESIGN OF FIRE TUBE BOILERS AND STEAM DRUMS, F. W. DEAN

DISCUSSION

W. F. KIESEL, JR.[1] (written). The ills of boilers and some remedies, as described by the author, are worthy of considerable thought. The remedies proposed seem to indicate a general rule, that is, to distribute unavoidable distortions or deflections over as much space as possible, thereby avoiding concentration of strains in isolated locations, at which points, due to stresses approaching or exceeding the elastic limit, detailed fractures will occur.

The author has pointed out possibilities of change in design which tend to distribute the distortions. Distortions due to varying pressures can generally be eliminated in this manner. Changes in shape due to temperature must receive careful consideration by the designer, who usually estimates the possible extent of the distortion and utilizes the best available means to counteract the resultant strains within sufficient limits of stress per square inch. He also makes it a point to leave as much freedom as possible for the parts to expand and contract, realizing that such obstruction to expansion and contraction creates undesirable strains in the plates.

It is undesirable to introduce holes or stays unnecessarily for which reason the writer cannot agree with Mr. Dean in his recommendation to eliminate dished heads. It is true that some such heads have failed, but in connection with these failures there is chance for grave suspicion that either the metal in the head has been damaged, or that the design of the head was faulty. A well-made and properly-designed dished head will give no trouble, and thousands of them are in use. A dished head should have sufficient metal in the cylindrical flange to resist the pull of the spherical dish. Another important feature is the transition radius at the circumference of the flange.

The calculations as given by Rankine and others are not easy to handle by ordinary inspectors and laymen, but the engineer has no difficulty in properly designing a dished head. The formulation of rules for the use of inspectors must, necessarily, be simple. Such rules are, therefore, inclined to err on the safe side, and result in dished heads which are stronger than necessary.

For reasons given, we believe that, within prescribed limits, dished heads would have preference for small drums and boilers. This permits eliminating unnecessary stays and rivet holes, which stays at the same time oppose natural expansion and contraction due to heat and thereby create unknown internal stresses in the material.

THOMAS E. DURBAN There is one point in the paper I would like to bring out, and that is in reference to the recommendation that all holes be drilled through the solid. Our experience is that in drilling a number of plates, such as a horizontal boiler, with butt straps, it is impossible to drill them through the solid clear through and make as good a job as you can make if a pilot hole is punched, and the drill run through the pilot hole. As a matter of fact, in the case of a multitude of plates drilled together, it is impossible to run the drills through with the rapidity necessary in order to do the job quickly and not have the drill run.

THE AUTHOR. Concerning Mr. Kiesel's view of the safety of dished heads, it is of course to be expected that mine would not be acceptable to everybody. I was not aware that the proper method of designing safe dished heads had been determined and hardly thought it likely to be. My view was therefore that it is best to have heads that are unquestionably safe.

In regard to Mr. Durban's view, I feel that his opinion would not be shared by all boiler makers, for there are some who make a practice of drilling rivet holes, and who, in fact, have no punches capable of punching holes through anything but plate about thick enough for boiler uptakes. I have always felt that the machines used for drilling holes in boiler plates are flimsy and unstable, and I think that in order to drill plates properly it is merely necessary to have machines that are of good stiff design. When such are used I feel certain that the difficulties mentioned by Mr. Durban will not exist.

THE HEAT INSULATING PROPERTIES OF COMMERCIAL STEAM PIPE COVERINGS, L. B. MCMILLAN

DISCUSSION

LEONARD WALDO. I doubt whether even the author is aware of the great importance of his timely discussion of this subject. Of late years there have developed new uses for steam under pressure developing mechanical power at distances from the point of steam generation; for instance, the application of steam to the atomization of oil in open hearth furnaces, where it is necessary to retain the full pressure power of the steam, and where it has usually to be conducted through transmission lines over long distances. In this use it is essential that no loss of terminal pressure power takes place from heat losses in the steam with consequent pressure lowering at the colder steam exits.

In this paper the very high insulating materials are not referred to. Infusorial earth, used at times in the insulation of large furnaces, has a transmission power of ¼ that of the magnesia used in the tests described. There are better insulating materials considered from the insulating standpoint alone than those mentioned in the paper, but the ability to transfer from the data given here to the conditions of practice in individual cases is of great value.

[1] Assist. Mech. Engr., Penna. R. R.

F. M. Farmer. At the Electrical Testing Laboratories we recently completed a series of tests of this character on about thirty pipe coverings. We used the Stott method, which I think the author will agree is of the same accuracy as the method he used and much simpler, although the matter of making extended tests is a question of having the necessary large current available. A 2-inch bare pipe heated to a temperature of only about 350 deg. required approximately 1500 amperes, showing that a large current source is one of the obstacles to the use of this method for the larger sizes of pipe.

Only one of our coverings can be assumed identical with one of those tested by Mr. McMillan. In that one case we obtained the same so-called efficiencies within about one per cent. However, our actual values on both the bare pipe and the covered pipe were of the order of 10 or 12 per cent higher, a difference which we ascribed to the size of pipe used. We made the bare test on a 2-inch pipe and the covered test on a 3-inch pipe.

Dr. Kennelly in some of his work on heat losses from very small rods quoted Professor Boussinesg as concluding that the connection losses varied inversely with the square root of the diameter. If that law holds for large diameters, it would fully account for the difference between the author's results and ours.

Herbert N. Dawes. This paper indicates much careful work and observation and contributes some very valuable data.

The question of the permanency of the various coverings is touched upon but lightly. Apparently no tests have been made upon coverings after they have been in actual service for some time. Some tests of this sort were made by Prof. C. L. Norton several years ago at the Massachusetts Institute of Technology. Some sections of 85 per cent magnesia covering which had been on a steam line in a tunnel for eight years were tested and found to be a fraction of 1 per cent more efficient than the new covering of the same make and thickness. This difference was probably due to the extreme dryness of the sample which had been so long in use. Other coverings which had been in service for a number of years were tested and their efficiency had dropped varying amounts.

In twenty years' experience with insulating materials of various kinds, I have seen some coverings which have deteriorated very much after a few years' service, in some cases so much so that there was not enough material left upon which to make any test.

The temperatures frequently used to-day in superheated steam lines are sufficient to drive the water of combination out of asbestos fiber, and of course make the use of wool fiber impossible. The effect of these temperatures on the asbestos fiber is to cause a breaking up and powdering, particularly in the presence of pipe vibration. Another practical point that should be considered is the effect of moisture from steam leaks or submersion. Along this line I have found that coverings of moulded form, such as 85 per cent Magnesia, have been less damaged at least as regards future efficiency, than those made up of wool or asbestos fiber. I have therefore to take issue with Mr. McMillan on his statement that fibrous coverings are the more permanent. They certainly do not compare favorably with 85 per cent magnesia covering.

Another point of great importance to be considered in selecting a pipe covering is the possibility of re-use, either for application in the same sectional form or in the form of plastic. Fibrous coverings, for instance, if once badly damaged, cannot be used again. On the contrary, some of the moulded coverings such as 85 per cent magnesia can be pounded up and reapplied as plastic, and are thus more or less permanent.

A factor affecting the efficiency of a pipe covering is the care of application. It has been found that a covering carefully applied and the same covering applied in a casual manner may show a difference of over one per cent in efficiency.

The proportion of surfaces to be covered which must be treated with a plastic rather than a sectional covering is a factor of interest. With 85 per cent magnesia covering, the plastic is of the same composition as the sectional, and hence of practically equal insulating value. When other types of covering are used, particularly those of a fibrous nature, the plastic has to be of a different composition, and this affects the efficiency of the entire insulation equipment in a substantial manner.

As the difference in nonconducting efficiency of several of the better coverings as shown by Mr. McMillan's figures is very slight it seems some of the practical points I have spoken of are really of more importance in determining the kind of covering to use on most steam installations.

A large number of the coverings tested by the author seem to be of the manufacture of one concern. There are at least five different makes of 85 per cent magnesia covering on the market, and in these tests but two were measured.

It would be interesting to know whether the author has made any investigation of the temperature drop in super-heated steam lines at different velocities. Some reliable information on this subject would be most useful in solving insulation problems in connection with superheated steam insulation.

Arthur M. Greene, Jr. (written). Last year we performed experiments on 85 per cent Magnesia and Nonpareil High Pressure covering and found a slight advantage for the latter, as the author has found, but for our range from about 220 to 320 deg. fahr., we found a much smaller change in the value of k. Our results gave the value of k as a constant.

It must be remembered that if k varies with the temperature difference, the expression

$$Q = k \frac{\theta_1 - \theta_2}{x} A\ t$$

gives on solution values of k which is now not the coefficient of conduction but the value of $Q\ x \div (\theta_1 - \theta_2)\ A\ t$. This quantity may be used in computing heat losses if its value is known for different values of temperature differences. It is of distinct value, but it is not a true constant of conduction. The value of the constant might be found by using an expression of the form

$$Q = k_1\ f \left(\frac{d\theta}{dx}\right) \frac{d\theta}{dx} A\ t$$

If this could be investigated, valuable information might be obtained.

$$W_1 = \frac{k\ (\theta_1 - \theta_2)}{r\ (\log_e r_2 - \log_e r_1)}$$

in which W_1 is the rate of heat flow per sq. ft. of pipe per hr.; k is the conductivity; θ_1 and θ_2 are the temperatures; r_1 and r_2 are the radii of the inner and outer surfaces of the pipe respectively, and r is the outside radius of the pipe, is apparently derived from

$$Q = k \frac{d\theta}{dr} 2\pi r$$

but it might be well to state the origin of the expression. I think the term r outside the bracket should have a subscript and should be r_2, and that W_1 should be W_2, since it corres-

ponds to the heat through the area at the outside. If it is the heat at the inside, r should be r_1.

The writer has not checked over the cost problems and monetary efficiencies, but would like to point out the importance of remembering that these results only hold for the assumed cost data and assumed rates of interest, depreciation, taxes and insurance.

It is hoped that the author may carry his investigations one step farther and use one and the same covering on from three to five different diameters of pipe, with say three different thicknesses of covering on each. There may be certain relations between the inner and outer surfaces at different radii which may affect the result. If this is not necessary, then the simpler methods used by Knoblauch or by Nusselt with flat disks of materials would be the better way to determine values of the quantity k.

L. R. INGERSOLL[1] (written). I am very glad to note that the author has applied the mathematical formulæ for heat conduction in his paper, for by the judicious use of theory in connection with experimental results, a piece of work of this sort is made vastly more effective than otherwise. It is not practicable to cover by experiment all the possible variations of size, thickness, etc., which enter into a problem of this kind, and the use of such well-grounded formulæ as those of head conduction to fill the gaps left by experiment and to extend the results is eminently desirable.

As I have pointed out in a former paper (Eng. News Oct. 30, 1913) it is a little unfortunate that the engineers have adopted a unit for the measurement of heat conductivity which —because of its inconsistency in using two different units of length, i.e. the inch and (sq.) foot—makes it difficult to apply heat conductivity formulæ to any but the simpler cases. With the general adoption of the metric units, will come an incentive to a wider application of theory to experiment along these lines than has existed heretofore.

THE AUTHOR. Replying to Dr. Waldo's remarks, the author believes that it would be highly desirable to have tests made on infusorial earth and other materials that are used in preventing loss of heat from hot blast stoves. However, it would be very remarkable if any of these were found to have four times the insulating value of 85 per cent Magnesia.

As Mr. Farmer says, the difference in size of pipe as tested by him from that used in the tests described might account entirely for the larger values of losses he obtained. This can be demonstrated mathematically. With 1 in. of covering the 5-in. pipe would lose only 85 per cent as much heat as the 2-in. and only 92 per cent as much as the 3-in., other conditions being the same. Therefore, his results are in almost perfect agreement with those in the paper.

In reply to Mr. Dawes, at the present time it is contemplated to collect data on the durability of various coverings, by correspondence with those who have had them in use for a number of years.

The reason for not testing more magnesia coverings was the very close agreement of the two which were tested. It was decided then that magnesia covering made up properly would be about alike for all manufacturers, and the author considered that it would be a waste of time and money to test all.

In reference to the temperature drop in superheated steam pipes at different velocities, the author can only refer Mr. Dawes to the paper by Eberle, the reference to which is given in this paper. Eberle's results are probably the best yet published on the subject, but the conditions under which they were obtained were not varied enough to make them generally applicable.

Professor Greene's discussion referring to the factor k is of interest in a mathematical discussion. However, the fact that k has different values at different temperatures is not sufficient justification for saying that it is not the conductivity of the material in question. Conductivity is defined as being the rate of heat flow per degree temperature difference per unit area per unit thickness per unit time. k, as used in the paper, conforms to this definition, and the fact that it is not constant but varies with the temperature has already been demonstrated by Nusselt as explained in the paper.

Professor Greene is correct as to the origin of the equation giving W_1. However, since it applies to unit area, the term $2\pi r$ does not appear and the fundamental equation is

$$\frac{Q}{2\pi r} = W = k\frac{d\theta}{dr}$$

The subscripts are correct according to the definitions given to the various factors.

The objection to the methods used by Knoblauch and Nusselt with flat discs instead of pipes as the covered surfaces is that such methods do not permit of the testing of commercial pipe coverings. But where the conductivities of the materials used have been accurately determined by those methods, the results may be made applicable to actual pipe covering conditions, as explained in the mathematical treatment of the subject.

The great truth of Professor Ingersoll's remarks on the advantages of the metric units over the more unwieldy ones now so commonly used by engineers will be appreciated by all those who have attempted to apply theory to the more complicated physical phenomena.

CIRCULATION IN HORIZONTAL WATER TUBE BOILERS, PAUL A. BANCEL

DISCUSSION

GEORGE L. FOWLER said that a few years ago he had made some investigations of the circulation in locomotive boilers, and had also watched the apparent circulation in some very finely constructed models of locomotives; and his whole experience led him to be very cautious about accepting the indications of circulation in a model.

He understood that the experiments with the model under consideration were made at atmospheric temperature. If the evaporation per square foot of heating surface were to be the same as in a full-size boiler, naturally in a boiler working under 100 or 200 lb. per sq. in. the bubbles would be smaller than they would be in a model boiler, on a proportion of perhaps 1 to 4 in diameter.

Now, the water spaces in a model boiler are small also, and proportionately small in comparison with the full-size boiler of the same general dimensions and proportions, and he thought the whole gist of the argument simmered down into what the author stated, that the rate of circulation is dependent upon the size of the bubble of steam passing through the boiler. Therefore the circulation would be very much more rapid in the model than in the full-size boiler. He originally had the idea that the circulation in a locomotive boiler was torrential, especially as investigation had shown that the rate of evaporation in the firebox was very much higher than it was in the tubes.

In his own experiments he had started with the idea he would have to provide for the measurement of a circulation of

[1] Assoc. Prof. of Physics., Univ. of Wisconsin.

400 or 500 ft. per sec., but after thinking the matter over, mentally came down to providing apparatus for measuring 125 to 150 ft. per sec. At about this time he saw an advertisement, in the form of a large inverted globe partly filled with water with air bubbles coming up through it. He timed these bubbles and found that they rose at a rate of about 4 ft. per sec. He reasoned that steam bubbles should not come up through water any faster than these air bubbles did.

By the time he started his investigations he had arrived at the conclusion that if he provided for about 8 or 10 ft. per sec., he would be about right. As a matter of fact, the highest circulation he got in a locomotive firebox, when the evaporation was of the rate of 12 lb. of water per sq. ft. of heating surface per hour, was about 2 ft. per sec. The condition of a locomotive boiler seems to be that we have a slow, gradual movement through the shell backwards and then some agitation, and the flowing up, on the inside sheet, and then a downward movement on the outside sheet, but the general tendency is back, and just about enough movement to supply evaporation, apparently.

Some recent work on full-size boilers corroborated that statement, he said. The temperature in the lower corner of the water leg at the front was never within 75 deg. of the temperature of the steam when the engine was working full. Perhaps it came within 50 per cent, but it was markedly below, whereas with that slow movement of water back through the firebox, in the back corner of the water leg down close to the mud ring, there was a temperature up to that of the steam. These experiments led him to be rather skeptical in regard to accepting any demonstrations from a model, where necessarily the water spaces are quite limited and the steam bubbles correspondingly large. That there is a general correspondence between a model demonstration and a full size boiler demonstration he did not doubt, but from a quantitative standpoint, he questioned the value of the model investigation described.

William Kent. The tests of the model boilers described by Mr. Bancel are interesting, but it is difficult to draw any conclusions from them that will be of any service in the design of full-size boilers. Some years ago the speaker had occasion to assist in the tests of a quarter-size model of a Rust vertical water tube boiler. The tubes were about 1 in. diameter and 5 ft. long. The ends of both upper and lower drums were fitted with disks of plate glass, and to the bottom end of each tube a slender white thread was attached by means of a fine wire so that the threads would show the direction of the circulation. Some surprising results were obtained. When the boiler was steaming at a moderate rate some of the tubes of the front bank would be carrying water upward while others were carrying it downward, but the upward currents would often change from one tube to another without any apparent cause.

Experiments on model boilers of the inclined water tube type cannot reproduce the conditions that exist in a full-size boiler, for in the latter there is at least 5 ft. distance between the water level in the drum and the highest point of the bottom row of tubes. This would make a difference of pressure of over 2 lb. per sq. in. if the water was at rest, and a greater difference if the water was in motion, on account of the frictional resistance of the upward passage. This extra pressure in the lower tubes would tend to prevent the generation of steam in them, and it is probable that they carry only water which is at a higher temperature and pressure than that in the overhead drum, and which begins to generate steam only when it passes into the region of lower pressure in the upper part of the headers and in the drum.

John C. Parker. The author says: "In addition, it is generally believed that a high velocity of circulation will retard scale formation and thus indirectly reduce the resistance to heat transfer and prevent overheating of the tubes." Some seventeen years ago I visited our late President, Prof. R. H. Thurston, at Cornell, and made the statement to him that the circulation was so rapid in our boiler that it would carry the solid matter along like dust in a strong wind and prevent scale formation. He said it would carry the insolubles, but not the solubles, and it turned out that way. Our experience has been that scale forms wherever the steam is made, and that if there is any carrying along of the scale it is after it is formed and then cracked loose.

It is quite desirable in designing a boiler to get the most rapid circulation possible. The strongest flow would be secured if we could get nothing but steam in the up-pass and nothing but water in the down-pass. Evaporation is secured in the horizontal tube by extending that long enough.

Arthur M. Greene, Jr. wrote that the experimental part of Mr. Bancel's paper was interesting in its qualitative nature but he could not see where quantitative results could be obtained from it.

In the rates of radiation given in the first paragraph, the author does not state the assumption on which the results are obtained. If the Steffan-Boltzmann law has been used with no corrections it should be so stated.

The formula $v = \sqrt{2\,g\,H}$ is only true for a free fall. The true formula is

$$v = \sqrt{\frac{2\,g\,H}{1+z}}$$

in which z is equal to the sum of loss coefficients and is quite large in the case under discussion. The formula

$$v = \phi \sqrt{\frac{v\,h}{A}}$$

is not a balanced equation of time and in distance unless ϕ contains these elements, ϕ must be variable and the variations must be great.

Ambrose B. Dean demonstrated a glass model to the scale of 1/18 of a water tube boiler in working condition, showing the action in the bank of tubes and the drum. He said he had not made any accurate determinations from this model but hoped to do so at some future time.

A. A. Cary agreed with Professor Kent as to the small amount of reliable information regarding circulation to be gained from the use of models, although he thought a glass model might give very useful suggestions. He said he had considerable experience in testing with glass models, and also testing with full-size boilers, and he had received a great many useful suggestions from glass models which he had verified in the full-size boiler. He thought the glass model would show the underlying principles, but beyond that care should be exercised in drawing conclusions from it.

The Author. In reply to the members who have questioned the value of experiments on models, the author wishes to point out that in the solution of problems involving the flow of fluids, that is in hydrodynamics and aerodynamics—the use of models is invaluable.

The fundamental data of the subject of aerodynamics has been derived very largely from experiments on models. Langley's figures for model planes, modified by Lilienthal's experiments, provided the information from which the earliest flying machines were constructed. The work of Lanchester, Bryan and Eiffel was based largely on experiments with models.[1] As to ship propulsion, the testing of models of ships has been carried on for years.

The circulation in a water tube boiler is a highly complex problem, involving not only a complicated circuit with tubes working at different loads, discharging into a common header, but also the movement of two fluids, steam and water, at dissimilar and varying velocities. In quoting results of researches with a model, the writer made no attempt to predict or state the circulation or the pressures influencing circulation in the various types of actual boilers, confining his remarks to the model. His knowledge of the laws of similitude connecting a model water tube boiler and its prototype when circulating non-homogeneous mixtures of steam bubbles and water, is not sufficient to permit of such predictions, but he sees no reason why the results obtained should not be similar in kind, at least, to those to be obtained in an actual boiler. He does not believe that "the circulation of all boilers is good enough," as stated by Professor Kent, first, because cases of tube failures, some of which caused loss of life, have occurred where the tubes were new and it was known that they were free from scale; second, because boiler loads and furnace temperatures are constantly increasing, and third, because the investigations undertaken indicate that present designs do not conform in several respects to the necessary requirements for the maximum delivery of water through the tubes nearest the fire.

Replying to the point raised by Mr. Fowler regarding the size of the bubbles in an actual boiler as compared to those in the model, experiments have shown that the size of the bubbles seems to be independent of the pressure, depending on the conditions of ebullition and the character of heating surface. See experiments on a small boiler in which pressures up to 12 kg/cm were carried, by M. Emanaud, Le Génie Civil, January 6, 1911.

Professor Kent states that "it is doubtful whether there is any steam at all in the lower tubes." The 2 lb. pressure calculated by Professor Kent would amount at 200 lb. boiler pressure to about 0.8 deg., and for every pound of steam formed by the "water bursting into steam" in the drum, there would have to be about 1000 lb. of water passing through the tube. For a tube working at 200 lb. of steam per sq. ft. per hr. evaporation, this would call for approximately 10 cu. ft. flow per second or a velocity through the tube of about 150 ft. per sec. Experiments show that the velocity of water entering a tube is on the order of 5 ft. per sec.

In reply to Mr. Parker, what we are after in boilers is to pump the most water through the bottom tubes. The water comes into the tubes zero per cent rich in steam and 100 per cent rich in water. It should come out as rich in water as we can make it, and we then have less chance of burning and blistering the tubes.

The statement made by the author regarding scale formation and referred to by Mr. Parker was not advanced except with reservation. Experimental evidence on the effect of water velocity on scale formation not only in boilers but feed heaters, evaporators, condensers and similar apparatus would add to the value of the present discussion.

Professor Greene has pointed out that ϕ in the equation in Par. 6 "Must be variable and the variation must be great." In fact, the variation is so great as to make the expression practically useless, and it is for that reason in part, that the model experiments were undertaken. The conditions as to the existence and effect of slip have not heretofore to the author's knowledge, been investigated. In the classic lecture on circulation by Mr. Babcock at Cornell University, the speed of circulation was calculated neglecting resistance, by the use of the equation $v^2 = 2\ g\ H$; H being determined by assuming an homogeneous mixture of steam bubbles and water and freedom from slip throughout the circuit.

Mr. Dean's model shows the difference in the quality of the mixtures discharged from the lower and upper tubes. The lower tubes discharge more nearly homogeneous mixtures containing small bubbles. The upper tubes discharge large steam bubbles intermittently; the circulation is reversed even, when the area at the entrance to the drum is reduced.

[1] Barlstow, The Laws of Similitude, Aeronautical Society of Great Britain, Feb. 2, 1913. See Engineering, London, Feb. 14, 1913.

PERFORMANCE AND DESIGN OF HIGH VACUUM SURFACE CONDENSERS, GEO. H. GIBSON AND PAUL A. BANCEL

DISCUSSION

LEO LOEB. The authors state it may be assumed, in the light of evidence given in the appendix, that the total heat transfer is a function of the first power of the temperature difference, and not of a fractional power as suggested by Loeb and Orrok, but the appendix contains no evidence to support this claim. However, in discussing certain data, they state it was concluded from these tests "that the coefficient was constant if the total heat transfer was assumed to vary as some fractional power of the temperature difference rather than unity." This is a misstatement, as there was no assumption of total heat transfer as an exponent of the temperature difference. It remains a fact, determined from many experiments, that the total heat transfer is proportional to a power of the temperature difference. This power is not necessarily less than unity, although in some of the tests I have examined of the transfer of heat from steam to water under practically air-free conditions the coefficient was less than unity. However, in the case of heat transmission from condensing steam and air, the coefficient is usually greater than unity. The quotation should therefore be recast somewhat as follows, "and from these it was shown the total heat transfer was proportional to some power of the temperature difference, usually less than unity, hence the coefficient for one rate of flow would be constant."

The manner in which this law was investigated in the experiments referred to was to introduce water at a reasonably low temperature into a short-pass heater, keeping the steam temperature as nearly constant as possible. The outlet temperature was carefully noted after a test of reasonable duration, and then the water was re-introduced at the inlet of the heater at the temperature at which it appeared at the outlet during the previous test, and so on, carrying this up along a true temperature gradient. When the gradient was plotted it was in exponential form, and not in logarithmic form as would be required by the law of heat transfer proportional to the first power of the temperature difference.

The authors call attention to the fact that in the tests on the Bureau heater, the steam temperature varied only 2 deg. In the experiments on the apparatus, we tried to keep the temperature constant, but the construction of this particular heater was such that with high rates of water flow there was a small condenser action and a slight drop in pressure within the shell making it almost impossible for the temperature to be kept absolutely constant.

The authors further state it is reasonable to expect that if the variation in temperature difference were obtained entirely by varying the steam temperature only, the exponent would be found to attain unity. Now in marine feedwater heaters, and in closed heaters generally, the object is to attain a standard of temperature; and while we did investigate the fact of varying pressure, and while the authors have taken three points from these tests and found them alike on a straight line with a slope of unity, that is simply a coincidence. The indisputable fact remains that a long series of experiments on single tube and commercial marine feedwater heaters shows the temperature gradient to be exponential, and no reasonable expectancy on the part of those who have not "lived" with the apparatus will change the fact.

The curves in the writer's paper to which the authors refer were plotted from heaters in which we were forced to use a different method of obtaining the temperature gradient, and while it does introduce a little more complexity, still these are the facts, and we must abide by them.

R. N. Ehrhart. The first part of the authors' paper consists in the collection and tabulation of results obtained with various surface condensing plants. As such, it is interesting. However, we do not believe that curves derived from the performance of various sizes and types of condensers of different manufacturers can be consistently grouped in curves to show typical results. It is quite evident that one style or design of condenser might give certain characteristics which could be successfully shown graphically, but to take all other types and put them on the same curve sheet with the expectation of getting something that is really of great value is impossible.

The latter part of the paper is based on misconceptions of the performance of modern condensers. For example: The performance of the condenser as shown in Fig. 10 is not at all in line with that given by modern design. In days gone by, we used condensers in which there was little rise in temperature in the lower pass, but condensers of to-day, if properly designed, will have about 60 per cent of the work done in the lower pass. It is obvious that this should be so. If the condenser is perfectly scavenged of air, the greatest temperature head exists in the lower portion of the condenser, which, in the contra-flow type, is nearest the end of the condensation zone, and in the beginning of the water circulation zone. The use of a hydraulic air pump makes it easy to get such results without the use of external coolers.

The authors attempt to show that there is a compression of the air in the condenser, and that this necessitates a lowering of the temperature of the steam space. Such a phenomenon need not exist at all. Where a hydraulic air pump is employed, using water of the temperature of that delivered to the condenser, the compression can all take place within the pump itself; that is, the readjustment of vapor and air pressures does not need to take place in the condenser.

The authors dwell on a suggested form of zone condenser, in which the lower pass uses little water and consequently little power is there absorbed. As pointed out above, the modern condenser does most of the work in the bottom pass, so that the suggested form of zone condenser, instead of accomplishing something desirable, turns out to be about the most undesirable modification that we could make in a modern condenser. Therefore, it can have no place in modern condenser practice.

George H. Gibson (written). In none of Mr. Loeb's tests did he work with a constant fixed water temperature and different steam temperatures; and that would be necessary in order to eliminate the variations that might be due to the water temperature, per se, or else the influence of the water temperature must be allowed for. In the tests described by Loeb, the influence of water temperature was ignored. It is therefore improper, on the basis of his tests alone, in which the variations in temperature difference were obtained by varying the water temperature, to state just what precise effect temperature difference by itself had upon the rate of transmission.

In reply to Mr. Ehrhart, the condenser tests presented are those to which we had access in publications and in reports by manufacturers and users. If there are in existence tests showing no temperature drop caused by enrichment of the air mixture, we would like to examine them. We concede that by putting on a supplementary condenser the mixture can be drawn out of the first condenser before the effects of air are apparent, that is to say, before steam condensation is completed, in which case only such drop of temperature as might be due to the steam flowing through the tube bank would exist. With the tubes properly arranged, this temperature drop would be comparatively small, at least at low vacuums and the attending low specific volumes.

However, if the mixture is to leave the tube bank at nearly its original temperature, a considerable percentage of the steam will remain to be compressed or condensed in the air pump. The objection to using the air pump for steam recompression is self-evident, while if a hurling water air pump is used in order to condense the steam, the temperature of the hurling water will be raised and the efficiency of the air pump impaired. If a large amount of water is used in order that the temperature rise in the pump may be small, a heavy expenditure of power to drive the pump will be encountered. Water handled by the circulating pump may have a temperature rise of 10 deg. fahr. and may be pumped against a head of 15 ft., whereas water handled by the air pump may have a rise of only a few degrees and the head pumped against will be 150 to 250 ft. To condense a pound of steam, 50 to 75 times as much power is taken by the air pump as compared with the circulating pump, for which reason it is not a good plan to allow much of the steam to pass to the air pump, which is what Mr. Ehrhart's claims really imply.

Paul A. Bancel (written). Replying to Mr. Ehrhart, the performance of the condenser from Josse's tests was cited to show conditions existing in a small condenser working at moderate vacuum with a considerable air leakage. The same conditions are noticeable, it is maintained, in large vacuum condensers even with small air leakage and large pump capacity (irrespective of the design of the pump), because due to its large specific volume, the steam cannot penetrate into the condenser and, due to the great rarification, the air cannot be removed except after some preliminary compression and concentration in the condenser.

The condition of temperature equivalent to pressure alleged by Mr. Ehrhart precludes any leakage whatsoever or else an air pump of such capacity that the air can be removed at immeasurably small partial pressure, together with an unavoidably large volume of steam.

With a *small* condenser heavily loaded under summer conditions when the vacuum is low and with a large air pump of the hurling water type using a comparatively large quantity of water and corresponding steam condensing capacity, most of the surface in the condenser can be brought into active working.

While it is possible to design a *large* condenser and attach

a pump of sufficient capacity to secure equally good results under summer conditions, under high vacuum conditions in the winter the proportion of active surface will fall off and the inactive zone which might originally have comprised a small percentage of the surface will now comprise a very large share of the tubes. High vacuum condensers recently installed in connection with 30,000 kw. turbines in several large cities and equipped with air pumps of the hurling water type show comparatively low average heat transmission coefficients under conditions of high vacuum and cool or cold water.

The condition of 60 per cent work in the lower pass of a condenser coincides in every case known to the writer with a design in which openings or steam lanes have been provided to pass the steam down to the lower tubes, thus allowing the steam to by-pass groups of tubes in the top of the condenser. The resulting average coefficients of heat transfer are low, as would be expected, since the surface is more or less out of active use. The active tubes instead of being concentrated in one pass of the condenser are now scattered throughout the shell wherever the steam has easy access and their location is not indicated by thermometers placed in the main water connections or water boxes.

Replying to Mr. Loeb, the authors' statement was to the effect that the experiments were not sufficiently complete to warrant conclusions regarding the relations of the heat transfer to the temperature difference. The temperature difference depends on both steam and water temperature, and to be conclusive experiments should be made in which the mean water temperature is maintained constant and the difference varied by changes in the steam temperature only, in order to eliminate the effects of water temperature.

HIGHER STEAM PRESSURES, Robert Cramer

DISCUSSION

William Kent (written). This paper contains some interesting figures of the gain in steam engine efficiency that may be obtained by increasing the steam pressure up to 600 lb. per sq. in. absolute. They supplement very conveniently some figures for the efficiency of the Rankine cycle which I calculated recently for pressures up to 250 lb. per sq. in. and superheat up to 300 deg., and which will be found on p. 1091 of the 9th edition of my *Mechanical Engineers' Pocket Book*. Taking the figures corresponding to 29 in. vacuum:

Press. lb. Absolute.	Superheat, deg. 0	50	100	150	200	250	300
	Efficiency of Rankine Cycle, per cent.						
200	32.2	32.3	32.6	32.8	33.1	33.4	33.8
225	32.7	32.9	33.1	33.4	33.6	34.0	34.3
250	33.2	33.4	33.6	33.9	34.1	34.5	34.8
Superheat corresp. to temp. 600 deg.				113.4	132.7	155.2	182.5
300			34.0	...	...	...	34.5
400	(Mr. Cramer's		35.3	...	..	36.1	
500	figures.)		36.4	...	36.7		
600			37.0	37.3			

Taking 225 lb. per sq. in. and 200 deg. superheat, corresponding to a temperature of 591 deg. and a Rankine cycle efficiency of 33.6 per cent, as about the standard of the most recent practice, the improvement that may be made by using a pressure of 600 lb. and a temperature of 600 deg. is (37.3-33.6) or 3.7, or 11 per cent. of 33.6 per cent. In order to obtain this gain it will be necessary to build stronger boilers than we now have, to use economizers to reduce the flue gas temperature, and to take extra precautions against steam leakage. These improvements are quite within the range of practicability, and it may be worth while to make them to gain a 11 per cent gain in efficiency, especially in locations where fuel is expensive and in plants having a high load factor.

Mr. Cramer says that it is possible to increase the effectiveness of the heating surface by proper design, and that modern boilers show an evaporation per square foot of heating surface twice as high as was customary only a few years ago, at the same time realizing a better efficiency than formerly. It does not appear that the improvements in rate of driving and in efficiency at high rates of driving have been due to any changes in the design or proportions of the heating surface; they have been due to greatly enlarged combustion chambers, mechanical stokers, and control of the air supply according to the indications of gas analyses. The highest efficiencies have been obtained with many different forms and proportions of boiler, and no evidence has yet been obtained that any new form of boiler will give greater effectiveness per square foot of heating surface than the forms of boilers that were built forty years ago.

R. J. S. Pigott. This interesting paper has presented the theoretical side of the question rather more strongly than the practical side. The sources of loss, especially in the turbine, have been passed over perhaps a little too lightly.

Those of us who have been interested in turbine designing for the last few years have noticed the very marked difference in the efficiency ratio of the various stages, between high and low pressure end of the machine. We know that the high pressure stages are very much less efficient. For instance, in a turbine working at 200 lb., with 100 deg. of superheat, the efficiency of the first stage is possibly 55 per cent or a little higher, depending upon the conditions, and that figure increases as we reach the lower stages, finally reaching 85 per cent, or even more, in the low pressure end.

The average efficiency ratio is ordinarily 70 to 75 per cent, including generator losses. The figure quoted by Mr. Cramer, of 77 per cent, must be quoted for overall efficiency, including generator loss. The actual efficiency of the Interborough Rapid Transit Company's turbines is over 80 per cent, if the losses to the generator are not considered, representing a high pressure efficiency of 70 per cent, and in the final stages somewhat over 90 per cent.

It is a fact that the efficiency of the stages of a turbine depends chiefly upon the density and condition of the steam, other conditions being equal. The reason for such low efficiencies in the high pressure stages is the high friction loss due to high steam density, and in the case of turbines running on saturated steam, on account of the additional friction due to the moisture. It is certain that if pressures are increased, the high pressure stages are going to become less efficient,—more especially as in substituting pressure for superheat, we are increasing the amount of moisture developed in the turbine and advancing the dew point to higher stages. In other words, the efficiency of each stage will be somewhat decreased, due to the presence of a greater quantity of moisture.

The author's expectations of the efficiency closely approximating present efficiency would not be reached with actual turbines. It is quite evident from our experience with up-to-date turbines that we cannot get very high efficiencies with the very dense steam to be expected.

Another point from the practical side is that of steam piping and pipe joints. It is generally felt that the best joint is one in which there is no gasket. Very good success has been made with ground joints, but the character of workmanship and pipe construction required for the ground joint is almost too high for ordinary construction and cannot be ob-

tained in the average plant. Therefore the forms which require metallic, or asbestos, or other soft gaskets, must be used for these temperatures and pressures, and there is trouble enough already with 200 lb. pressure.

In the plants of one large western company, the joints are made by fusing the edges of the lap flanges with the acetylene torch, so as to avoid gaskets. This, it seems, is the first step in the change that would be required for higher pressures. The next step would be to abandon flanges almost entirely, and weld the pipes in place, without joints. We are now using large quantities of welded material under very severe conditions. With the degree of skill now developed, satisfactory welding could be readily accomplished in the field. It would mean the substitution of a welding gang for steamfitters, on the larger work.

G. I. Rockwood. In regard to the facility of making pipe joints, I have been rather surprised, in working out the problem of making pipe union joints out of ground bronze seats, to find what a poor job of grinding is usually done. If the grinding is done properly, as I find it can be done with a properly developed machine, the joint will stand all pressures up to 10,000 lb. per sq. in., and the union will burst before it will leak.

Pipe unions will probably replace flanges in the larger sizes, and if higher steam pressures are to become at all general, the practical requirements of pipes, built in sections rather than welded together, will call for pipe unions properly made.

R. H. Rice. The subject of utilization of higher steam pressures in motive power apparatus has been before the designers of such apparatus for some time. The most active proposal in that direction was made, I think, by Mr. Faraday of England, some two or three years ago, and a great deal of investigation on this subject has been stimulated.

The author has very clearly set forth the theoretical possibilities involved in the use of higher pressures. The practical consideration is that of temperatures. Several years ago the writer constructed and operated an engine utilizing a maximum temperature of 800 deg. Although this engine operated successfully, we find, in investigating the materials to be used for these pressures and temperatures, at 600 deg. practically all the materials we would ordinarily use in the construction of such apparatus begin to lose strength. Therefore, we are limited to that critical temperature, or else have to choose special materials, or, as a third possibility, must greatly increase the proportions of parts in order to keep down the stresses.

Expansion of pipes would also be troublesome at high pressures on account of the rather extreme thickness of the pipes and their consequent stiffness.

The effect on turbine design has been clearly brought out by Mr. Pigott. In addition to the difficulties in realizing the highest efficiency which he has pointed out there is the very important one of leakage. If we attempt to use very high pressures on the upper stages of turbines, we will certainly have to develop improved forms of vacuum.

All these considerations do not by any means indicate difficulties which cannot be surmounted; on the other hand we are fitted at the present time to undertake the development of apparatus to meet these conditions. A considerable amount of development work will be necessary, however, and the new conditions will give rise to radical changes in the design of power stations. For instance, it is obvious that if these expansion stresses in pipes are to be difficult, we should limit the length of the pipe as much as possible, which means putting the boiler and turbine, or engine, close together.

The question of higher pressures is entirely a commercial one. Assuming that the gains indicated in the paper, or even half of them, can be realized, can apparatus be constructed of such cost and placed in our power stations under operating conditions, which will involve operating expenses in such amounts that the total operating gain, counting interest on the investment, operating cost, and general liability, make the proposition a profitable one for our power stations?

Walter N. Polakov. The question of advantages of higher steam pressures may be regarded from two angles of view. One is purely a theoretical consideration, setting aside the commercial advantages, and the other, the commercial advantages under the present state of the art.

If the steam is used at high pressure, and saturated, the condensation will have very quick deteriorating effects on the blading of the turbine. This is one of the financial questions which ought to be primarily considered before it is decided whether at the present state of the art the high pressure is advantageous.

Another consideration is whether the added cost of construction of the steam vessel for the higher pressures will be warranted. Incidentally, in European practice, temperatures are not confined to 600 deg. fahr., but go up to 800, and in some cases to 1000.

Carl C. Thomas. In regard to turbine design for higher pressures, the high pressure stage would necessarily be of the impulse type, because of the otherwise extensive leakage past the ends of the blades with steam of such high density as that at 600 lb. The turbine would therefore seem to require an impulse high pressure stage, velocity compounded, probably followed by Parson's stages.

Professor Carpenter's tests on the White steam car showed that at high pressures very good economy could be attained, even with small reciprocating engines. An engine of the general type of the Westinghouse single-acting vertical engine, with the lower end of the cylinders closed so that a vacuum could be maintained, but fitted with an exhaust port like that of the Stumpf engine, might be very efficient for use with these high pressures.

D. S. Jacobus. The statement is made in the paper that standard boiler designs do not permit the construction for higher pressures than 200 lb. That is a little below the limit, because there are standard designs operating at good high overlaps over 300 lb.; 200 lb. is surely too low a pressure to set today as the limiting pressure for standard designs.

The Author. Professor Kent has pointed out that the improved boiler efficiency in recent designs is not due to any change in the boiler itself, but rather to the furnace. If the point is conceded that high efficiencies can be obtained with high pressure boiler designs, then whether the necessary changes are made in the boiler or in the furnace is immaterial. I concede that most of the recent improvements in boilers have been made in the furnace, and not in the boiler proper, and the most efficient boiler designs used to-day are practically the same as those of twenty years ago. The question brought up in the paper is, however, entirely different. If steam pressures as high as 600 lb. are used, it will be necessary simply from that point of view to change the boiler design, and as pointed out in the paper, to do away with large drums and a small factor of safety.

Mr. Pigott raises the question of efficiency of the high pressure stage in the turbine. In the first place, it will almost be impossible in large turbines to utilize some of the principles employed to-day. It will not be possible to carry the high steam pressures right into the turbine. As a matter of fact, in most of the present large turbine designs, with the exception of the straight Parsons type, there is a large drop in pressure before the steam enters the turbine proper; in other words, in the very first drop of pressure, a good part of the energy of the steam is converted into velocity. The steam after it leaves the first nozzle, has now to be utilized in a scheme of velocity staging, and in that respect the turbines for high pressure will be practically identical with the present types of turbines, but the velocity stage at the beginning will be carried out to a greater extent.

It is quite true that with high pressures, losses in the high pressure stage of the turbine will be greater, but it must be remembered that all the losses occurring in the individual stages reappear in the steam in the shape of added heat, because there is no other way of disposing of them. While this loss of heat decreases the efficiency of the high pressure stage, it is partly utilized in the lower stages. Of course the losses that occur at the high pressure end, say between 600 lb. and 200 lb., will not be fully recovered in the low pressure end of the turbine, but by proper design they can be recovered to a very great extent.

Regarding piping, in the western plants which Mr. Pigott mentions, they have a welded seam between the flanges. The strength of the joints is given by the flange bolts, and the welding is used merely as a seal, and that works out in practice very well. Of course it is necessary in case of repairs to cut the seal, but on the other hand most of the repairs in these cases are caused by failure of the gasket, and that is the very thing the welding avoids.

I do not mean to point out that it is not possible to depend on the strength of the weld. In high pressure design with which I have experimented and carried out a great deal of practical work during the last few years every joint is welded. I have tested welded joints with pressures between 9,000 and 10,000 lb. per sq. in. and have burst the tube, being unable to injure the weld. It is therefore possible to depend on the strength of the weld if it is properly made.

At higher pressures, it is possible with a pipe line less than 12 in. in diameter to supply all the steam necessary to operate a 20,000 kw. turbine, and from that point of view the question of strength of joints is disposed of, because it is certainly easier to make 12 in. joints and welds for 600 lb. than to make 18 and 20 in. joints for 200 lb.

Mr. Rice has pointed out that loss of strength of the materials occurs in temperatures higher than 600 deg. The paper does not advocate raising temperatures while increasing pressures. For that reason the question of the loss of the strength in the material at high temperatures is eliminated.

In reply to Professor Thomas, the unaflow design of reciprocating engine is specially fitted for the adaptation to high pressures. It is a remarkable fact that such knowledge as we possess today points to the possibility of realizing fully in a unaflow engine efficiencies given by theoretical considerations. Such engines, too, are much simpler and are also less bulky than other engines used on lower pressures to obtain the same results.

In the light of Doctor Jacobus' criticism, I must modify the statement that the present day boiler designs are not suitable for higher pressures than, say, 200 pounds. At higher pressures, however, say 250 lb. and over, standard boiler designs become expensive enough to offset all the gain which would otherwise result from the employment of these high pressures.

Boiler designs are possible which will utilize high steam pressures without necessarily increasing the cost of the boiler to such an extent that the theoretical gains are almost wholly wiped out. The question is not merely a theoretical one, although the paper attempts to present only the theoretical aspect, it is primarily an economic one. Most of the discussors concede the possible theoretical gains, so the question remains: Can high pressures be realized in practice, without involving such high charges, due to initial cost of installation, interest on the investment, repairs, and up-keep, that the theoretical gains are offset? It has been my contention that these extra expenses necessitated for high steam pressures are not high enough to offset the theoretical gain, even to a small extent. As the problems of design are more clearly understood, and are properly met, we will within a very short time see the general adoption of higher steam pressures, especially in large power plant work.

PROPORTIONING CHIMNEYS ON A GAS BASIS, A. L. MENZIN

DISCUSSION

A. G. CHRISTIE. The author has rendered a distinct service in presenting the derivation and application of the various formulae relating to chimney problems when considered on the basis of the gases handled. His methods are quite rational and could be applied readily if definite information were available on all the factors involved.

The writer had occasion a number of years ago to design some chimneys for large cement kilns which operated on the wet process. These chimneys had, therefore, to handle the hot gases from combustion of the coal, the steam from the drying of the raw material, and the hot gases given off when the limestone was reduced to quick lime. As the regular formulae were not readily applicable, an attempt was made to solve the problem in the manner Mr. Menzin outlines, but so many unknowns were involved that the final design was based as much on guesswork as on engineering data.

Engineering literature is distinctly lacking in available data on the performance of chimneys, particularly as regards what takes place in the chimney itself. The variations of temperature, density, and draft from top to bottom of the various types of chimneys are practically unknown. Hence the velocities and volumes in the chimney are also unknown. The effect of wind has not been worked out, particularly in regard to the air leakage into the chimney under heavy winds, to the cooling of the gases, or to the suction, if any, over the top of the stack. Some recent experimental work has shown that humidity has a very appreciable effect on the flow of air in pipes. It is, therefore, reasonable to expect that humidity in chimney gases, due to the combustion of the volatile matter of bituminous coal and oils, and particularly in the case of lignite, must also have an effect on the operation of the chimney.

The chimney of the power plant of the new Johns Hopkins University has been specially built with the particular object in view of studying certain of these problems, and some work along this line will be undertaken in the near future.

Mr. Menzin submits tables based on assumed gas volumes and velocities, but does not supply any experimental data to indicate which, if any, of these velocities gives the best performance, nor are his friction factors derived from actual stack performance. The value of the paper would have been greatly enhanced by the addition of these experimental data.

UNIQUE HYDRAULIC POWER PLANT AT THE HENRY FORD FARMS, Mark A. Replogle

DISCUSSION

Clemens Herschel[1] (written). The idea of utilizing that portion of the freshet river flow that wastes over the dam for increasing the head acting on the turbines, at those times suffering from a diminution of the normal fall (or from backwater), is not new. Experiments on an apparatus of this kind were made by M. Saugey, superintendent of the Chevres power plant, owned by the city of Geneva, Switzerland, as early as June, 1905, and perhaps earlier. His system was described in the *Zeitschrift des Verein Deutscher Ingenieure*, about 1907, and in other journals, and a pamphlet, without date, issued by the Société Hydro-Motrice of Geneva, describes these and later experiments.

The efficiency of the Saugey apparatus, in terms of water lifted a certain height by means of other water falling a certain height, was about 3 per cent. This is poor, even for an apparatus that operates by induced currents of fluids. It gave the writer the impetus to accomplish something better, however, and in the *Harvard Engineering Journal*, June, 1908, he described a hydraulic apparatus for the purpose named above, which was called the "fall increaser." This had a maximum efficiency of 30.4 per cent.

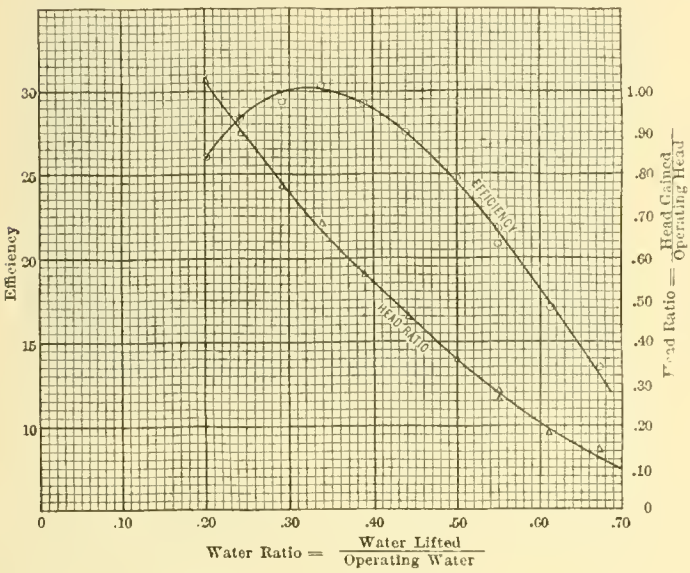

Fig. 1 Results of Tests on Fall Increaser

A brief mention of the fall increaser, with an up-to-date design of a power house fitted with fall increasers, may be found in Transactions Am. Soc. C. E., November, 1915, in a discussion of a paper on Induced Currents of Fluids, by F. zur Nedden.

30.4 per cent. does not sound like a very high efficiency to turbine builders and others, but is believed to be very good for an induction current hydraulic apparatus.

There is nothing, not one word or figure, in the paper under discussion, to permit one so much as to guess at the mechanical efficiency of the "discharge accelerator." As one who has conducted experiments with both fall increaser, and also, to some extent at least, with a discharge accelerator, the writer has not much faith in the efficiency of the accelerator. The following is what he wrote in the *Harvard Engineering Journal*, June, 1908: "The fall increaser is not an ejector, and experiments made with an ejector form of throat-piece, and a 5½-in. nozzle endeavoring to operate it, gave so poor results (efficiency) that there was no encouragement to continue along those lines." As the statement is made in the paper under discussion that the accelerator is not an ejector, it will be necessary to add that what above has been called "an ejector form of throat-piece," was similar to the discharge accelerator now shown. The difference consisted in this: The turbine discharge entered the throat-piece or mixing chamber through the annular area around the nozzle, instead of the operating water entering through the annular area, as in the discharge accelerator, with the turbine discharge blowing in

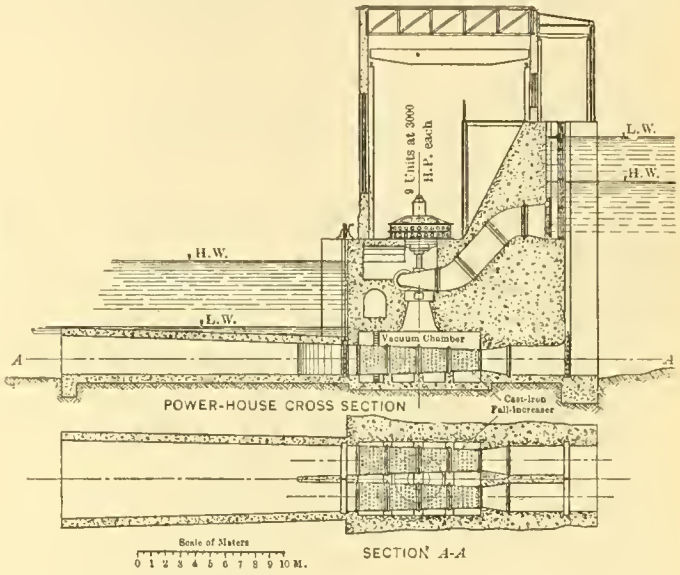

Fig. 2 Power House with Fall Increasers

through the nozzle. There can not, in the opinion of the writer, be any material difference in efficiency between these two arrangements. The discharge accelerator arrangement is, however, the better one for regulating or varying the discharge of the operating water.

Here is another quotation from the June, 1908, article: "Nor does it seem to me that the forms of formulae found in the books and learned transactions for computing the work of ejectors, based on the assumption of an impact of the nozzle stream upon the water within the throat-piece, are based upon a proper assumption to produce a correct formula for representing ejector action. To my mind an ejector is only another form of negative pressure apparatus, in which suction causes the water to enter the throat-piece through a ring-shaped orifice situated all around the nozzle (in the accelerator, through the nozzle), rather than through holes fashioned in the throat-piece itself, and distributed over its whole outside surface, as in the fall increaser."

It might be thought that inasmuch as all these low fall turbine aids use freshet runs of the river to furnish the operating water, their efficiency is of no consequence; but as will be shown in detail, this is not so, unless at exceptional times; at the Henry Ford Farms the times called *e*, which last only, as one may judge, for certain set periods of hours during the

[1] 2 Wall Street, New York

year. From an experience of seven years in designing these plants for river situations of all kinds, the writer can state positively that the mechanical efficiency of the apparatus is of great importance; and so is the regime or character of the river on which the fall increaser is to be used.

It is all a question of kilowatt-hours produced by the fall increaser in the course of an average year's run of the river, set off against the construction cost of the fall increasers; and as one may or may not pay too high a price for a cube of gold, so fall increasers may or may not according to their efficiency be of economic value. They have this in their favor, that their product is of annual recurrence, forever; while their construction cost (operation and maintenance are negligible quantities) is incurred but once. As a numerical example and to fix ideas: In a case examined some years ago, when the fall increaser was as yet new, the annual product of the fall increasers would have been 153 million kw-hr. in an average year, delivered at times of high water and low fall,

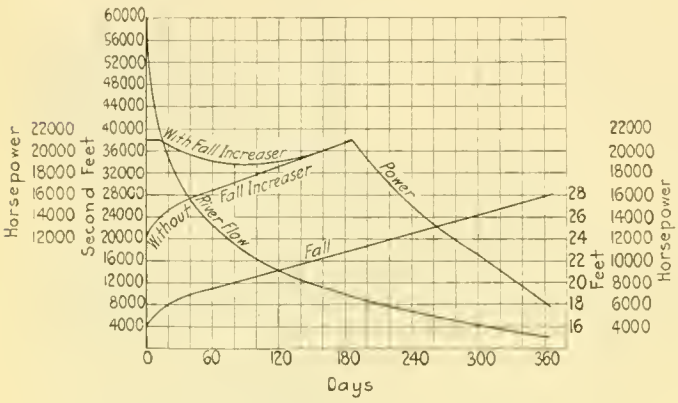

Fig. 3 Fall Increasers at Kanawha Falls

lasting in all some 180 of the days of the year; and the estimated construction cost (my estimate) was one million dollars. From this case—a very favorable one—the net advantages conferred range towards nothing, until in other cases, with rivers of a different regime, those advantages wholly disappear.

Dr. Ernst Duebi, at one time of Zürich, Switzerland, repeated the writer's tests, in 1911, at Zürich, and added much information to that previously known concerning the fall increaser. The results were published in book form by Rascher & Cie., of Zürich and Leipzig, 1912.

The essential results found in the writer's tests are shown in Fig. 1.

Fig. 2 shows a design of power house, with fall increasers, made for the City of Geneva, Switzerland; site not yet built upon. That the design had novelty in 1907 may be gathered from the fact that patents were issued for it by the United States, Canada, France, Switzerland, Italy, Sweden and Germany.

At the site named, the water upstream from the power house is lowest (must be *held* lowest), in times of freshet in the river; there being lift gates designed to create the mill pond, instead of a dam. At the same time there is backwater; or in other words, the fall is reduced doubly (shutting up like an accordion); which accounts for the elevation of H. W. shown on the drawing, being at a *lower* elevation than that of L. W.

Note the ready means supplied by fall increasers for getting rid of rack-trash. It needs but to be pushed *down*, into the suction area of the fall increasers, to pass through them and out through the tail-race; instead of being laboriously raked *up* and carried ashore and away.

It is evident that to enable the use of freshet water to operate the fall increasers, a head race of any material length is inadmissible. The power house must be at or very near the dam. This requirement eliminates the majority of hydroelectric plants from a consideration of fitting them with fall increasers.

The next elimination takes place when the character or regime of the river is taken into consideration. Rivers differ in this respect far more than one would suspect; and a careful analysis of their modes of flow during all the days of several years, the more the better, are required, before their regimes may be adequately portrayed. This is done by setting up for them what have been called "duration curves." Every engineer knows what hopeless looking messes a plotted series of daily discharge "curves," (or pictured saw teeth) make, the ordinates representing *consecutive* days of the year the abscissae representing gage heights, or second-feet of river flow. But let each year be represented by these same daily quantities, plotted in the order of their size, and we get at once a smooth curve of quantities flowing in the river for the 365 days of the year, useful in more ways than one. Fig. 3 shows such a curve of river flow. See also, on this point, Transactions Am. Soc. C. E., 1907, a tabular analysis of 20 years' flow of the Connecticut River, at Holyoke, Mass., which could readily be converted into curves such as have been spoken of; and Document 1400, H. R., 62nd Congress, 3d Session, 15 years' flow of the Potomac River at Great Falls near Washington, represented both in tabular and diagram form.

The diagram, Fig. 3, needs little explanation. Besides showing a curve of river flow, it shows the corresponding falls that obtain synchronously at the mill-site under consideration; and from these two the power curve at this mill-site, *without* the use of fall increasers, may readily be computed and plotted. After this we may, with the aid of Fig. 2, compute, and then plot, the power curve for the backwater days of the year *with* the use of the fall increaser; and the area of the diagram included between the last two curves named, gives the total horsepower days or kilowatt-hours, which fall increasers would produce annually forever on that mill-site. Note that at first there is not water enough in the river to operate *all* the fall increasers, causing a sagging down of the curve; which only gradually brings the power curve up and back to normal full power. Here is where the efficiency of fall increasers becomes of great moment.

There only remains to compare their productive value with the interest on the construction cost. The result depends mainly on the regime of the river. Fall increasers are useless where the river flow is effectively regulated by great lakes or reservoirs, causing a uniform discharge of the river. They are uneconomical on rivers that have only a few days of the year of backwater. On the other hand at times a single year's output of kilowatt-hours will nearly pay for their construction cost; and heat engines put in to supplement the low water run of the river, can not afford to burn fuel in competition with the cost of kilowatt-hours when produced by the fall increasers in the days of freshet water during the year.

It would also seem that tide mills, which may have an inexhaustible water supply, but which all have a greatly varying fall during the 24 hours, could materially benefit by the use of fall increasers; and if the "discharge accelerator" will show up the proper cost and efficiencies, it could presumably compete in this and other cases.

R. L. Daugherty.[1] The writer has been much interested in this paper by Mr. Replogle. It is hard for some people to realize that a water power plant may have to shut down because of a superabundance of water as well as because of lack of water. Such a situation is only met with in the case of a low head plant where the fall available may be almost destroyed in time of flood. The writer has found it necessary to explain a number of times why it is that such a fall decreases in time of high water. This point is illustrated in Fig. 4. This photograph, while of a relatively small stream, shows the effect just as well as one of a much larger stream and fall. In this particular case the depth of water flowing over the crest of the submerged dam was practically equal to the height of the dam above the bed of the canal. It may be seen that the dam does little more than create a disturbance in the flow of the water, and the fall is very slight. In fact a portion of this very small fall is due to the fact that some of the water is diverted at this point.

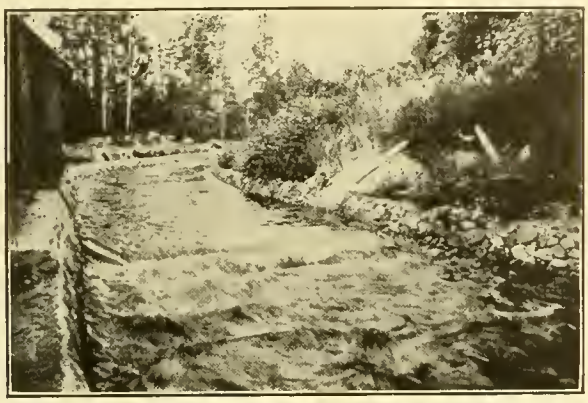

Fig. 4 Low Head in Time of High Water

Under such circumstances the amount of water consumed by a turbine will be much less than the normal amount, and the head being less also the power will be seriously reduced. The device which Mr. Replogle has employed makes it possible to consume more water and thus to compensate for the reduction of head.

It would be of considerable interest if we knew the amount of water actually discharged by the turbines during the tests made by the author, and also the additional water used to produce this effect. It is to be hoped that the author will be able to secure this data at some future time.

It is well known that it costs more per horsepower to develop a given amount of power under a low head than under a high head. As the author states, many low head powers are not utilized, though there is an abundance of water, due to the high cost. Such a device as this, used constantly, converts a low head plant into one of somewhat higher head. The actual amount of water consumed by the plant including that wasted through the accelerators may not be much more than the amount required to develop the same power under the lower head without the accelerators. It would be interesting if the author could give comparative efficiencies in such a case. Of course for the discharge of flood waters only, the efficiency is of no consequence, but for constant use it would be.

While this accelerator is different in detail, it seems to be similar in principle to the fall increaser described by Clemens Herschel in *Engineering News*, Vol. 73, p. 84.

[1] Assist. Professor of Hydraulics, Sibley College, Cornell University.

The Author. In reply to Mr. Dougherty, data regarding the amount of water actually discharged during the tests could not be procured at the time the tests were made. Some data have been secured in preliminary tests of a very small turbine, and these compare favorably with the results secured by Mr. Herschel.

It was preferred to make no reference to efficiency tests until such tests could be made in a logical and comprehensive manner. These will be made in the course of further development.

Of constructions suggested by other engineers the author obtained his first knowledge through the U. S. Patent Office. He believes the construction described is original.

Any construction designed for the purpose of mechanically mixing the two streams of water is erroneous from an efficiency point of view. Mixing implies eddies, and eddy currents transform the kinetic energy in the inducer water into heat. In the preliminary tests the very poorest results out of several hundreds were from a carefully designed mixer.

In reply to Mr. Herschel, there can be no doubt of the real values to be obtained from the use of the atmospheric head with surplus water. The means applied are of no special importance. The doubt in Mr. Herschel's mind is in regard to efficiency, but as he says best overall efficiency is in returns from investment.

The efficiencies quoted by Mr. Herschel seem to be low. From the author's point of view the apparatus he shows has been provided with the best possible means to produce eddy currents and friction. The grating or perforated throat certainly impedes the inducer stream. The turbine water entering at right angles to the inducer stream causes endless eddy currents. The abrupt orifices are causes of much friction. It is possible that if the whole throat section were removed the efficiency would be as high as that stated.

In conclusion, it was thought that the facts gathered to date regarding the accelerator described in the paper might be of interest, but the author has substantial reasons to believe that much higher efficiencies than those given can be obtained from this class of apparatus.

OIL ENGINE VAPORIZER PROPORTIONS, Louis Illmer

DISCUSSION

Wm. T. Price (written). The author has invaded a very difficult field and has carried his calculations as far as reasonable general assumptions will permit.

The subject of vaporizer proportions involves so many factors requiring for practical mathematical treatment so many specific assumptions, that the only safe method to follow is backward calculation and interpolation. Exterpolation, even to a moderate degree, I have found to be not very reliable.

Mr. Illmer assumes for the Hornsby-Akroyd vaporizer a uniform input of heat over the entire inner surface of the cap and a marked temperature gradient from center to edge. This is not correct. With this engine the spray strikes the cap on the side at an angle, and at this point instead of an input of heat there is a momentary subtraction, as heat is given up to gasify the liquid fuel. At full load a dark area is usually plainly evident; around this region the temperature is higher, and then the color dies out to a black at the edge. Mr. Illmer has pointed out that the contact of the cap with the water-cooled portion is only over the area of a narrow copper gas-

ket; the temperature gradient must therefore be explained as being due to radiation and convection from the large flange area.

With the De La Vergne type FH engine, using air injection, the input of heat to the vaporizer does appear to be uniform over the interior surface, but examination of the hot vaporizer shows no perceptible temperature gradient. At full load in a dark room there is usually a dark red color of uniform shade from end to end. The output of heat seems to be uniform over the whole surface, therefore, the flow of heat to the edge being negligible.

There is a great difference in oils and often with Hornsby-Akroyd engines the caps must be changed to suit the different fuels. The writer has known cases where it was necessary to insert a metal coil in the vaporizer to maintain the temperature at light loads. When the temperature of a Hornsby-Akroyd vaporizer shows symptoms of dying, first the water circulation is reduced, then the compression is increased by inserting plates between crank pin box on connecting rod, then a ribbed cap is substituted for the plain cap.

The author's comparison of the high compression engine with the vaporizer engine is in the writer's opinion entirely correct, but he appears to lean toward a 2-cycle vaporizer engine with a compression pressure of about 300 lb. per sq. in. and with air injection.

The addition of the vaporizer to allow of reducing the compression from 500 to 300 lb. per sq. in. is only a half-way measure. The compression must be reduced still lower and then we must go further and eliminate the air compressor. Already there is in fairly wide commercial operation a new oil engine which operates without air injection with compression of 150 lb. and with fuel consumption under favorable conditions very slightly below ½ lb. per bhp-hr., a consumption of 0.55 lb. at three quarters to full load being a conservative guarantee.

Mr. Illmer has pointed out the advantages of timed injection and has explained the difficulty of forming a thorough explosive mixture in the reduced time interval allowed. The logical solution of the problem is *first,* an abundance of oxygen to increase the combustion rapidity, suggesting at once a 4-cycle design. *Second,* an efficient mechanical spray to divide the oil into the smallest possible particles so as to present the greatest oil surface to the oxygen; this suggests a certain shape of spray and a uniform distribution of oil particles throughout the spray volume. *Third,* a combustion chamber conforming as perfectly as construction considerations will allow to the natural shape of the spray. *Fourth,* as completely as possible confine the entire charge of air in the vaporizer at the time of injection. *Fifth,* a vaporizer cap located so as to complete the vaporization of heavy oil particles and ignite the charge.

The Author. In deriving the formulae presented a series of alternative assumptions were tried out, but the given equations were found to be in best agreement with the Hornsby-Akroyd vaporizer proportions. The primary aim has been to show that rational vaporizer proportions must rest upon something better than a purely empirical basis.

The exception taken by Mr. Price to the assumption made as to the uniform input of heat over the entire inner cap surface of the vaporizer cap appears to be valid inasmuch as the theoretical temperature gradient would not occur in practice. The discrepancy noted resulted from the simplification resorted to in deriving the formulae. A more refined basis for derivation should make allowance for the fact that this temperature head, t_h, is not uniform over the entire cap surface, but is actually smaller at the center than at the edge of the cap.

In addition the oil spray is usually directed against the hot center portion of the cap, which sets up localized cooling and thus further contributes to a reduction of the temperature drop from that expected on the assumed basis of a uniform distribution of input and output heat.

A more complete analysis, taking into account the varying rate of heat input from center to edge of the cap, would no doubt show a temperature distribution more nearly in accord with Mr. Price's observations, but it is thought that such rather involved basis of calculation would not materially alter the average cap temperature t_c as given. This view is based in part upon Prof. Hopkinson's[1] series of non-cooled piston temperature determinations, which show a temperature gradient for the head-plate to be in fair agreement with the drop indicated in the present paper.

Experimental measurement along the lines of Hopkinson's investigations on pistons would no doubt offer the most satisfactory method of finding the actual temperature gradient in vaporizers. Such data would readily make it possible to fix upon the degree of cooling due to the fuel injection and show its effect in reducing the ratio of maximum to average cap temperature, besides providing a check for the series of other dependent assumptions which had to be made as to existing temperature relations.

In closing, the heat flow from center to edge of the cap is not due primarily to the increased external radiation into the atmosphere from the flange surface, as indicated by Mr. Price, but is rather to be explained by direct metallic conduction of heat from the cap flange into the jacketed portion of the vaporizer. While the contact surface of the copper gasket is small, the conducting power of such restricted contact may nevertheless be relatively quite large under the existing temperature head, the effect being analogous to the cooling action exerted by the seat upon the head portion of a poppet valve.

As indicated by the quantitative figures given in the paper, the external radiation of heat into the atmosphere can at best account for but a relatively small portion of the total heat input into the cap. Hence while the restricted gasket contact does serve to prevent excessive cooling of the cap edge, it still has sufficint capacity to conduct away the major portion of the heat received by the cap wall.

[1] "On Heat-Flow and Temperature-Distribution in the Gas-Engine," Proc. Inst. C. E., Feb. 2, 1909.

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

Provisions have been made by the Publication Committee for Correspondence Departments in The Journal as follows:

A Department for contributed discussions on papers previously published, or new matter.

A Members' Correspondence Department including suggestions on Society affairs.

Contributions for these departments are earnestly solicited.

ADVANCE PUBLICATION OF PAPERS IN THE JOURNAL

To the Editor:

The Journal should be mainly considered from the standpoint of the members who do not live in New York, and who are, for various reasons, unable to attend the meetings of the Society. It is the "means of communication," if one might use this term, between these members and the Society as a whole. Furthermore, these out-of-town members constitute the majority of the total enrollment in the Society.

When a member does not attend the meetings, he often neglects, in the rush of routine work, to send for the advance copies of the papers to be presented. Even those members who have a direct interest in certain papers, and who might contribute valuable discussion, frequently receive their advance copies too late to allow of more than a hurried perusal of them before the meeting.

As soon as the meetings are over, the regular weekly technical journals publish abstracts of all the more important papers, with discussions of the same, and the outside engineer usually reads those reprints. Later on, when the papers and discussions appear in the Journal, he has no keen interest in the matter and does not read it. Even if the Journal were a weekly publication, it would still have to meet the competition of the commercial trade publications in the same way as at present.

Briefly then the situation is that the earlier publication of papers and abstracts in the regular technical weeklies render later publication in the Journal of less value and small interest.

The best remedy for such minimizing of the value of the Journal to the members would seem to be the return to the earlier plan of publishing all papers in the Journal before the meetings. This would place such engineering information before the membership at first hand, would encourage freer and fuller discussion by allowing the members more time to consider the papers and would serve as a spur to men preparing papers, for those received earliest would probably be published at once. Since it has been decided to retain the Transactions in the old form, there would be no specific objection to having discussions presented in later issues separate from the text, as is done in the publications of other societies.

Objection will be raised that the issues preceding a meeting will be unnecessarily large, for authors do not get papers in on time. This could be remedied by making a rule that only papers published in the Journal could be presented at each meeting. Then members submitting late papers would have to allow these to stand over till the next meeting. This would form an incentive to earlier submission of papers.

A. G. Christie.

Baltimore, Md.

RECORDS OF MOTOR TRUCK PERFORMANCE

To the Editor:

The writer has a particular interest in motor driven vehicles for the carrying of goods and because of the economic importance of this means of transportation, and the direct bearing it has on the greater problems of distribution and marketing, and he believes that other members of our Society might well be interested.

Merchants and manufacturers and others owning motor trucks have begun to show more interest in keeping a daily record of their performance, and for this reason accurate operating figures are now being made available. The following results were recently reported by owners employing motor trucks of the same capacity and manufacture but engaged in different industries:

MONTHLY SUMMARIES. 1½-TON TRUCKS FOR NOVEMBER, 1915.

Location	Butte, Mont.	St. Louis, Mo.	Detroit, Mich.	Baltimore, Md.
Business	Who. Groc.	Paint Mfg.	Lumber.	Packers.
Days in service	24.5	25	26	25
Days out for repairs	0	0.5	0	0
Numbr of trips	123	166	94	32
Number of customers	1,230	392	214	900
Load in pounds	307,500	270,640	82,254 bd. ft	79,600
Mileage traveled	803	829	1,502	907
Gallons of gasoline	140	143	228	163
Pints of cylinder oil	48	40	90	73
Pints of transmission oil	16	7	2	1
Pounds of grease	2	0.75	1.5	2.25

DAILY AVERAGES FROM THE ABOVE SUMMARY.

	Butte.	St. Louis.	Detroit.	Baltimore.
Number of trips per day	5	6.64	3.31	1.28
Customers per day	50.2	15.68	8.23	50.2
Weight per day in pounds	12,500	10,825.6	3,164 bd. ft.	3,184
Weight per trip	2,500	1,630	875 bd. ft.	2,487
Mileage per day	32.77	33.16	57.76	36.28
Miles per gallon of gasoline	5.73	5.79	6.59	5.56
Miles per pint of cylinder oil	16.73	20.72	16.69	12.42

The large variations indicated above suggest that many motor trucks are being managed to better advantage than others, and that the operating efficiency in the latter case might well be improved by studying carefully the conditions surrounding the work and advising the owner accordingly.

This work brings into action another branch of engineering which has been developed to a marked degree in some European countries, and this communication is addressed in the hope that other members of the Society having similar work in hand may find assistance through the columns of this Journal.

R. C. Hargreaves.

Detroit, Mich.

TURBINES VS. ENGINES IN UNITS OF SMALL CAPACITIES

To the Editor:

The data regarding economy of turbine driven pumps given in Mr. Barstow's paper on Turbines vs. Engines in Units of Small Capacities (The Journal, September, 1915), does not represent the highest performances that have, up to the present time, been obtained with a turbine driven centrifugal pumping unit.

The geared turbine pumping unit installed at the Ross Pumping Station, Pittsburgh, was the first pumping machine of this description ever built. Since that time other units have been constructed where better results have been obtained. I refer to the official test made by the City of Cleveland of the 30 million gallon centrifugal pumping unit installed at the Kirtland pumping station. This unit showed a duty of 128,400,000 ft. lb. per million B.t.u. or 152,020,000 ft. lb. per 1000 lb. of steam. The unit in question during test showed a delivery of 30.3 million gallons per day against a total head of

236.3 ft.; the steam supplied was 153.58 lb. per sq. in. gage with 102.6 deg. Fahr. superheat, and the turbine exhausting into a vacuum of 28.25 in. of mercury.

It may be of interest for comparison with other data given in Mr. Barstow's paper to analyze what this duty obtained would mean in operating cost. The unit consisted of a turbine reduction gear and two 24-in. pumps operating in series. It occupied approximately a space 10 ft. by 35 ft. and had a total weight of about 57 tons or about 326 lb. per sq. ft. of foundation. The price of the unit including condenser was $35,750, and the price of the bituminous coal burned at the plant averages $1.64 per ton. Assuming the cost of building a foundation at $20,000, and all boilers of a nominal horsepower equal to the steam requirements at $30 per horsepower, interest rate at 4 per cent, and the probable life of twenty years for the complete plant, the annual cost per water horsepower is $23.11, on the basis of twenty-four hours' operation, three hundred and sixty-five days per year of $25.90 per annual water horsepower on the basis of full load operation, sixteen hours per day.

Mr. Barstow, discussing boiler feed pumps, gives the impression that turbine driven centrifugal boiler feed pumps of less than 250 gallons per minute are not practicable. In this connection I would like to add to Mr. Barstow's data that centrifugal boiler feed pumps are built and used in quite large numbers in quantities ranging from 50 to 200 gal. per min. I would like to cite one instance where a small boiler feed pump of the centrifugal type is used for quite an abnormal condition. The ordinary demand of the boilers requires the pump to deliver an average of 15 gal. per min., due to the condition of the plant load; there may be some days enough demand from the boiler plant to require the feed pump to deliver as much as 60 to 75 gal. per min. The boiler feed pump in this instance is direct driven by a turbine and its speed is controlled by an automatic pump governor, which will change the speed of the unit to suit the requirements of the boiler plant. The pump is handling water at 200 to 210 deg., and is pumping against an average pressure of 200 lb. per sq. in.

C. R. Waller.

Trenton, N. J.

To the Editor:

As Mr. Barstow stated in his paper on Turbines vs. Engines in Units of Small Capacities (The Journal, September, 1915), the general advancement of the steam turbine has been exceedingly rapid. It is not surprising, therefore, that there has been a small region from which the engine has not yet been driven. Small turbines have already begun to invade this field, however. Usually as pointed out by Mr. Barstow, the water rate of a small turbine has been unimportant. By proper selection of the number of stages, number of bucket rows per stage, and wheel diameter for a given horsepower, speed and steam supply, almost any desired water rate can be obtained. Single stage machines with two or three rotating bucket rows have been very popular. Now, however, more efficient turbines are available with a greater number of moving bucket rows. A balance must always be made between increased first cost and increased operating cost.

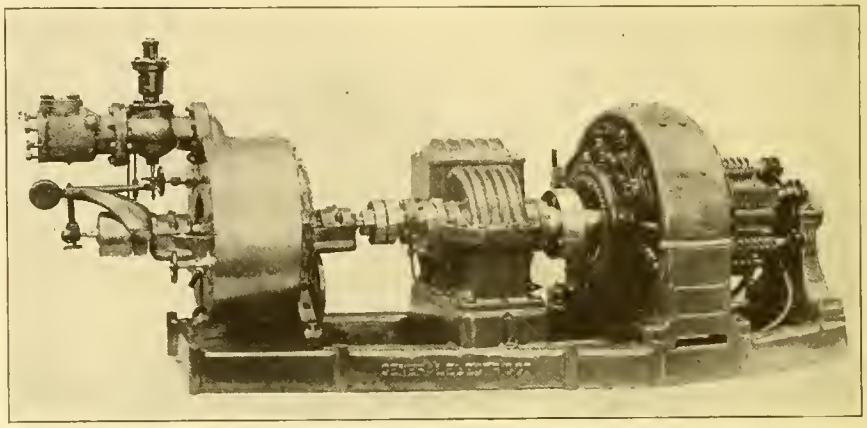

Fig. 1 Example of a Recently Developed Single Stage Turbine

The accompanying photograph (Fig. 1) shows a machine of a type recently developed. These give comparatively good non-condensing water rates, and are designed to meet present-day requirements regarding the balance between simplicity and high efficiency.

One advantage of turbines over reciprocating engines which Mr. Barstow has not mentioned, is the fact that the turbine maintains its original water rate, while many types of engine fall off appreciably. This was very clearly shown in a series of tests published by F. W. Dean in The Journal for June, 1908.

Sanford A. Moss.

Lynn, Mass.

Society Affairs

Engineering Survey

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SOCIETY AFFAIRS

ATTENTION is called to the announcement of the Spring Meeting scheduled at New Orleans, La., on April 11-14, and also the announcement of the publication of the report of the Power Test Committee, which will be welcomed by the large number who have anxiously awaited the completion of this testing code. A statement of the important action requested by the President of the United States is given in the report of the special Council meeting, and notices appear in connection with the Engineer Reserve Corps and the new aviation service. The important part taken by the Society in the Pan-American Scientific Congress is also here reported.

SPRING MEETING

PLANS for the Spring Meeting to be held at New Orleans, Louisiana, April 11-14, are nearing completion, and are most promising for a strong meeting and an enjoyable one.

It is probable that there will be a group going or coming by boat and that one or more parties will be formed for the trip by rail. The trip by boat in either direction requires five days, and will be made on one of the best coastwise steamers. Invitations have been received from the local members at Cincinnati and Birmingham for members en route to New Orleans to stop in those cities, and it is possible that arrangements will be made by at least a part of those attending to accept the invitations.

The rate for the round trip from New York is $75, which includes steamship both ways, or railroad going and steamship returning, or vice versa; and includes also meals and berth on steamer. This provides further for those who start from an inland city, such as Cincinnati, to go by rail to New Orleans, and return by steamer to New York and thence by rail to Cincinnati. Round trip by rail between New York and New Orleans is $56.30; Pullman fare, $8.00 for lower berth and $6.40 for upper berth.

The headquarters of the meeting will be at the Hotel Grunewald. The meeting will open as usual on Tuesday afternoon of the week of the Convention, when registration will begin. On Tuesday evening there will be an informal gathering at the hotel.

The first professional session will be on Wednesday morning following the business meeting, at which, besides such technical papers as may be assigned, it is expected that there will be a discussion upon Industrial Preparedness: What It Means, and How It Can Be Accomplished.

Following this meeting the visiting members will be in the hands of their New Orleans friends until Friday morning of the Convention, when the last general professional session will take place. The New Orleans local committee have in preparation one session for their part of the program which will include papers by representative engineers on engineering problems of the South, including papers upon Low-lift Pumping Plants, Multiple Evaporators, such as used in the sugar industry, and a description of the Mechanical Equipment used in the Port of New Orleans.

On Wednesday evening, there will be an address by W. D. Thompson, Commissioner of Public Utilities of the City of New Orleans. Various excursions are being arranged and as the month of April is one of the most delightful of the whole year at New Orleans, the week, under normal conditions, should offer much pleasure to all who attend the meeting.

It is particularly urgent that those who are to contribute papers should send them to the Secretary at the Society headquarters at once, since it is desired to have these papers printed for distribution well in advance of the meeting. It cannot be assured that papers received later than February 10 can be considered for the Spring Meeting and such papers may have to be held over until a later meeting.

Full information as to the program, rates, and routes to be taken will be published in the next number of The Journal, and in a circular which will be issued to the membership.

ANNUAL MEETING

The Committee on Meetings is already considering plans for the next Annual Meeting, and desires to announce that papers which are to be contributed should be in hand by September 20, 1916. On account of the time required for all of the members of the Committee on Meetings to read the papers submitted, and because of the insistence of the membership that the accepted papers be printed and distributed well in advance of the meeting, any papers received after the date mentioned are liable to be held over for a later meeting. In view of the fact that the date announced is immediately following the summer season, which is the usual vacation period, the members are urged to prepare papers during the coming spring so far as possible, and to submit them early in the summer.

REPORT OF POWER TEST COMMITTEE

ON RULES FOR CONDUCTING PREFORMANCE TESTS OF POWER PLANT APPARATUS

The Power Test Committee was appointed by resolution of the Council on April 13, 1909, to "revise the present testing codes of the Society relating to boilers, pumping engines, locomotives, steam engines in general, internal combustion engines, and apparatus and fuels therefor, and to extend these codes so as to apply to such power generating apparatus as the present codes do not cover, including water power, bringing them into harmony with each other and with the best practice of the day."

As originally organized, the Committee consisted of D. S. Jacobus, *Chairman*, Edward T. Adams, George H. Barrus, L. P. Breckenridge, William Kent, Chas. E. Lucke, Edward F. Miller, Arthur West and Albert C. Wood. Dr. Lucke resigned early in 1912 and the vacancy thus made was not filled. Owing to pressure of business duties, Dr. Jacobus resigned the chairmanship in December 1911, but the Committee laid his resignation on the table and appointed Mr. Barrus vice-chairman to serve as active chairman in his place. Later, the Committee accepted the resignation from chairmanship of Dr. Jacobus and promoted Mr. Barrus to the chairmanship, this action being in due time approved by the Council.

The general plan of the revision was devised by Mr. Barrus, who at the Committee's request soon after its appointment, submitted the first draft of a form of report which was afterward substantially agreed upon and carried out. The first

draft was discussed by the Committee, and later the whole matter was referred for revision to a sub-committee consisting of Messrs. Kent, Wood, and Barrus, who were appointed at a meeting of the General Committee in December 1911. The results of the sub-committee's work were approved by a majority of the full Committee and submitted to the Society in a preliminary report which was published in The Journal of November 1912.

This preliminary report was presented at the Annual Meeting in December 1912, and was widely discussed and criticised at the meeting, both verbally and in writing. After that it was further discussed by correspondence. In the light of the suggestions and criticisms attending these discussions, the sub-committee again made an extensive revision, which has now been approved by the entire committee.

The work of the Power Test Committee has been carried on mainly by correspondence, though the sub-committee has held a large number of meetings. Many members of the Society, and a few engineers not members, have commented upon the work, either verbally or in writing, and all comments have received consideration. In a large number of instances, the report has been modified in accordance with the suggestions made by these individuals.

Copies of the proposed report were also sent to the three committees of the Society on Railroads, Gas Power and Bureau of Engineering Standards (now Committee on Engineering Standards), to the Standards Committee of the American Institute of Electrical Engineers, and to the U. S. Bureau of Mines, all of whom were asked for comments. Suggestions received from these sources were availed of in preparing the final revision.

A report of this kind cannot be expected to deal with all the refinements of laboratory tests, or to conform to the methods practiced by every individual who engages in testing work; but it is intended to set forth the correct governing principles and serve the practical purposes of the engineering public.

The final report was received by the Council at its meeting on December 7, 1915, and was ordered printed. This is now in process, and copies will be available at an early date. The report embraces sections on tests of boilers; reciprocating steam engines; steam turbines; pumping machinery; compressors, blowers and fans; complete steam power plants; locomotives; gas producers; gas and oil engines, and water-wheels.

COMMENTS ON ANNUAL REPORT OF COUNCIL

In the January number of The Journal was published the Annual Report of the Council, which reviews the important phases of the work of the Society for 1915, and which it is hoped every member has had an opportunity to look over. In presenting this report at the Annual Meeting, Secretary Calvin W. Rice pointed out features of particular interest to the membership at large. A report of his remarks made at the meeting follows:

In the report of the Council for 1915 there is first shown the progress of the Society with respect to its increase in membership. There are a good many in the Society who have the impression that the present rate of increase of membership cannot be maintained except at the expense of quality. I want to answer this squarely. In this country, which has the largest industrial population of the world, we have, all told, about twenty-five thousand engineers in all of the societies. In Germany, with two-thirds of the population, their one society has more members than all of our societies combined. There are one hundred million people in this country, and more industries and a greater variety of industries than in any other country, and it is reasonable to suppose that our Society, which is the Society of the Industries, should be able to get the leaders of those industries to become members.

The American Society of Civil Engineers has steadily increased its membership, until it now has seven or eight hundred more members than has our Society. The American Institute of Electrical Engineers, specializing on electricity alone, has more members than we have. We have now about sixty-eight hundred members. The object of increasing the membership is not merely to get members, but to acquire greater strength for constructive work so that we may maintain our position with the other national engineering societies.

We have raised the requirements for membership so that now they are the strictest of any professional society in America. Every member of this Society can be assured that no one is being admitted into full membership who is not thirty-two years of age, who has not been ten years in the practice of his profession, and five years in responsible charge of important work. That these conditions exist with respect to each candidate for full membership must be shown in detail and confirmed by five members from their personal knowledge. Each application for membership is visé by the Secretary, and it is an open secret that no application for membership is ever submitted by him to the Membership Committee if it lacks any of these essentials.

Only after all of these statements in an application for membership have been analyzed and shown to meet the requirements do five members of the Society, the Committee on Membership, sitting as an impartial jury, consider the application. For consideration, five copies of the statements are prepared, so that each one of the five committee members has a file of the replies in front of him. Each member in turn then reads aloud the statements to the others. I cannot see how any man can get by this jury, except as he deliberately misstates the facts and gets five others to say that, from their personal knowledge, all of his misstatements are correct.

Another thing,—formerly it was permissible and considered proper to receive a man into membership who had either the ability to design or to construct. Three years ago we took out the *or* and substituted an *and*, so that now there is no man admitted to this Society who cannot both design *and* construct, and the possibility of a man being admitted to membership who designs things that would never work, or a man who builds things that he could not design, is past. He must have both abilities and be a well-rounded engineer.

It is essential that the financial side of every institution shall be well in hand, and the membership can feel safe on this matter. Since I have been Secretary our income has been increased from $45,000 to $145,000. All of the trust funds are invested in bonds, and we even have a separate fund of $44,772.67 invested to cover the dues of Life and Honorary Members, and as far as I know we are the only Society in the world which does this.

All of the gifts ever made to the Society are intact and invested, and the initiation fees are also invested in a separate fund, amounting now to $43,718.90, which is being used to retire the certificates of indebtedness which were issued for the purpose of paying off our share of the land on which the Engineering Societies Building stands. Our sister societies had some wealthy and generous members, who came forward and

paid off the $180,000 which was each society's share of the purchase price, but we were not so fortunate in this respect, and have had to finance the matter on a different basis. Yet with contributions amounting to only about two-thirds of the gifts received by our sister societies, we were the first to pay off the mortgage on the land by means of certificates issued to the membership. We lack only about $13,000 of being completely out of debt. On the other hand we have enough surplus to pay off that debt at any moment, if desirable to do so, but our funds are invested at the same rate of interest as we are paying on the certificates, so that by reason of the plan we are pursuing, we have the benefit of that extra working capital.

It is the duty and obligation of the officers of any society to act as trustees for the members and to conserve the interests of the members in every proper way. Last year, therefore, when a serious business depression was feared, precautionary measures were taken and we conserved our interests a little more than was proved necessary, but not more than seemed wise, at the beginning of the year. The result is that we saved $26,000 last year to go into the surplus.

Now, the use which can be made of that surplus and of our growing income will be made apparent in the near future. The Council prior to the Annual Meeting voted to strengthen the staff of the Society by the employment of a Business Manager, and we have an ambitious program for the Society for the benefit of every member. Coupled with that is a plan—and emphasis should be put on the fact I now mention—to make every member of this Society take a more active part in its government, and Dr. Jacobus will call later on the Local Sections of the Society to assist him in choosing a Nominating Committee.

The remainder of the features which are embodied in the report can be read by the members at their convenience.

COUNCIL NOTES

At the meeting of the Council held on January 14, 1916, the following members were present: Dr. D. S. Jacobus, *President*, John H. Barr, R. M. Dixon, *Chairman of the Finance Committee*, A. M. Greene, Jr., Henry Hess, Alex. C. Humphreys, F. R. Hutton, C. T. Main, H. de B. Parsons, John A. Stevens, J. E. Sague, William H. Wiley, *Treasurer*, and Calvin W. Rice, *Secretary*.

The following matters were brought up in the order of business and voted upon:

Dr. D. S. Jacobus, Chairman ex-officio, J. H. Barr, Arthur M. Greene, Jr., Henry Hess, Spencer Miller and J. E. Sague were appointed an Executive Committee of the Council for 1916.

Sub-Committee on Gas Power: Heinrich J. Freyn, Chairman, G. F. Gebhardt, Secretary, C. J. Bacon, C. H. Benjamin, A. D. Blake, W. D. Ennis, F. R. Hutton, Wm. T. Magruder, J. M. Spitzglass and H. H. Suplee.

The recommendation of the Committee on Student Branches with regard to the establishment of Student Branches at Bucknell University, Lewisburg, Pa., and Louisiana State University, Baton Rouge, La., were accepted, and F. E. Burpee and E. W. Kerr appointed as the respective Honorary Chairmen.

The President was authorized to appoint a committee of five on the determination of the Cost of Electric Power, to coöperate with the A.I.E.E. and similar committees of other societies, in response to the invitation of the A.I.E.E. through H. G. Stott, representing the Standardization Committee.

Prof. F. R. Hutton, *Chairman*, R. H. Fernald and D. S. Kimball will continue as a Committee on Student Prizes for the year 1916; R. H. Fernald, Chairman, Fred E. Rogers and George B. Brand as a Committee on Junior Prizes. The Boiler Code Committee as constituted for the year 1915 will continue in service for another year. The Committee for the New York Local Section will continue unchanged with the exception of Edward Van Winkle, whose term of office has now expired and who will be succeeded by A. D. Blake, H. R. Cobleigh succeeding as chairman. The activities of the Minnesota Local Section will be cared for by a committee consisting of Chas. W. Tubby, *Chairman*, J. V. Martenis, *Vice-Chairman*, Quincy A. Hall, Wm. Kavanaugh and Max Toltz, in accordance with the nomination of members in St. Paul-Minneapolis.

Announcement was made by the President of the following appointments:

(a) Finance Committee, George M. Forrest
Meetings Committee, D. S. Kimball
Publication Committee, Charles I. Earll (reappointment)
Membership Committee, Fred J. Miller
Library Committee, Walter M. McFarland (reappointment)
House Committee, Maxwell M. Upson
Research Committee, C. C. Thomas
Public Relations Committee, (to be announced later)
Standardization Committee, Henry Hess, John H. Barr, Chas. Day, Carl Schwartz and Wm. F. Kiesel, Jr.
Constitution and By-Laws, Jesse M. Smith, F. R. Hutton, J. E. Sague, Geo. M. Basford, I. N. Hollis
Tellers of Election, Robt. Kirk, *Chairman*, H. A. Hey, E. S. Cooley

(b) Honorary Vice-Presidents, for the meeting of the Society for Promotion of Industrial Education at St. Paul, W. H. Kavanaugh and Max Toltz

(c) Joseph A. Holmes Memorial, Dr. John A. Brashear and W. H. Bixby

(d) Student Branch Chairman (Honorary)
Pennsylvania State College, Hugo Diemer
University of Kansas, A. H. Sluss

(e) Tolerances on Screw Thread Fits, Chas. D. Young, in place of H. M. Leland, resigned.

The Secretary reported that ballots closing November 23 and December 17, 1915, containing the names of applicants recommended to the Council after investigation by the Membership Committee, had been approved by letter ballot, all these newly elected members being duly notified of election to membership in the Society.

The announcements of the deaths of L. M. Brigham, F. S. Scarborough and S. B. Whiting were received with regret.

The vacancy caused by the death of James Mapes Dodge, Past-President of the Society, will be filled by Dr. Alex. C. Humphreys, as announced at the Council Meeting by Major Wiley, Chairman of the Committee on Engineer Reserve Corps. Further information upon this is given elsewhere in this number.

Calvin W. Rice,
Secretary.

SPECIAL COUNCIL MEETING

To Consider Letter from President Wilson

A special meeting of the Council was held pursuant to call of the President, Dr. Jacobus, to receive the communication from Hon. Woodrow Wilson, President of the United States, asking for nominations by the Society of a representative in

each state of the Union to act with the representatives of the four other national societies, in making an industrial survey of the country. The letter is as follows:

The White House
Washington

January 13, 1916

My dear Sir:

The work which The American Society of Mechanical Engineers has done through its members on the Naval Consulting Board is a patriotic service which is deeply appreciated. It has been so valuable that I am tempted to ask that you will request your Society to enlarge its usefulness to the Government still further by nominating for the approval of the Secretary of the Navy a representative from its membership for each state of the Union to act in conjunction with representatives from the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Chemical Society, and the American Institute of Mining Engineers, for the purpose of assisting the Naval Consulting Board in the work of collecting data for use in organizing the manufacturing resources of the country for the public service in case of emergency. I am sure that I may count upon your cordial coöperation. With sincere regard,

Cordially yours,

Woodrow Wilson.

Dr. D. S. Jacobus, President, The American Society of Mechanical Engineers, New York City.

There were present at the meeting of the Council, D. S. Jacobus, J. Sellers Bancroft, Alex. C. Humphreys, Julian Kennedy, F. R. Hutton, H. de B. Parsons, Spencer Miller, Ambrose Swasey, William H. Wiley, *Treasurer,* and Calvin W. Rice, *Secretary.*

A tentative list was prepared and a Committee of the President and the Secretary appointed to confer with similar committees of the American Chemical Society, American Institute of Electrical Engineers, American Institute of Mining Engineers, and the American Society of Civil Engineers, which joint committee will prepare the final list that there may be no overlapping in the selection of engineers by the various societies.

THE LIBRARY BOARD

The Library Board administering the libraries of The American Society of Mechanical Engineers, American Institute of Electrical Engineers and American Institute of Mining Engineers, maintained as the Joint Library of the United Engineering Society, according to the By-Laws of that Society, has just issued its annual report for 1915.

Library of the United Engineering Society

This photograph shows the main floor of the Library. A large part of the books on this floor are bound periodicals which are most frequently consulted. Current numbers of periodical literature are also kept on the main floor. The stack room floor below is mainly devoted to books of reference. The library is made available to all members of the Society through the medium of the Library Service Bureau.

The Board for 1915 consisted of Edward A. Adams, W. P. Cutter, Karl Eilers, Alex. C. Humphreys, F. L. Hutchinson, John W. Lieb, W. M. McFarland, Harold Pender, Calvin W. Rice, E. F. Roeber, Samuel Sheldon, W. I. Slichter, Jesse M. Smith, E. Gibbon Spilsbury, Bradley Stoughton and Leonard Waldo.

A feature of the year's work was the organizing on a definite basis of the service given to members by furnishing reference lists, making translations, and preparing photostat copies. A Library Service Bureau was established on May 6, 1915, and members of the Society were notified of the service proposed.

In July, 1915, the Library published a catalogue of technical periodicals to be found in seven libraries in New York City and vicinity. The total number of periodicals is 2066 and the number of sets 4236.

Over three thousand accessions were made to the Library during the year, and the collection now amounts to 62,446 volumes. Several notable gifts were received during the year from private sources, and a large collection of trade catalogues was donated by the New York Public Library. Dr. James Douglas contributed $5000 to serve as a nucleus for an endowment fund, the income from which should be used for library purposes.

1020 periodicals are now received regularly by the Library, constituting it the greatest and potentially the most useful engineering library in the world. Current numbers of over 1000 periodicals are filed upon the shelves in the reading room so as to be readily accessible.

The Board emphasizes the need of an adequate general index to technical literature. Of the two general indexes now existing, the largest covers only one fifth of the periodicals received. The possession of an adequate index would make it possible for the technical worker, located at any place where he is separated entirely from library facilities, to find articles desired without laborious search and to obtain direct from a central library typewritten or photographic copies and translations. An estimate of the cost of preparing such an index is included in the report.

PAN-AMERICAN SCIENTIFIC CONGRESS

During the month of January the Second Pan-American Scientific Congress concluded its sessions, and accomplished a comprehensive effort to develop our cultural relations with Central and South America. The Congress was held in Washington under the auspices of the Department of State, and convened on December 27, 1915; and no affair ever attracted a more enthusiastic coöperation between the Government and scientific and engineering bodies, and the beneficial results were in proportion and far-reaching.

According to precedent set at the first Congress held at Santiago, Chili, in December 1908, and to the proper interpretation of the Spanish counterpart *scientifice* of our word *scientific*, the second Congress covered all branches of knowledge. Its main activities were divided into nine sections, as follows:

I Anthropology
II Astronomy, Meteorology and Seismology
III Conservation of Natural Resources, Agriculture, Irrigation and Forestry
IV Education
V Engineering
VI International Law, Public Law and Jurisprudence
VII Mining and Metallurgy, Economic Geology and Applied Chemistry
VIII Public Health and Medical Science
IX Transportation, Commerce, Finance and Taxation.

These sections were further divided into subsections as found necessary.

By invitation of the Department of State, the section on Engineering was conducted under the auspices of the five national engineering societies, American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, Society of Naval Architects and Marine Engineers, and The American Society of Mechanical Engineers.

The members representing the Society on the Joint Committee conducting the Engineering Section were Brig. General W. H. Bixby, U. S. A., retired; Prof. Carl C. Thomas; Charles T. Plunkett, and Calvin W. Rice. By choice of all the societies, Brig. General Bixby was appointed chairman of the Joint Committee, and in turn was made a member of the Executive Committee of the entire Congress. Dr. Elmer L. Corthell, President of the American Society of Civil Engineers, was chosen Secretary of the Joint Committee.

Our recently-retired president, Dr. John A. Brashear, was selected by the Department of State as the representative of the United States to the Congress, and the delegates of the Society were Ambrose Swasey, Past Pres. Am.Soc.M.E., and Waldo H. Marshall. Prof. Carl C. Thomas was presiding officer of Subsection 5: Mechanical Engineering.

Among the papers presented at the sessions of the Engineering Section was one by William Kent, Mem.Am.Soc.M.E., on Economy of Steam Power Plants Using Gas, Gasoline, Coal and Other Pan-American Fuels. The calorific values of all fuels obtainable in Pan-American countries, including the lighter oils, tar and some agricultural products, were given, and the paper discussed the conditions governing the choice of each fuel and the costs of operation with the various fuels.

Other papers at the Congress of mechanical engineering interest were those on Present Status of Water Power Development, by H. W. Buck; Hydro-Electric Utilization at Niagara and Elsewhere, by Maurice Deutch; Engineering Nomenclature, by Alberto Smith; Engineering Education in the United States, by Dr. Charles S. Howe, Mem.Am.Soc.M.E., and Chronocyclograph Devices for Measuring Achievement, by Frank B. Gilbreth, Mem.Am.Soc.M.E. During the week of the Congress, Dr. Brashear delivered a particularly instructive lecture on An Evening Journey Among the Stars.

During the Congress, the Secretary of the Society extended to the whole of the delegates an invitation to visit our headquarters and avail themselves of our facilities, and already several of the delegates have called and, among other things, visits to industrial plants have been arranged for them.

At the close of the Congress, the United States Government arranged a tour for the delegates to Philadelphia, New York, New Haven and Boston.

ENGINEER RESERVE CORPS

To the Special Committees of
American Society of Civil Engineers,
American Institute of Mining Engineers,
American Institute of Electrical Engineers,
American Institute of Consulting Engineers,
The American Society of Mechanical Engineers,
on the Organization of a National Engineer Reserve.

Dear Sirs:

The Joint Committee (consisting of the chairmen of your several committees) formed under the authority of the five societies, in order to facilitate the carrying out of the organization of an engineer reserve as part of the military forces of the United States, for which work you were appointed, now beg leave to report as follows:

The Committee has been in personal communication with the Secretary of War, the officers of the General Staff, the officers of the War College, and with the Hon. Geo. E. Chamberlain, Chairman of the Senate Committee on Military Affairs, and the Hon. James Hay, Chairman of the House Committee on Military Affairs.

As the result of these interviews there has been incorporated in the draft of the legislation proposed by the Secretary of War and included also in the bills drawn by the committees of the Senate and of the House, a provision for the organization of an officers' reserve on broad lines, including an engineer reserve. As now drawn these bills provide that an officer shall

be commissioned for a period of five years with rank up to and including that of major, after passing such requirements of character and qualifications as shall be prescribed by the President. The bill also provides that a certain amount of duty with pay shall be performed each year by the officers in the reserve.

The Committee is waiting for the Navy Department to formulate its plans for the increase in the naval forces, and as soon as a decision has been reached by that Department and the Committee is in possession of the facts, the Committee will take up the question of the organization of an engineer reserve for the Navy, similar to that contemplated for the Army.

It is the intention of the Committee to attend any Congressional hearings that may be had on the bill or bills introduced for the creation of an engineer reserve.

Prior to the enactment of the necessary legislation, no enrollment for the proposed reserve can be made.

Very truly yours,

(Signed) Wm. H. Wiley, H. A. Gillis,
John A. Hill, W. F. M. Goss.

THE BOILER CODE IN TECHNICAL SCHOOLS

That the work of the Boiler Code Committee is meeting with increasing recognition is indicated by its use in technical schools as a text or reference book. The A.S.M.E. Boiler Code is being used as a reference book at Stevens Institute of Technology at Hoboken, N. J., at Sheffield Scientific School of Yale University, and in the course in boiler design at the Rennselaer Polytechnic Institute at Troy, N. Y. At Rensselaer, the Code supplements the text and lecture notes; in the actual design work the requirements of the Code are examined and the design made to meet the requirements. It is reported that the Code is also in use at Virginia Polytechnic Institute, Georgia School of Technology, University of Texas, and The Tulane University of Louisiana.

MEMBERS FOR AVIATION SERVICE

Mr. Raynal C. Bolling, Commander Signal Corps, National Guard, State of New York, in a letter addressed to the Society, states that he is especially desirous of securing men whose professional training or business occupations give them particular qualifications for service in the Aviation Detachment of the National Guard. He believes that among the members of the Am.Soc.M.E. there will be many younger men who would make very desirable members of this organization, and asks that those who would like to join the Aviation Detachment communicate with him (c/o U. S. Steel Corp., 71 Broadway, New York).

NOTES

A cordial invitation has been received from F. E. Pierce, secretary of the New York Section of the American Institute of Mining Engineers, for the members of the Society to attend the monthly meetings of the Institute. These meetings are scheduled for the evening of the first Wednesday after the first Tuesday of each month, from October to May inclusive. The notices are sent out to the members and associates ten days or two weeks in advance of the date set, and duplicate notices may be obtained in the rooms of the A.I.M.E. It is the present custom to hold these meetings at the Machinery Club, 50 Church St., preceded by a dinner at 6.30 p.m., the cost of which is $1.50 per plate.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON MARCH 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The Candidates will be balloted upon by the Council unless objection is received by March 10, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Adams, Clarence S., Draftsman and Designer, Engrg. Dept., Copper Queen Cons. Mining Co., Douglas, Ariz.
Allen, J. S., Ch. Engr. and Supt., Metropolitan Dredging Co., New York
Andersen, Oscar E., Mgr. Chicago Off., Wheeler Condenser & Engrg. Co., Chicago, Ill.
Austin, Harold R., Ch. Engr., Chimney Dept., The M. W. Kellogg Co., New York
Banch, Ladislaus R., Designing Engr., Corrigan, McKinney & Co., Cleveland, Ohio
Billings, David L., Asst. Secy. and Systematizer, Remington Arms Co. of Delaware, Eddystone, Pa.
Bower, Clarence B., Efficiency Engr., Carnegie Steel Co., New Castle Wks., New Castle, Pa.
Cavin, Gustave, Asst. Mech. Engr., Canadian Locomotive Co., Ltd., Kingston, Ont., Canada
Charlton, Richard C., Mech. Engr., Henry Disston & Sons, Philadelphia, Pa.
Corey, Varian S., Supt., The Hampden Watch Co., Canton, O.
Donovan, William P., Supt., Gypsy Oil Co., Kiefer, Okla.
Francois, Richard G., Cons. Engr., New York
Hoffmann, Karl F., Cons. Mining Engr., New York
Holcombe, Amasa M., Patent Lawyer, with Carr & Carr, Attys.-at-Law, St. Louis, Mo.
Johnson, Francis E., Jr., Ch. Engr. and V. P., The M. W. Kellogg Co., New York
Kingsbury, W. P., Constr. Engr., Gypsy Oil Co., Tulsa, Okla.
May, Edwin M., with The Richardson-Phenix Co., Milwaukee, Wis.
Messer, Vladimir V., Engr., with P. R. Moses and Frederick Pope, Cons. Engrs., New York
Mooney, James D., with Hyatt Roller Bearing Co., Newark, N. J.

Mowery, Harold W.,
American Abrasive Metals Co., New York
Oederlin, Frederick, Mem. Genl. Management,
Messrs. Sulzer Bros., Winterthur, Switzerland
Rhines, George, Genl. Supt.,
Stanley G. Flag & Co., Stowe, Pa.
Roane, R. Royal, Mech. Engr.,
James Stewart & Co., Inc., and Canadian Stewart Co., Ltd., New York
Rogers, A. A., Pres.,
Portales Utilities Co., and Portales Pwr. & Irrigation Co., Portales, New Mex.
Romann, John H., Maintenance Engr.,
Amer. Steel Foundries, E. St. Louis, Ill.
Sandstrom, Charles C., Mech. Engr.,
Hunt Engrg. Co., Kansas City, Mo.
Sladky, Alexander C., Asst. Supt.,
Natl. Enameling & Stamping Co., Milwaukee, Wis.
Starkey, Lewis C., Prof. of Mech Engrg.,
Drexel Inst., Philadelphia, Pa.
Steere, Robert E., Master Mech. and Ch. Engr.,
Nashawena Mills., New Bedford, Mass.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bertram, H. Graham, Mech. Engr. Order Dept.,
John Bertram & Sons, Dundas, Ont., Canada
de Bruyn, Charles E., Mgr. of Efficiency Instr. Dept.,
Scientific Materials Co., Pittsburgh, Pa.
Elmes, Clyde C., Asst. Supt. M. P. and Rolling Equipment,
Philadelphia & Reading R.R., Reading, Pa.
Farrar, John G., Asst. Ch. Draftsman,
McIntosh & Seymour Co., Auburn, N. Y.
Flood, Henry, Jr., Ch. Engr.,
Central Hudson Gas & Elec. Co., Poughkeepsie, N. Y.
Lynch, Albert S., Efficiency Engr.,
Winchester Repeating Arms Co., New Haven, Conn.
Mervine, Arthur E., Ch. of Service and Maintenance Dept.,
New Jersey Zinc Co., of Pa., Palmerton, Pa.
Palmer, Guernsey A., Draftsman,
J. P. Devine Co., Buffalo, N. Y.
Sheedy, Michael M., Ch. Insptr.,
Penn. Mfrs. Assoc. Casualty Ins. Co., Philadelphia, Pa.
Smith, Edward W. G., Chief Draftsman,
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
Thomas, Stephen, Special Apprentice,
Hooven Owens Rentschler Co., Hamilton, Ohio
Thompson, Uldric, Jr., Engr.,
Internatl. Steel & Ordnance Corp., Parlin, N. J.
Volkmar, Walter H., Investigation and Time Study,
Winchester Repeating Arms Co., New Haven, Conn.

FOR CONSIDERATION AS JUNIOR

Betts, Walter L., Asst. to Genl. Foreman, Bayonet Dept.,
Remington Arms & Ammunition Co., Bridgeport, Conn.
Blakeman, Samuel P., Mech. Draftsman & Designer,
The Terry Steam Turbine Co., Hartford, Conn.
Bready, William M., Jr.,
with The Kennicott Co., Chicago, Ill.
Carpenter, Frederick S., Engrg. Dept.,
United States Rubber Co., New York
Day, Oscar L., Asst. Designer,
Harbison-Walker Refractories Co., Pittsburgh, Pa.
Fenton Paul, Engr.
Amer. By-Product Mchy. Co., New York
Harris, Murray W., Asst. to Dept. Supt., Gun Shop,
Remington Arms & Ammunition Co., Bridgeport, Conn.
Hoffman, Armin S., Mech. Engr.,
with B. P. Clapp Ammonia Co., Washington, D. C.
Kneass, Strickland, Jr., Asst. Steam Engr.,
Youngstown Sheet & Tube Co., Youngstown, O.
Koch, William H., Jr., Asst. Supt.,
A. & F. Brown Co., Elizabethport, N. J.
Mankin, Clarence E., Dist. Supvr. of Service,
Studebaker Corp. of America, New York
Patterson, James C., Mech. Engr.,
The Standard Cotton Co. of Amer., Philadelphia, Pa.
Shaffner, Charles R., Steam Expert,
Illinois Steel Co., Joliet, Ill.
Smith, Charles W., Efficiency Engr.,
Inspiration Cons. Copper Co., Miami, Ariz.
Snavely, Amos B., Genl. Engrg. Wk.,
Hershey Chocolate Co., Hershey, Pa.
Walter, Edford M.,
with B. F. Sturtevant Co., Boston, Mass.
Wellons, Charles M.,
with The Curtiss Aeroplane Co., Buffalo, N. Y.
White, William C., Designer,
The Moulton Engineering Corp., Portland, Me.
Wilkins, Charles N., Asst. to Mgr.,
Air Conditioning Dept., Warren Webster Co., Camden, N. J.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Crawford, Charles C., Mgr.,
A. M. Lockett & Co., Ltd., Houston, Tex.
Elliott, Benjamin G., Assoc. Prof. of Mech. Engrg.,
Univ. of Nebr., Lincoln, Nebr.
Rowse, William C., Prof. of Mech. Engrg.,
Univ. of Manitoba, Winnipeg, Man., Canada
Singer, Sidney C., Supt. of Distribution,
Syracuse Lighting Co., Syracuse, N. Y.

PROMOTION FROM ASSOCIATE-MEMBER

Lang, Charles W., Ch. Ord. Engr.,
U. S. Standard Arms Co., Inc., New York

SUMMARY

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Promotion from Junior	4
Promotion from Associate-Member	1
Total	66

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Arizona
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Miami—Smith, Charles W.
Connecticut
Bridgeport—Betts, Walter L.
Harris, Murray W.
Hartford—Blakeman, Samuel P.
New Haven—Lynch, Albert S.
Volkmar, Walter H.
District of Columbia
Washington—Hoffman, Armin S.
Illinois
Chicago—Andersen, Oscar E.
Bready, William M., Jr.
E. St. Louis—Romann, John H.
Joliet—Shaffner, Charles R.
Maine
Portland—White, William C.
Massachusetts
Boston—Smith, Edward W. G.
Walter, Edford M.
New Bedford—Steere, Robert E.
Missouri
Kansas City—Sandstrom, Charles C.
St. Louis—Holcombe, Amasa M.
Nebraska
Lincoln—Elliott, Benj. G. (J.)
New Jersey
Camden—Wilkins, Charles M.
Elizabethport—Koch, William H., Jr.
Newark—Mooney, James D.
Parlin—Thompson, Uldric, Jr.
New Mexico
Portales—Rogers, A. A.
New York
Auburn—Farrar, John G.
Buffalo—Palmer, Guernsey A.
Wellons, Charles M.
New York—Allen, J. S.
Austin, Harold R.
Carpenter, Frederick S.
Fenton, Paul
Francois, Richard G.
Hoffmann, Karl F.
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Lang, Charles W. (A.M.)
Mankin, Clarence E.
Messer, Vladimir V.
Mowery, Harold W.
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Poughkeepsie—Flood, Henry, Jr.
Syracuse—Singer, Sidney C. (J.)
Wellons, Charles M.
Ohio
Canton—Corey, Varian S.
Cleveland—Banch, Ladislaus R.
Hamilton—Thomas, Stephen
Youngstown—Kneass, Strickland, Jr.
Oklahoma
Kiefer—Donovan, William P.
Tulsa—Kingsbury, W. P.
Pennsylvania
Hershey—Snavely, Amos B.
Eddystone—Billings, David L.
New Castle—Bower, Clarence B.
Palmerton—Mervine, Arthur E.
Philadelphia—Charlton, Richard C.
Patterson, James C.
Sheedy, Michael M.
Starkey, Lewis C
Pittsburgh—Day, Oscar L.
de Bruyn, Charles E.
Reading—Elmes, Clyde C.
Stowe—Rhines, George
Texas
Houston—Crawford, Charles C. (J.)
Wisconsin
Milwaukee—May, Edwin M.
Milwaukee—Sladky, Alexander C.
Canada
Dundas—Bertram, H. Graham
Kingston—Cavin, Gustave
Winnipeg—Rowse, William C. (J.)
Switzerland
Winterthur—Oederlin, Frederick

PERSONALS

THIS department is intended for items about members of the Society, their professional work and incidents concerning them which may be of interest to the membership in general. Items are solicited upon important engineering developments in which members have been associated, and also newspaper clippings or manuscripts of addresses delivered by members at meetings of any kind are desired. It is hoped that every member of the Society will furnish an interesting item occasionally for publication in the Journal.

George A. Wieber has accepted the position of chemist with The Bartlett Haywood Company of New York. He was formerly employed by the Westinghouse Machine Company, East Pittsburgh, Pa., as an engineering apprentice.

John E. Taylor, until recently associated with the New York Central and Hudson River Railroad Company at Canastota, N. Y., has become identified with the Locomotive Superheater Company, New York, in the capacity of draftsman.

Frank C. Clark, superintendent of the Pacific Locks, Panama Canal, at Pedro Miguel, Canal Zone, has accepted a position with the New Castle Construction Company, New Castle, Del., as superintendent.

Le Roy Hilyard has entered the employ of Edward G. Budd Manufacturing Company, Philadelphia, Pa., as assistant engineer. He was until recently affiliated with the International Steam Pump Company of Philadelphia, Pa.

Ernest O. Hickstein is no longer connected with the Wichita Natural Gas Company, Bartlesville, Okla., having accepted a position in the stoker department of the Westinghouse Machine Company, East Pittsburgh, Pa.

William A. Cowell, formerly designer and checker with the McIntosh and Seymour Corporation of Auburn, N. Y., has accepted the position of chief draftsman with the William Tod Company of Youngstown, O.

James W. Smith has recently severed his connection as works manager of the Wyman and Gordon Company, drop forgers. Mr. Smith was formerly connected with the American Steel and Wire Company at Pittsburgh, Pa.

William J. A. London has accepted a position with the Sterling Blower Company, Hartford, Conn., in the capacity of works manager. He was until recently chief engineer of the Terry Steam Turbine Company of the same city.

Otto S. Beyer, Jr., formerly general foreman of the Rock Island Lines at Horton, Kan., has become associated with the University of Illinois, Urbana, Ill., in the railway engineering department.

Arthur F. Murray has become affiliated with the New England Westinghouse Company, Springfield, Mass. He was until recently equipment engineer of the Blake and Knowles Steam Pump Works at East Cambridge, Mass.

Waldemar R. Kremer was appointed general sales manager of the Vilter Manufacturing Company, Milwaukee, Wis., at the recent meeting of the board of directors, succeeding the late Fred Ulrich. Mr. Kremer has been connected with the company for nearly ten years as consulting electrical and mechanical engineer in the sales department. In his new capacity he will have general charge of sales and supervision of branch offices and agencies in this and foreign countries.

Walter N. Polakov has opened an office in New York, for the practice of consulting engineering.

Paul M. Lincoln, whose connection with the Westinghouse companies in their operating and engineering activities dates back for over 23 years, has become associated with the sales organization of the Westinghouse Electric and Manufacturing Company with the title of commercial engineer.

Ervin G. Bailey, who has been associated with the Fuel Testing Company, Boston, Mass., for the past six years, has been made president of the Bailey Meter Company of Boston, Mass., which has perfected a line of recording and integrating meters for measuring the flow of steam, water, air and other fluids.

Russell Huff, chief engineer of Dodge Brothers, Detroit, Mich., was elected president of the Society of Automobile Engineers at its annual midwinter meeting in New York, January 5.

In the January 20 issue of the American Machinist is published the first of a series of articles by Charles Piez, on the Personal Reminiscences of James Mapes Dodge. This article deals with the development of the conveying and coal storage business and covers a period of Mr. Dodge's life to about 1900.

G. W. Lewis and A. G. Cressler are co-authors of an article on Empirical Design of Gas-Engine Piston Pins which appears in the January 20 issue of American Machinist.

Elmer A. Sperry is one of the winners of the medals awarded by the American Museum of Safety for meritorious work in promoting safety and conserving life. Mr. Sperry will receive the Scientific American medal for his gyroscopic compass.

H. M. Byllesby has been appointed a member of the public service corporation committee of the Investment Bankers' Association of America.

Charles A. Stone, president of the American International Corporation, New York, and a member of the firm of Stone and Webster Engineering Corporation of Boston, Mass., has been elected president of the alumni council of the Massachusetts Institute of Technology.

Bernard Lester has been appointed manager of the small-motor section of the industrial department of the Westinghouse Electric and Manufacturing Company.

Thomas A. Edison, Hon.Mem.Am.Soc.M.E., was the guest of honor at the thirtieth annual banquet of the Ohio Society of New York at the Waldorf-Astoria Hotel, January 15. Preparedness for Defense was the subject of addresses by Hon. Henry D. Estabrook, the Reverend S. Parkes Cadman, D.D., and the Hon. Josephus Daniels, Secretary of the Navy.

John L. Harper, chief engineer for the Hydraulic Power Company, Inc., of Niagara Falls, N. Y., has been appointed supervising engineer of the Niagara Falls Grade Crossings Commission.

F. H. Newell, of the department of civil engineering, University of Illinois, will be the speaker at the annual dinner of the Minnesota Surveyors' and Engineers' Society on February 11.

Frederick W. Ballard, formerly commissioner and chief engineer of the light and heat division of the City of Cleveland, is now connected with the firm of F. W. Ballard and Company, engineers, Cleveland, O.

S. P. Brown, chief engineer of the Mount Royal Tunnel and Terminal Company, Ltd., Montreal, Canada, has contributed to the Engineering Record a series of articles on Tunnel Drill Carriages—Their Economic Possibilities. The first and second articles, which appear in the January 8 and January 15 issues, discuss the evolution of the drill carriage and the adaptation of European and American ideas to an advanced type of heading carriage used in the Mount Royal Tunnel. The third and last article, which is published in the January 22 issue, deals with the work done by unique types of drill carriage for bench work and trimming.

George W. Bissell, dean of engineering of Michigan Agricultural College, East Lansing, Mich., was elected president of the Michigan Engineering Society at the January 18-20 convention in Grand Rapids.

W. B. Goentner, formerly assistant engineer of the Department of Water Supply, Gas and Electricity of New York City, has been appointed superintendent of the factory of the McCabe Chemical Company at Charlotte, N. C.

John A. Mathews, president of the Halcomb Steel Company, Syracuse, N. Y., addressed the Chicago section of the American Institute of Mining Engineers, January 14, on Iron in Antiquity and To-Day.

L. A. Perkins, mechanical engineer at the Addyston, O., works of the United States Cast Iron Pipe and Foundry Company, has been made assistant superintendent of the company's plant at Bessemer, Ala.

Werner Nygren has withdrawn from the firm of Nygren, Tenney and Ohmes, New York, and has established independent offices for the practice of consulting engineering in steam power, heating and ventilating installations at 101 Park Avenue, New York.

Arthur L. Jennings has retired as president and general manager of the Russell-Jennings Manufacturing Company of Chester, Conn.

William R. Blair, formerly works manager of the Landis Machine Company, St. Louis, Mo., has accepted a similar position with the Measuregraph Company of St. Louis, Mo., makers of a yardage measuring instrument for stores and warehouses.

Walter B. Snow and staff, advertising agents and publicity engineers of Boston, Mass., have added to their organization, Charles W. Burrage, formerly instructor in mechanical engineering at the Massachusetts Institute of Technology and associated with the F. W. Dodge Company in connection with the preparation of Sweet's Index.

E. Gybbon Spilsbury was elected president of the Engineers' Club of New York on January 25.

Jos. C. Regan has accepted a position with the Timken-Detroit Axle Company of Detroit, Mich., as general factory manager. He was until recently assistant general superintendent of the Yale and Towne Manufacturing Company, Stamford, Conn.

Milton R. Jonas has become associated with the Allegheny By-Products Company of Glassport, Pa.

Arthur C. Merrill, until recently connected with the Bureau of Water, Department of Public Works of Philadelphia, Pa., in the capacity of district engineer, has accepted a position with the E. I. du Pont de Nemours and Company at Carneys Point, N. J., as assistant supervisor of production.

George B. Kaley, formerly employed by the Taylor-Wharton Iron and Steel Company, High Bridge, N. J., as chief draftsman, has become affiliated with the Ross Rifle Company of Quebec, Canada.

George W. Scott has become connected with the H. H. Franklin Manufacturing Company, Syracuse, N. Y., as plant engineer. He was, until recently, identified with the Faultless Rubber Company of Ashland, O., having had charge of the mechanical department.

NECROLOGY

FRANCIS WINTHROP SCARBOROUGH

Francis Winthrop Scarborough was born in Cincinnati, Ohio, on September 6, 1865. He received his preparatory education in the public schools of Cincinnati and graduated from the Rensselaer Polytechnic Institute in 1888. Soon after this, he entered the service of the Chesapeake and Ohio Railway Company as engineer, from which service he resigned in 1908. While with the railway he became Engineer of Bridges and Signals and at the time he resigned was Chief Engineer of Maintenance of Way and Structures. Immediately after his resignation he became actively engaged in the operation of coal mines in the New River region of the Chesapeake and Ohio Railway Company. Here he held the position of General Superintendent in charge of the operation and development of eight coal companies controlling 30,000 acres of coal land and shipping at that time over one million tons annually.

He was a member of the American Society of Civil Engineers, American Institute of Mining Engineers, American Society for Testing Materials, and American Railway Association. He became a member of the Society in 1905.

Mr. Scarborough died in New York City on December 24, 1915.

RAFAEL ESTRADA

Rafael Estrada was born in Havana, Cuba, on October 19, 1840. He received his early education in Cuba and later went to Lowell, Mass., where he was instructed privately. During 1855 and 1856 he served an apprenticeship in the machine shop of William Sellers & Company, of Philadelphia, and then resumed his studies in Cuba. In 1860 he entered the Southwark Foundry & Machine Company as an apprentice and rapidly rose to the position of erecting engineer, having charge of the erection and starting of sugar mills on several of the large plantations in Cuba and the Facala Refinery in Peru, S. A. In 1870 he became manager of the Grocers Sugar House in Philadelphia, and remained there until the house was closed in 1891. In 1892 he took charge of the sugar business of Bea Bellido & Company in Cuba, for whom he designed, completed and managed a molasses sugar house. From 1897 to 1904 he owned and operated zinc and lead mines in Joplin, Mo., but in 1904 he resumed his activities in the Cuban sugar industry, During this time he was active in the reconstruction and management of sugar mills on several large plantations and was retained as consulting engineer on several others.

Mr. Estrada became a member of this Society in 1904. He died at his home in Cuba on December 26, 1915.

WILLIAM H. DOANE

Dr. William H. Doane was born near Norwich, Conn., on February 3, 1832. He received his early education at Woodstock Academy in Connecticut, and later went to Cincinnati, where he took an active part in business and religious affairs. He was president of the J. A. Fay & Co., wood machinery makers, for many years, and when the firm was consolidated with the Egan Company he relinquished his connection with the enterprise. At the Paris Exposition in 1889, Dr. Doane was one of the three Americans to receive an award of honor. His exhibit of woodworking machinery was one of the features of the display in the French capital.

Dr. Doane's chief interest was music. He was granted the degree of Doctor of Music and wrote many compositions. His great interest in harmony caused him to take an extensive trip to many lands and in his world journey he collected marvelous groups of instruments. The collection aroused considerable interest among music lovers and Dr. Doane presented it to the Cincinnati Art Museum, where it is preserved.

He was elected to membership in the Society in 1885. He was President Emeritus of the American Baptist Publishing Company of Philadelphia, Trustee of Denison University, Granville, Ohio, and was affiliated with a number of religious societies.

He died at the home of his daughter in South Orange, N. J., on December 23, 1915.

LOCAL MEETINGS

IT is of the highest importance in the development of the monthly meetings of the Society, both of the Local Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

LOCAL SECTIONS

ATLANTA, NOVEMBER 22

On November 22, 1915, the Affiliated Technical Societies of Atlanta held a meeting at which Mr. Speller of the National Tube Works of McKeesport, Pa., gave a lecture on Steel Making from the Ore to the Finished Product. His lecture was illustrated with moving picture films showing the manufacture of the steel company's product.

J. E. Latta of the Underwriter's Laboratory of Chicago, Ill., presented moving picture illustrations of the testing work of the laboratory and gave a discussion of the pictures as they were shown.

MILWAUKEE, DECEMBER 15

At a meeting of the Milwaukee Section, held on December 15, W. B. Hanlon, Consulting Engineer, President of the Cleveland Engineering Society, gave an address of The Relationship That Should Exist Between the Engineers' Society and the Administration of Municipal Affairs. To illustrate his subject, Mr. Hanlon took as an example the Cleveland Engineering Society and cited some instances of its activities in matters of public policy.

At the late November election, three important ordinances relating respectively to the proposed New Union Station, which involved the exchange of city property with one of the railroad companies; four track freight subway extending across the city under East 55th Street, embracing a harbor terminal on the Lake front, and the Cleveland and Youngstown rapid transit terminal, which embraced the closing up of several streets and the establishment of a large freight terminal on the level with the city's principal warehouse and wholesale district, were submitted to a referendum vote of the membership of the society. About two weeks before the election a meeting was held at which each one of the projects was presented by the respective engineers and discussed, and afterwards a general discussion took place, with the result that on election day each ordinance was approved.

Another case was that in which a society in southern California requested the Cleveland Society to join it in recommending to the Government a change in the weather observation stations in that State. As the result of a request to the Government for information, an observer at the Cleveland Weather Station and another from the Washington Office of the U. S. Geological Survey presented papers at a meeting of the society giving data showing why the present location of the stations was of best value to the State.

As a further index of the society's connection with municipal affairs, shortly after the election of the present Mayor, a letter was addressed to him recommending that the departments handling engineering questions be headed by engineers.

In conclusion, Mr. Hanlon stated that the training of the engineer fits him naturally either for official or advisory services in the economical administration of the departments of a municipality, and it is not going beyond the confines of the requirements of public opinion to predict that soon all municipal activities will be placed under strict professional supervision.

ST. LOUIS, DECEMBER 18

The St. Louis Section of the Am.Soc.M.E. held a very successful fellowship dinner at the American Hotel Annex on December 18. The speaker of the evening was Paul Brown of the St. Louis *Republic*, who spoke on The Economic Development of the American Railway. At the close of Mr. Brown's remarks a roll call was held and each man stated briefly what work he is now engaged in, and several members gave interesting short talks. About forty members and guests were present.

BUFFALO, JANUARY 5

At a meeting of the Buffalo Engineering Society on January 5, Dr. John A. Mathews, Mem.Am.Soc.M.E., and president and general manager of the Halcomb Steel Company, of Syracuse, gave a talk on Iron in Antiquity and Today. He said that iron was probably in use some 5,000 years ago, and that Asia and India were probably the places where iron was first used.

From Belgium, he said, came the first steel rails and the first locomotive. The world owed much to the scientific advances made by the metallurgists of England. In America little attention had been paid to the scientific side; more time had been devoted here to mining and manufacture of iron and steel products.

Dr. Mathews called attention to the advances in the industry being made in China, Japan and India, in which countries evidently remarkable iron works are in operation. He said also that the introduction on the Pacific Coast of America of iron and steel products from Asia was a direct challenge to American industry.

Thos. E. Durban, chairman of the American Uniform Boiler Law Society, described the A.S.M.E. Boiler Code and urged the members present to use their influence to have the Code adopted by New York State.

BOSTON, JANUARY 14

At a meeting of the Boston Section of the Am.Soc.M.E. on January 14, Dr. Ira N. Hollis, Mem.Am.Soc.M.E., and president Worcester Polytechnic Institute, gave an address on Naval Lessons of the Great War for America, and gave an analysis of the elements that make up a fighting fleet, including the submarine and the aeroplane, the battleship, the armored cruiser, and the scout, and described methods of destroying them.

Dr. Hollis pointed not only to the necessity but also to the inevitableness of preparedness. He spoke in disfavor of prohibitive regulations in the Navy, considering that such were

not necessary except in the case of certain plans and devices that need to be kept secret. He also commented on the frequent failure to give publicity to naval matters with the proper accuracy, stating that this lack of care sets up an undesirable screen between the people and the Navy. He advocated coördination in the various Navy Departments, and also such education of enlisted men as would increase their morale and make them contented and valuable units in the service.

CHICAGO, JANUARY 14

At a meeting of the Chicago Section, January 14, P. A. Boeck, mechanical engineer of the Kieselguhr Company of America, presented a paper on High Temperature Insulation. H. M. Montgomery, Chairman of the Section, presided and introduced the speaker.

Mr. Boeck said that the problem of prevention of heat losses has been the subject of considerable investigation in certain industries, more especially in the applications of cold storage installations and of steam lines. He reviewed the mechanics of heat flow, the requirements of insulators, the amount of insulation necessary, and other phases.

He then described the insulating properties of Celite, a siliceous mineral occurring on the Pacific Coast in practically a pure state. It contains numerous hollow cells, and weighs in its natural rock-form, air-dried, from 25 to 30 lb. per cu. ft. When ground properly, it weighs 8 lb. per cu. ft., and has a thermal insulating power about equal to that of cork, or from 9 to 10 times that of ordinary firebrick; the ground material is called Sil-O-Cel powder. He concluded with examples of the use of this material.

A brief discussion, complimentary to the speaker, followed the presentation of the paper.

LOS ANGELES, JANUARY 18

About 30 members attended the meeting of the Los Angeles Section held on January 18. W. W. Smith reported on his trip to the Conference of Local Sections in New York, explaining to the members in a general way, certain proposed changes in the method of handling Society affairs.

The question of affiliation and coöperation with the local sections of similar organizations was very ably discussed by various members. It was further proposed to attempt the formation of an Engineers' Club in Los Angeles, this club taking in the various technical societies.

Following this discussion, F. W. Harris, Mem.Am.Soc.M.E., talked briefly on the subject of Patents, outlining the general theory and procedure in handling patent cases, and the general defects of the patent system which is in operation at the present time.

ST. LOUIS, JANUARY 19

A joint meeting open to all the Associated Engineering Societies was held at the Engineers' Club of St. Louis on January 19. Carl Barth, Mem.Am.Soc.M.E., spoke on Certain Phases of Scientific Management of Machine Shops. He paid tribute to the work of the late Dr. Frederick Taylor, and emphasized particularly the necessity of standardization of equipment before attempting so-called efficiency work in any of its branches. Attention was called to the possibilities of the application of mathematics to nearly all machine shop problems. Mr. Barth was for many years Dr. Taylor's principal assistant in the efficiency movement, and is one of the foremost experts on machine shop efficiency in this country. Previous to the meeting, an informal dinner was tendered Mr. Barth and his friend, Dr. Rover, at the West End Hotel.

STUDENT BRANCHES

CASE SCHOOL OF APPLIED SCIENCE

The December meeting of the Case School of Applied Science Student Branch was held on the fifteenth of the month. F. R. Hutchinson, of the East Ohio Gas Company, gave a paper on Gas for House Heating, which covered the cost and application of heating homes by gas. Figures showing the comparative costs of operation of the different systems used were presented, together with illustrations of the houses where the tests were performed, and the various forms of heating plants on which the figures were based.

The January meeting of the branch was held on the fifth. Following a supper, J. H. Stratton, Mem.Am.Soc.M.E., of the Wellman-Seaver-Morgan Co., gave an illustrated talk on Ore Unloading Machinery on the Great Lakes. Mr. Stratton reviewed the history of the ore business and gave statistics showing the increase in ore shipments from the start down to the present time, showing how the meager means of transportation in early times were soon replaced. From the horse and wagon, down to the Hulett unloader of to-day, the various appliances used were shown. Details of many types of grab-buckets were given, and their advantages and disadvantages summarized. The speaker then told of the many ways in which the late Alexander Brown had advanced the methods of ore unloading, and closed his talk with a short summary of the great transportation problems of the future.

COLORADO AGRICULTURAL COLLEGE

A meeting of the Colorado Agricultural College Student Branch was held on January 10, at which N. L. Chatfield, a travelling engineer connected with the Great Western Sugar Company, gave an interesting talk on the Manufacture of Sugar from the Mechanical Standpoint. In his discussion pieces of apparatus used and in many cases the construction of each were described, and a review of all the processes was given.

COLUMBIA UNIVERSITY

A meeting of the Student Branch of Columbia University was held on January 14, at which Neil MacCoull, Jr., gave a talk on Aeroplane Design. With the aid of a number of lantern slides, he showed the development of the modern type of aeronautical machine, and described the design of its various parts.

He said that in military uses the climbing speed is often of more importance than the horizontal speed. The depth of the wing determines the lifting power. In body design two factors are determining ones; wind resistance is a very important factor, and for military use the position of the guns and their angle of fire are of extreme importance. As to engine design, recent developments have shown that the stationary, water-cooled cylinder engine is the best for machines that are to make flights of more than about two hours.

LEHIGH UNIVERSITY

On December 15, the engineering societies of Lehigh held a joint meeting, at which R. S. Perry, president of the Alumni Association of the University, spoke on the Function of Engineering and Industrial Activities as Coefficients of Preparedness. He said that there is a vast difference between modern and earlier warfare. Men reared in the Navy and the Army, and who have trained themselves for war, had an idea of what modern war would be like, but their wildest imagination never reached what we are beginning to realize modern warfare is. Former wars were small affairs compared with the present. In our own Civil War the armies went into winter quarters, while now fighting is carried on through the winter. Former wars used only a fraction of the explosives which are used to-day. The food supply was heretofore obtained from entirely local sources. Through the present war there has been an abnormal drain on normal industries, and also on abnormal ones, such as industries making munitions. He then cited examples to show the effects of the European war on the industries of the great nations.

LELAND STANFORD UNIVERSITY

At a meeting of the Leland Stanford University Student Branch held on December 1, Horner Ling read a very interesting paper on Mechanical Railway Signals, in which he discussed the development of various types of railroad semaphore signalling devices, and described the signal practice of various railway companies and the form of signals which they use. He explained also the working of the block system used by the Southern Pacific Railroad, both for single and double track service.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At a meeting of the Student Branch of the Massachusetts Institute of Technology held on January 5, Clarence B. Sawyer, salesman for the Dodge Sales and Engineering Company, addressed the members on Rope Drive, laying special emphasis on the comparative merits of the American and English systems.

PENNSYLVANIA STATE COLLEGE

A meeting of the Student Branch of the Pennsylvania State College was held on January 13, at which the following officers were elected: G. Jeffery, president; O. L. Stevens, vice-president, and G. S. West, secretary.

POLYTECHNIC INSTITUTE OF BROOKLYN

The Student Branch of the Polytechnic Institute of Brooklyn held a very interesting and instructive meeting, at which a lecture was given by J. J. Ruckes, Jr., Mem.Am.Soc.M.E., on the Manufacture of Paper and Wood Pulp. The talk dealt with the production of medium quality paper such as is used for ordinary commercial work. The lecturer described the two principal methods of preparing the wood pulp and the most widely accepted process of turning it into paper.

The raw materials usually consist of poplar, spruce, or pine trees, while for some cheaper grades various straws and bamboos are used. Entering the pulp mills, the wood is cut into 2-ft. lengths, separated from the bark, and ground or crushed by chippers. The crushed wood is then screened to remove knots and slivers. The refuse and waste from these operations are used as fuel for the furnaces. There are two methods of preparing the pulp, the sulphite method utilizing sulphurous acid, and the soda process using caustic soda. The finished pulp is placed in a beater and mixed with the requisite coloring matter, sizing and clay. The latter is introduced to give the paper weight and good inking qualities. The pulp then passes through a refiner and screen to a Fourdrinier machine containing a wire cylinder over which the pulp plays. This separates much of the water. The layer of pulp issuing from this machine is next pressed and passed through dryers, which further reduce the moisture contents. The final operations consist of calendering and winding. It has been estimated that, in paper making, it requires, for the various operations, 56,000 gallons of water to prepare one ton of finished product.

The lecture was illustrated by slides and photographs, and samples of pulp and paper were exhibited.

PURDUE UNIVERSITY

A meeting of the Purdue University Student Branch was held on January 11. Thomas T. Eyre, Mem.Am.Soc.M.E. and head of the Engine and Boiler Department of the University, spoke on the Effects of Early Cut-off upon Wire Drawing in Steam Engines. Professor Eyre has arrived at the results he gave after much work, involving a great number of experiments. He illustrated his lecture by means of Zeuner and other valve diagrams, sample indicator cards, velocity curves, and different types of governors.

STATE UNIVERSITY OF KENTUCKY

At a meeting of the State University of Kentucky Student Branch on January 14, the report of the Chicago Association of Commerce Committee on Investigation of Smoke Abatement and Electrification of Railway Terminals was discussed. W. H. Dix, M. G. Horton, A. B. Huff, R. E. Hundley and Miss Margaret Ingels presented an outline of the report giving the reasons for making the investigation, the data secured, the results obtained as shown graphically, and the conclusions drawn from these factors. This report is especially interesting to the seniors, who make annually an inspection trip to Chicago and vicinity. The information given in it on the industrial and transportation conditions in Chicago, the problem of purifying the atmosphere and the solution of the Chicago transporation difficulties, are all of great interest in instructing them as to what to look for on the inspection trip.

UNIVERSITY OF MICHIGAN

The University of Michigan Student Branch held a "get-together" smoker on December 3, at which a concentrated effort was made to increase the membership of the branch. Prof. J. R. Allen and W. F. Verner, Members of the Am.Soc.M.E., each gave short talks on the benefits of membership in the Society and the advantages of meeting members of the mechanical engineering profession.

Commander J. H. Rowen, U. S. N. (retired), gave a paper in which he discussed a new kinetic theory of the relations of spectra to each other, and told of the work being done to discover waves connecting the light and heat spectra.

On December 17, H. H. Esselstyn, Mem.Am.Soc.M.E., and chief construction engineer for the Eastern Michigan Edison Co., gave a talk on Reminiscences of Engineering Work. Afterwards Mr. Esselstyn discussed, in answer to questions, some of the tentative plans for additions to the Connors Creek Plant of the Detroit Edison Company, including the installation of a 40,000 kw. Curtiss turbine.

UNIVERSITY OF MINNESOTA

The regular meeting of the University of Minnesota Student Branch was held on January 8, at which the following officers were elected: G. A. Ek, president; I. L. Johnson, corresponding secretary; C. Swenson, recording secretary, and C. I. Guggisberg, treasurer.

Prof. W. H. Kavanaugh, Mem.Am.Soc.M.E., and head of the experimental engineering department of the University, gave an address on the Annual Meeting of the Society, 1915.

UNIVERSITY OF MISSOURI

The regular meeting of the University of Missouri Student Branch was held on December 2. Prof. E. R. Hedrick, of the Mathematics Department of the University, spoke on Graphical Analysis. He discussed principally the straight line graph, particularly that plotted on logarithmic paper. He demonstrated the value of logarithmic paper for finding the correctness of assumed equations for empirical curves. He pointed out that it was easier to tell whether points lay on a straight line, when plotted on logarithmic paper, than whether they conform to a certain curve when plotted on common coördinates.

At a meeting of the branch on January 6, the subject of Different Types of Present Automobile Construction was discussed by F. Nelson Westcott, I. O. Royse, R. M. Lotz and Fred P. Hutchinson. The various types of motors, including the four- and six-cylinder, etc., and the Knight motor were discussed and compared. The new model Stanley steamer car was diagnosed and compared with former steam cars and with present gasoline cars with which it has to compete.

UNIVERSITY OF NEBRASKA

A meeting of the University of Nebraska Student Branch was held on December 7. Prof. C. L. Dean, Associate Professor of Mechanical Engineering of the University, gave a most interesting lecture on the Development of the Modern Locomotive.

Professor Dean said that because of the great field covered by this subject he could only touch the high spots, as any one phase might be worked up into a two or three-hour lecture. He first emphasized the increase in size, weight and speed of trains, necessitating larger and stronger engines, the engines themselves being increased in weight from 25,000 to 800,000 lb.; drawbar pull from 10,000 to 200,000 lb.; steam pressure from 125 to 320 lb. per sq. in., and having grate areas as large as 120 sq. ft. He then described devices for increasing efficiency, such as brick arches, superheaters, reheaters, feedwater heaters, mechanical stokers and valve gears.

He cited an example of a Mallet engine in which, with no superheater, 20 per cent of the steam was condensed in the

pipes before reaching the cylinder. Using a superheater placed in the path of the hot gases reduced the coal consumption 20 to 25 per cent without additional fuel, reduced the water consumption 25 to 35 per cent, increased the boiler pressure, reduced boiler maintenance, increased the boiler capacity without increasing the weight, and increased the hauling power 33 per cent.

WORCESTER POLYTECHNIC INSTITUTE

At a joint meeting of the Worcester Polytechnic Student Branch, the American Institute of Electrical Engineers, and the Civil Engineering Society, on January 10, 1916, Prof. George F. Swain, of the Harvard M. I. T. Engineering School, delivered an address on Water Power in the United States. In his introduction, Professor Swain spoke of the movement for the conservation of our natural resources, including forests, minerals, lands and water. The fact was brought out that the conservation of water power is really a triple one. Coal not used is not wasted, but, on the contrary, water power not utilized is lost; and by neglecting its use and allowing coal to replace it, we are wasting, it is estimated, over nineteen million horsepower a year which is economically capable of development. By placing dams and locks, we not only make the development of power possible and save a tremendous amount of coal, but we may also improve the navigation in a river. This possibility of wonderful conservation has not been as fully recognized in our country as in many countries of Europe, and our national laws and public sentiment are more prone at present to discourage than to encourage attempts to bring about a saving of this power, which would mean a decrease of three hundred million dollars in our annual coal bill. The disadvantages of very high initial investment and uncertainty of water power have caused many promoters and investors to place their interests in steam rather than in water power plants.

The speaker discussed the law of riparian rights, which states that every owner of land bounded by a stream has a right to the flow of the water past his land so long as he does not hinder this same privilege of the owner below him or pollute the stream. In cases in which the Government has built a dam for the improvement of navigation, the question has been raised whether the power developed belongs to the Government or to the parties whose land borders on the river above the dam. It is claimed by some that the Government owns the power, since it made the development of power possible, while others claim that the Government can lawfully use the water for navigation only, and that by the law of riparian rights, the power belongs to those through whose land the river flows.

The fact was brought out that in some instances when private parties have secured permits to build dams in rivers they have not only been required to light the dam, furnish land to the Government for canals, build locks and operate them, etc., but have been required to pay to the Government certain amounts of money for the privilege. In view of the fact that these dams improve the navigation of the river, it does not seem that the encouragement to conservation offered by the National Government is very overwhelming, and it is hoped that legislation will greatly improve the present conditions.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices now appear in the Employment Bulletin in a form which indicates the classificotion.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.

461 Engineer-Designer on multiple effect evaporators and equipment for chemical plants; man must be well recommended, of good character and exemplary habits, good appearance and address. Permanent connection at adequate salary. Location Middle West.

462 Young Engineer with one or two years shop experience for efficiency department in large corporation; technical graduate preferred but not absolutely essential; require man who is tactful in handling workmen and who has a well developed analytical mind. Location Western New York. Apply by letter, name confidential.

1 Electrical Engineer with good knowledge of physics, for experimental work in laboratory of large electrical manufacturing company in the East. Preferably a technical graduate. Salary $20 to $30 a week, depending on ability.

2 Young Mechanical Graduate, with one or two years experience in machine shop practice. Location New England.

4 Production Engineer for progressive power laundry in important city near New York. Ability to select the proper type of employee for a given task, and to develop and maintain to the maximum, individual and departmental efficiency; general mechanical and electrical training; practical experience in laundry production. Opportunity is afforded for lucrative and continuous employment with assurance of advancement.

5 Manager of Sales, to handle product in New England, the Eastern, Middle and Atlantic Coast and Southern States, for up-to-date cement plant equipped with the most modern type of machinery.

6 Detail Draftsmen, experienced, for an industrial concern. Men preferred who have had three to ten years experience in steel mills of smelter plants. Apply by letter.

7 Professor of electrical engineering of high grade technical capacity, experience in practice, teaching ability, vigor, personality. One of high standing among engineers and recognized as an authority. Location Middle West.

8 Assistant in purchasing department of concern handling purchases from $3,000,000 to $4,000,000 per annum; principal commodities, plates, shapes, bars and allied lines; coal, coke, pig iron and high and low pressure fittings. Man preferably between the age of 28 and 35, and one who has had rolling mill experience. Applicants must state age, nationality, whether married or single, by whom employed and over what periods. All references and communications will be treated confidentially. Location New Jersey.

9 Young Engineer between 22 and 24 for some designing and office work and part time on outside sales wanted by galvanizing concern. Location New York.

16 Young Technical Graduate for general sales office work such as estimating, data, correspondence and possibly publicity work, for turbine company in New England; salary about $1,000.

17 Engineer speaking fluently technical French and English wanted in iron and steel business; familiarity with manufacture of rails. Attractive salary to the right man. Eastern location.

20 Testing Engineer wanted, who is familiar with power plant conditions and is capable of assembling and installing recording meters and power plant instruments measuring flow of steam, water and gases. Young technical graduate with one to three years experience in machine shop and power plant work preferred. Location Maryland.

21 Foundry Superintendent. Energetic and aggressive man is desired to take charge of a non-union foundry located in the Central West, and pouring between 400 and 800 tons per month, on medium and heavy engine and blower work; favorable opening for a high-grade man. State experience and salary expected.

22 Task Setter, some experience in time study and drafting. Salary $75 to $100 a month. Location Maine.

23 Mechanical Engineer with factory experience, able to work out problems in mechanical handling of materials, and in installation of machinery generally. Location Cleveland.

25 Assistant Purchasing Engineer for the inspection of incoming materials for Massachusetts manufacturer of small electrical apparatus; applicants thoroughly familiar with electrical, insulating and composition casting materials, with practical knowledge of metal working machinery, etc. In reply, confine answer to the following: Age, nationality, education, practical experience, salary expected, when at liberty.

26 Business Associate Wanted; a young man of good business habits having $5000 to invest in a newly established business in which profits are perfectly satisfactory, but present resources inadequate to cover the whole country.

28 Production Engineer to take charge of department, operate it by present methods, and to develop it as fast as possible into an up-to-date planning department. Also time study man. State age, education, experience, salary expected, name references and send photograph.

29 Safety Engineer for Massachusetts factory employing 1500 hands; must be familiar with machine tool guards of all kinds and factory safety devices; one who has had theory and practice combined and able to design and standardize guards. Experience along electrical work preferred. Applicants requested to furnish in brief the following data: Age, nationality, experience, references, salary.

34 Steam Specialty Salesman, or others, who desire to handle a line of vacuum heating specialties on a commission basis, can secure restricted territory to represent manufacturers. Representatives wanted in Portland, Maine; Boston, Pittsburgh, Cincinnati, Detroit, Chicago, St. Louis, Milwaukee and other large cities. Apply through Society.

36 Partnership: a consulting engineer of New York, with practice in a special field which can be greatly extended, desires to take into partnership an engineer experienced in vibration causes in buildings, who can invest some money and with qualifications for conducting investigations in the fields of physics and applied mechanics. Apply by letter.

37 Cadet Engineers: recent graduates of technical schools, for work in connection with study of central station power house operation, in line of improving operation and methods. Salary starts at $40.00 per month and increases to a maximum of $75.00 per month. Further advance entirely a matter of personal ability to fit into the organization. Location New Jersey.

38 Mechanical Draftsman, capable and qualified in design of special heavy machine tools. Location Pennsylvania.

39 Young Engineer, competent and familiar with the practical use of pulverizing coal for fuel. Name and location confidential. Apply by letter.

41 Engineer familiar with operation and construction of chemical plants.

42 Salesman with technical education as mechanical engineer to become head salesman of heavy capacity automatic scales for factory and warehouse uses; man between 30 and 40; traveling position; one-third of time at factory in Middle West, two-thirds in field. Salary liberal. Apply by letter.

47 Young Technical Graduate, with one or two years experience, excellent opportunity to enter a machinery concern with view of learning the business. All replies held confidential. Location Rhode Island.

MEN AVAILABLE

The published notices of "men available" are made up only from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

B-43 Works Manager, 20 years experience in manufacturing firearms, typewriters, automobiles, power house equipment, etc., wishes to make a change. At present employed.

B-44 Chief Operating Engineer or Superintendent of Power with 14 years experience, good floor machinist and erecting man. Several years satisfactory service with each of last two employers as chief engineer. Experienced in steam, gas and Diesel engines, a.c. and d.c. current, air compressors and hydraulic machinery. Good organizer; at present employed. Location immaterial.

B-45 Plant Engineer, technical graduate, age 30, nine years experience as plant engineer on construction and repair of mill buildings and selection, layout, installation and maintenance of equipment in various lines, wishes position with manufacturer. At present employed.

B-46 Mechanical Engineer, Consulting Engineer and Executive, college graduate, owning valuable patents on poppet-valve engines (several engines in successful operation), would consider investment and connection with engineering, contracting or consulting firm, or to act as representative in New York, preferably where combination of engineering business and organization ability is demanded. English, German and French correspondent.

B-47 Mechanical Engineer and Superintendent. M.E. graduate, age 33, seven years experience with consulting engineer on the layout and purchase of complete mechanical equipments, including power plants, heating and ventilating systems, wiring, fire protection, conveyors, manufacturing apparatus, etc., for factory, office and mercantile buildings; last three and one half years in full charge of construction work, previous five years machine shop and drafting experience. Good executive ability and knows how to get results, desires position with corporation or engineering firm.

B-48 Sales Engineer, Manager or Superintendent. Worcester Polytechnic Institute graduate, M.E., age 36, thirteen years practical experience on pumping machinery, air compressors, internal combustion engines, pressure tanks, overhead tanks and towers, design of pumping combinations and managing contract sales; wide experience handling engineering correspondence. At present employed as executive in contracting concern but open to make new connection at once. Location preferred New York or vicinity.

B-49 Chief Draftsman or Assistant Chief Engineer. Mechanical and civil engineer, admitted to both degrees, twenty years experience in industrial works and waterfront engineering; drafting, designing and supervising construction work, desires position as chief draftsman or assistant to chief engineer.

B-50 Research or Mechanical Engineer. Graduate M.E., eighteen years experience, four years as field expert and superintendent of erection of steam engines in public service stations. Eight years as chief engineer, designing gas and steam engines, pumps, hoists and special machinery and conducting tests and thermodynamic investigations, also experienced in design of automatic machinery, desires a position as research or mechanical engineer. At present employed.

B-51 Manager, Chief Engineer or Sales Engineer. Engineering graduate, age 33, with broad experience in boiler manufacture and general plate work. Good organizer. Salary $3000.

B-52 Printing Press Expert and Designer, fifteen years experience, successful designer of automatic machinery for

paper goods, boxes of any description, paper bags, envelopes, corrugated board containers, folding boxes, lace, labels, tags, etc. Experienced executive and organizer, solicits correspondence with Pacific Coast concern, machine shop, publishing house or paper goods manufacturer with a view of introducing up-to-date methods, machinery and specialties. Salary to start $3000. Partnership considered.

B-53 Assistant Chief Engineer or Chief Designer. Graduate mechanical engineer, age 31, eight years designing experience in oil engines (Diesel oil engines, European and American practice), large variety of special and automatic machinery manufactured on the interchangeable basis, desires responsible position as assistant chief engineer or chief designer with reliable firm building Diesel oil engines, or concern contemplating building these prime movers. Salary $2000; at present employed.

B-54 Sales Engineer. Graduate mechanical engineer, age 35, competent to handle sales either by correspondence or personal interview and intimately acquainted with modern power plant practice, thirteen years experience handling sales of the following classes of equipment: pumping machinery of all classes, steam, power and centrifugal; condensing apparatus of all types; feed water heaters; internal combustion engines; steam engines and air compressors for all services. At present employed but open for engagement March 1. Location immaterial.

B-55 Executive for Automatic Machinery. Member, technical education together with ten years practical experience in manufacturing duplicate parts on the interchangeable basis, also familiar with design of tools, jigs, fixtures, etc., for this work, wishes to communicate with reliable firm desirous of securing the services of a live up-to-date executive, especially trained in handling difficult problems in all kinds of automatic machines and the die-casting of intricate parts.

B-56 Factory Manager, Engineer or Production Manager, age 37, sixteen years automobile and gas engine experience, practical manager and able executive, well acquainted with the trade, has worked through all departments of a manufacturing business and thoroughly understands all details, is open for a position.

B-57 Sales Manager or Manufacturers' Representative, ten years successful experience in sales engineering, graduate mechanical engineer, age 35, large industrial and engineering acquaintance in Eastern territory.

B-58 Technical Graduate, age 27, energetic and tactful, three years experience in machine shop, fifteen months drafting room designing power plants, two years testing and general operation in a large turbine station. Especially familiar with surface condensers. At present employed but wants to change.

B-59 Factory Manager, age 33, fourteen years experience in handling men and affairs, thoroughly trained in machine shop and foundry management and business affairs; for the past five years engaged in operating large gasoline engine factory in Middle West, desires to make a change.

B-60 Designer, Layout Draftsman, Mechanical Engineer, now in charge of drawing office in Boston, desires position as engineer or draftsman in East or Middle West. Salary $125-$150.

B-61 Munitions Manufacturing Expert. Graduate United States Naval Academy, age 33, married, with several years experience in engineering executive position with a Public Service Corporation, has lately designed large machine shop and heat treating department for the manufacture of large calibre, high explosive shells, at the same time served in a consulting capacity on power plant, construction work and factory organization for the same company. Knows where lathes, electrical and furnace equipment for large calibre shells may be purchased, as well as a suitable manufacturing plant with excellent rail and water shipping facilities.

B-62 Representative for the Far East. Japanese graduate of electrical and mechanical schools, connected with telephone and railway companies of New York, wishes to communicate with American firms planning to develop their business in Japan or China. Will consider agencies.

B63 Mechanical Engineer with shop, field, designing, sales, executive and business experience. Specialties, power plant, heating and ventilating, desires responsible position with a view to permanency.

B-64 Manufacturers' Representative, graduate of Massachusetts Institute of Technology, has a large experience in the selling of building materials and an extensive acquaintance with architects, engineers and contractors, wishes to represent as sales engineer in New England, with headquarters in Boston, manufacturing concerns specializing in material, either mechanical or electrical, connected with building operations.

B-65 Specialist in Steam Engineering and Power Plant Equipment, Associate member A.I.E.E., conversant in practical efficiency engineering methods, will consider one or two year contract in investigating, organizing or executive capacity. Available July 1, 1916.

B-66 Pulp or Paper Mill Engineer, with thorough experience in pulp and paper mill engineering, including developments, reports, designs, specifications and contracts for buildings, power requirements and manufacturing equipment, capable of assuming responsibility and control, desires position.

B-67 Manufacturing Engineer, six years manufacturing experience, at present employed, desires to locate in New York or vicinity.

B-68 Factory Maintenance, Assistant to Executive, or Purchasing. American graduate mechanical engineer desires position with an industrial concern in an executive capacity. Has handled men and had charge of power plant investigations, testing department and erection work; energetic and reliable. At present employed as chief inspector in large concern.

B-69 Factory Manager, Superintendent or Efficiency Manager, technical graduate, M.E., age 30, ten years experience in costs, statistics, production work, office and factory management, can refer to several successful concerns as to ability and results obtained as an organizer.

B-70 Executive, member with wide experience in industrial construction, as executive in responsible control of purchasing, organization, and operation of work in the field.

B-71 Assistant to Machine Designer or Consulting Engineer, mechanical engineer, experienced machine designer, thorough knowledge of patents, desires association with salary about $1200 per annum.

B-72 Assistant Foundry Superintendent of an iron foundry. Graduate mechanical and metallurgical engineer, having experience in all branches of foundry practice, including loam, dry and green sand molding, machines, the cupola, mixtures, etc. Location immaterial.

B-73 Assistant to Consulting Engineer. Cornell M.E., 1912, age 27, past three and one half years employed as mechanical engineer in an Eastern plant, has made plans for new buildings, machinery layouts and superintended installation of all mechanical and electrical apparatus. Location preferred New York.

B-74 Assistant to Consulting or Contracting Engineer, mechanical engineer, technical graduate, age 28, has had charge of responsible mechanical and electrical engineering work for consulting engineer, desires position along similar lines. Location preferred in or around Philadelphia.

B-75 Engineer and Executive, mechanical engineer, executive and representative ability, twenty-five years experience in general machinery and machine tools, desires position. Has been granted several patents.

B-76 Executive, graduate M.E., age 38, fifteen years engineering experience, of which nine was in the executive capacities of chief draftsman, chief engineer, assistant works manager, and works manager with two big corporations and operating spelter works, machine shop and ship yards. Has specialized in heavy hydraulic presses, Diesel oil engines, blast furnace gas engines, suction dredges and ships, metallurgy of steel, and electric furnaces, shop layouts and organization. Has traveled extensively, conversant with European and American business methods, speaks German, French, English, Spanish and Russian, desires position where broad theoretical and practical experience could be advantageously applied.

B-77 Assistant to Superintendent, Junior, graduate Massachusetts Institute of Technology, five years experience as assistant to the mechanical superintendent in a manufacturing plant having an up-to-date machine shop, thoroughly versed in tool and plant maintenance, desires position.

B-78 Executive and Production Engineer, age 34, married, technical man, last nine years engaged as executive and production engineer for large manufacturing concern, has reached limit of present position and desires to become associated with live concern which needs an executive capable of producing systematic results at maximum efficiency.

B-79 Assistant to Superintendent or Works Manager. Mechanical and electrical engineer, technical graduate, energetic and possessing knowledge of shop costs, wage systems and efficiency methods. Has worked in engineering department, drafting room and as practical machinist with large concern manufacturing refrigeration and electrical machinery, also chemical plant (pigment manufacture) experience, desires position as assistant to superintendent or works manager of a growing concern. Salary commensurate with position. Location preferred Middle West.

B-80 Iron, Steel and Coke Engineer. Member with twenty-five years practical experience in the manufacture of iron and steel, and eight years in the manufacture of by-product coke, invites correspondence or conference with parties desiring mature advice on the improvement or addition to plants; on efficiency, metallurgical or heat-treatment problems in iron and steel manufacture; on the arbitration of technical disputes between producers and consumers; on patent litigation, etc. Prefer to work in coöperation with engineering staff of companies, thus attaining maximum benefits at minimum expense.

B-81 Office Manager or Assistant to Manager, open for temporary engagement in connection with sales or purchasing; extensive experience in travelling for well known machine builders.

B-82 Executive, graduate engineer, age 35, thoroughly experienced in all methods of scientific management. Previous work has been in the manufacture of hoisting and conveying machinery, textiles and fine stationery. Competent to take responsible executive position.

B-83 Superintendent or Factory Manager, mechanical engineer, graduate of Massachusetts Institute of Technology, seventeen years experience in manufacture of water tube boilers, also tanks, stacks and kindred products. Has also had considerable to do with general correspondence, purchasing, accounting and cost keeping and can produce results that count.

B-84 Power Plant Superintendent. Graduate engineer, age 36, has had nine years power plant experience, capable of taking charge and running it (especially the boiler room), on an economical basis.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE AM. SOC. M. E.

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

Account of an Excursion for the Inspection of the Work of Agricultural Tractors on Private Estates in the South of Russia in 1912, A. B. Treiwass and A. A. Baranovski. In Russian. *St. Petersburg, 1913.* Gift of Russian Department of Agriculture.

Applicability of Motor-Driven Plows in Russia, A. A. Baranovski. In Russian. *1915.* Gift of Russian Department of Agriculture.

Book of Definitions and Standard Stock Parts for Use of Otis Elevator Company, John H. Buckley. *1915.* Gift of author.

Bureau of Farm Mechanics of the Russian Department of Agriculture. Proceedings, 1913, Tome V, pts. 6-8, 1914, Tome VI, pts. 1-6. *1914-15.* Gift of Russian Department of Agriculture.

Business Opportunities of Louisiana and Adjacent States, Geo. B. Davis. *New Orleans, 1915.* Gift of Ford, Bacon and Davis.

The Conservation of Energy. A Plea for the language of experiment in the teaching of physics, W. S. Franklin and Barry Macnutt. Reprint from Bulletin of the Society for the Promotion of Engineering Education, vol. VI, no. 3, 1915. Gift of C. W. Rice.

Columbia University. Department of Physics. Four lectures on Mathematics, delivered in 1911, by J. Hadamard. Publication no. 5.

——— Eight Lectures on Theoretical Physics delivered in 1909, by Max Planck. Publication no. 3. *New York, 1915.* Gift of Department of Physics, Columbia University.

Economic Advantages Resulting from Port Development. Geo. B. Davis. *New Orleans, 1915.* Gift of Ford, Bacon and Davis.

The Government and Business, S. O. Dunn. Gift of Bureau of Railway Economics.

History of The American Society of Mechanical Engineers from 1880-1915, F. R. Hutton. *New York, 1915.* Gift.

Illinois Society of Engineers and Surveyors. Twenty-seventh Annual Report, 1912. *Wheaton, 1912.* Gift of Society.

The Imperial Valley and the Salton Sink, H. T. Cory, with introductory monograph, by W. P. Blake. *San Francisco, J. J. Newbegin, 1915.* Gift of H. T. Cory.

This is an account of irrigation and river control in the Colorado River delta, a reprint of a paper read before the American Society of Civil Engineers in January 1913, to which certain supplementary matter has been added. W. P. C.

Indiana Engineering Society. Proceedings of the 34th and 35th Annual Convention. *Indianapolis, 1914, 1915.* Gift of Society.

Indiana Sanitary and Water Supply Association. Proceedings of the 6th-8th Annual Convention. *1913-15.* Gift of Association.

Marine and Stationary Diesel Engines, A. H. Goldingham. *New York, Spon & Chamberlain, 1915.* Gift of publishers.

There has been need for a handbook of the Diesel engine, as the literature on the subject has never been properly summarized. The present work is essentially a practical one, concise, and well illustrated. W. P. C.

Master Car and Locomotive Painters' Association. Proceedings of 46th Annual Convention. *Reading, Mass. 1915.* Gift of Association.

The Menace to National Prosperity. An Address by Newman Erb. Gift of Bureau of Railway Economics.

Motion Models; their use in the transference of experience and the presentation of comparative results in educational methods, Frank B. and Lillian M. Gilbreth. Paper presented before American Association for the Advancement of Science, Dec. 27, 1915. Gift of authors.

Motor Culture of Land, Collection of Articles. In Russian, *1913*. Gift of Russian Department of Agriculture.

Motor Tractors and Plows at the IV International Automobile Exposition in St. Petersburg, A. A. Baranovski. In Russian. *St. Petersburg, 1913*. Gift of Russian Department of Agriculture.

Motor Tractors for Transportation of Heavy Loads and Motor Plows, and on Tractors and Farm Automobiles. In Russian, from German. *St. Petersburg, 1912*. Gift of Russian Department of Agriculture.

National Association of State Universities in the United States of America. Transactions and Proceedings. vol. 13, 1915. Gift of Association.

National Commercial Gas Association. Proceedings of the Tenth Annual Convention. *New York, 1914*. Gift of Association.

The Need of Educated Men in Industrial Affairs. Lecture at Cambridge University, May 15, 1911, Frank H. Taylor. Gift of author.

New Orleans Sewerage and Water Board. Twenty-ninth semi-annual report, 1914. Gift of Sewerage and Water Board.

New York State Engineer and Surveyor. Annual Report 1914, vol. I. *Albany, 1915*. Gift of State Engineer and Surveyor.

Pavement Guaranties, Their Use and Abuse, J. W. Howard. *Newark, 1907*. Gift of author.

Paving Brick the Necessity of Uniform Quality. Tests for high grade paving bricks, J. W. Howard. *New York, 1913*. Gift of author.

Permanent Tariff Commission. "A National Business Policy." Referendum of Commercial Organizations, 715 votes for 9 votes against. Gift of U. S. Chamber of Commerce.

Portland Cement, Concrete Pavements, Causes of Failures and Possible Basic Defects, J. W. Howard. Gift of author.

Portland Cement, Concrete Roads from a Quarter Century Practical Experience, J. W. Howard. *New York*. Gift of author.

Principles and Practice of Cost Accounting, Frederick H. Baugh. *Baltimore, published by author, 1915*. Gift of author.

This is a treatise on cost accounting as applied to manufactured articles, and treats of the basic principles, and their application in a general manner. W. P. C.

Prohibition Movement, Percy Andreae. *Chicago, 1915*. Gift of author.

Programs and Methods of Testing Agricultural Machines and Implements, Book I-III. In Russian. *St. Petersburg, 1911, 1912, 1914*. Gift of Russian Department of Agriculture.

Psychrometric Tables for Cooling Tower Work. Steam Tables for Condenser Work, ed. 3. (1 vol.) *Carteret, N. J.* Gift of Wheeler Condenser and Engineering Co.

Railway Motor Cars, List of References, Prepared by the Bureau of Railway Economics, Nov. 30, 1915. Gift of Bureau.

Relation of the Railroad and Its Securities to Land Values, Fairfax Harrison. Gift of Bureau of Railway Economics.

Safety in the Foundry, Magnus W. Alexander. *Chicago National Founders' Association, 1915*. Gift of publisher.

The Committee on Safety and Sanitation of the National Founders' Association have carried out investigations for two years, and this book, written by the Chairman of that Committee, is the result. It is profusely illustrated. W. P. C.

The Second Law of Thermodynamics, W. S. Franklin and Barry Macnutt. Reprint from Bulletin of the Society for the Promotion of Engineering Education, vol. VI, no. 3, 1915. Gift of C. W. Rice.

Some Trade Schools in Europe, Frank L. Glynn. U. S. Bureau of Education, Bulletin no. 23. *Washington, 1914*. Gift of F. L. Glynn.

Street Paving and Maintenance in European Cities. A report by Henry Welles Durham. Dec. 31, 1913. *New York, 1913*. Gift of President of the Borough of Manhattan.

Structure and Properties of the More Common Materials of Construction, G. B. Upton. *New York, John Wiley & Sons, 1916*. Gift of publishers. Price $2.50 net.

The work is restricted almost entirely to the theoretical discussion of the subject. It is an outgrowth of lectures given at Cornell University to laboratory students. W. P. C.

Testing of the Comnick Motor Plow, A. B. Treiwass. In Russian. *1915*. Gift of Russian Department of Agriculture.

The Testing of the Hart-Parr Tractor, I. B. A. Lintvareff. In Russian. *1915*. Gift of Russian Department of Agriculture.

The Testing of the Holt Caterpillar Tractor, B. A. Lintvareff. In Russian. *St. Petersburg, 1914*. Gift of Russian Department of Agriculture.

Tests of Tractors at the Sredne Rogatski Farm of the Bureau of Farm Mechanics, N. Morozoff. In Russian. Gift of Russian Department of Agriculture.

Traveling Engineers' Association. Proceedings of the 23d Annual Convention, 1915. *Buffalo*. Gift of Association.

Treatise on Safety Engineering as Applied to Scaffolds. Hartford, 1915. Gift of Travelers' Insurance Company.

U. S. Army. The Service of Information. *Washington, 1915*. Gift of U. S. Army.

U. S. Interstate Commerce Commission. Fourth Annual Report of the Chief Inspector of Locomotive Boilers, 1915. *Washington, 1915*. Gift of U. S. Interstate Commerce Commission.

U. S. Lighthouses Commissioner. Annual Report, 1915. *Washington, 1915*. Gift of U. S. Lighthouse Board.

What is the Matter With Railway Regulation, S. O. Dunn. Reprinted from North American Review, Nov. 1915. Gift of Bureau of Railway Economics.

EXCHANGES

National Association of Cotton Manufacturers. Transactions, no. 98, *Boston, 1915*.

North East Coast Institution of Engineers and Shipbuilders Transactions, vol. XXXI. *Newcastle-upon-Tyne, 1915*.

U. S. Naval Observatory. Annual Report, 1915. *Washington, 1915*.

The W-PVT Chart, Merl R. Wolfard and Charles K. Carpenter, *New York, John Wiley and Sons, 1915*. Gift of publisher. Price 50 cents.

This chart contains several novel features. The area beneath an exponential curve has been integrated by the use of a suitable plotted scale so that the external work done on or by any gas may be read directly from the chart for any ratio of expansion or between any desired pressure limits. The external work done by the Rankine Cycle in a steam engine or by any similar cycle can be obtained directly in foot pounds. The chart can be used directly no matter in what units of pressure, temperature, or volume a problem may be stated. The chart is separated into two quadrants by the use of a heavy diagonal line only, so that the PV quadrant is brought into close juxtaposition with the TV quadrant, which enables one to determine the pressure, temperature, and volume relations throughout any gas engine or air compressor cycle. Brief instructions are given for the use of the chart and several examples taken from actual engineering practice are given illustrating the methods of using the chart which, by the way, may be used for obtaining the cube, cube root and the 3/2 or 5/2 power or root of any number. It is plotted on logarithmic ordinate paper which was engine divided to a 10 in. base. G.

TRADE CATALOGUES

Champion Rivet Company, *Cleveland, O.* Addenda to scientific facts. *1916*.

Electric Storage Battery Co., *Philadelphia, Pa.* Bulletin 151. The "Exide," "Hycap-Exide," "Thin-Exide" batteries for industrial trucks and tractors. *Dec. 1915*.

——— 152. The "Exide" batteries for electric pleasure and commercial vehicles. *Nov. 1915*.

Flannery Bolt Co., *Pittsburgh, Pa.* Staybolts. *Dec. 1915*.

Stephens-Adamson Mfg. Co., *Aurora, Ill.* Labor Saver. *Dec. 1915*.

Texas Company, *New York, N. Y.* Lubrication. *Dec. 1915*.

Under-Feed Stoker Co., *Chicago, Ill.* Publicity Magazine. *Dec. 1915, Jan. 1916*.

Valley Iron Works Co., *Appleton, Wis.* The Beater. *Dec. 1915*.

Walworth Mfg. Co., *Boston, Mass.* Walworth Log. *Dec. 1915.*

Waterloo Cement Machinery Corporation, *Waterloo, Iowa.* Wonder Paver. 7 pp.

Wemlinger Co., Inc., *New York, N. Y.* Wemeo specifications for making concrete floors. Report upon "National Frost-proofing."

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

American Scenic & Historic Preservation Society. Twentieth Annual Report, 1915. *Albany, 1915.* Gift of George F. Kunz.

Auskunftsbuch für die Chemische Industrie, H. Blücher, ed. 9. *Leipzig, 1915.*

Bau der Dampfturbinen, Alfred Musil. *Leipzig, 1904.*

Callendar Steam Tables, H. L. Callendar. *New York, 1915.*

Andrew Carnegie. An anniversary address delivered before the Carnegie Institute of Technology, Nov. 24, 1915 by Henry S. Pritchett. *Cleveland, 1915.* Gift of William Howard Brett.

Century of Inventions of the Marquis of Worcester, Charles F. Partington. *London, 1825.*

Die Chemische Industrie, Gustav Müller. *Leipzig, 1909.*

Concrete Stone Manufacture, Harvey Whipple. *Detroit, 1915.*

Copper Deposits of the Eastern Townships of the Province of Quebec, Report. *Quebec, 1915.*

Dartmouth College. Catalogue 1915-16. *Hanover, N. H., 1915.* Gift of Dartmouth College.

Deutschen Buchdrucker-Berufs-Genossenschaft. Geschäfts Bericht 1914. *Frankfurt am Main, 1914.* Gift of Deutschen Buchrucker Berufs-Genossenschaft.

Directory of Directors in the City of New York, 1915-16. *New York, 1915-16.*

District Heating, S. M. Bushnell and F. B. Orr. *New York, 1915.*

Dynamometers, F. J. Jervis-Smith. *New York, 1915.*

Economics of Contracting, D. J. Hauer. Vol. II. *Chicago, 1915.*

Elasticity and Resistance of the Materials of Engineering, Wm. H. Burr. ed. 7. *New York, 1915.*

Electric Elevators, Their Construction and Operation. Elmer G. Henderson. *Chicago, 1915.*

Electroplating, W. R. Barclay and C. H. Hainsworth. *London, 1912.*

Elevators, John H. Jallings. *Chicago, 1915.*

Engineer Field Manual, Parts I-VI. ed. 4. Professional papers of the Corps of Engineers, U. S. Army, no. 29. *Washington, 1912.*

Engineering Index. 1915. *New York, 1915.*

Estimating the Cost of Work, William B. Ferguson. *New York, 1915.*

Factory Power and Costs, Joseph G. Branch. *Chicago, 1914.*

Field Service Regulations, United States Army, 1914. *Washington, 1914.*

Ford Methods and the Ford Shops, H. L. Arnold and F. L. Faurote. *New York, 1915.*

History of Money in America, Alexander Del Mar. *New York, 1899.*

International Acetylene Association. Seventeenth Annual Report. *New York, 1915.* Gift of Association.

International Exposition, St. Louis, 1904. Official Catalogue of the Exhibition of the German Empire. Gift of Edward Caldwell.

International Railroad Master Blacksmiths' Association. Proceedings of the 23d Annual Convention, 1915. Gift of Association.

Iowa. Board of Railroad Commissioners. Thirty-fifth Annual Report, 1912. *Des Moines, 1912.* Gift of Commissioners.

Ironmonger Diary, 1916. *London, 1916.*

Irrigation Practice and Engineering. Vol. II—Conveyance of water, B. Etcheverry. *New York, 1915.*

Jahres Bericht über die Leistungen der Chemischen Technologie für das Jahr 1914, pts. 1-2. *Leipzig, 1915.*

Koninklijk Instituut van Ingenieurs. Jaarboekje. 1916. *'s-Gravenhage, 1916.*

Life of Henry Bell, Edward Morris. *London, 1844.*

Der Luftkrieg, 1914-15. *Leipzig, 1915.* Gift of Leon Goldmerstein.

McGraw Waterworks Directory, 1915. *New York, 1915.*

Mechanical Engineers' Pocket-book. William Kent. ed. 9. *New York, 1915.*

Michigan Engineer. Containing the Proceedings of the Michigan Engineering Society, 1915. *Ann Arbor, 1915.* Gift of Michigan Engineering Society.

Micrometers, Slide Gauges and Calipers, Their Constructions and Use, A. W. Marshall and Geo. Gentry. ed. 2. *London.*

Military Railways, Major W. D. Connor. Professional Papers, no. 32, Corps of Engineers, U. S. Army. *Washington, 1910.*

Die Moderne Vorkalkulation in Maschinenfabriken, M. Siegerist und M. F. Bork. *Berlin, 1915.*

Moody's Manual. Complete list of securities maturing Jan. 1, 1916-Dec. 31, 1917. Arranged chronologically. Vol. I. *New York, 1915.* Gift of Moody Manual Co.

Motoren. Göpel und Windmotoren, Wasserräder und Turbinen, Verbrennungsmotoren. Uhland's Handbuch für den praktischen Maschinenkonstrukteur, V. Band. *Berlin.*

Motorluftschiff Studiengesellschaft M. B. H. Jahrbuch 1908-10. *Berlin.*

Müllerei und Mühlenbau, Friedrich Kettenbach. Vols. 1-2. *Leipzig.*

National Highways Association. Literature and maps of the Association. 1915. Gift of Association.

New Geographical Survey of the United States and the World, Based on the Latest Official Data. *New York, 1915.*

New Jersey Interstate Bridge Commission. Report, 1st-4th. 1909-1913. *Union Hill, 1913.* Gift of New Jersey Interstate Bridge & Tunnel Commission.

——— Zone Map Showing Counties, Cities and Towns within the Metropolitan District of New York. Gift of New Jersey Interstate Bridge & Tunnel Commission.

New York Interstate Bridge Commission. 2d-6th. Report. 1909-1914. *Albany, 1909-14.* Gift of New York State Bridge & Tunnel Commission.

Der Oelmotor. I. Jahrgang, 1912-13. *Wien, 1913.*

Practical Electro-plating, W. L. D. Bedell. ed. 3. *1912.*

Problems Pertaining to Steel Tubes When Used as Liquid Conductors. A treatise by O. G. Wellton. Part I. *Lund, 1915.*

Public Utilities Reports. Annotated. 1915, E. *Rochester, 1915.*

Reminiscences of Captain James B. Eads of Jetties Fame, Edmond Souchon. Read before Louisiana Historical Society, May 19, 1915. Gift of Wm. Beer.

Rockefeller Foundation. Annual Report, 1913-14. *New York.* Gift of Rockefeller Foundation.

Specifications Covering the Construction at Crossings of Overhead Lines of Public Utilities. Prepared by a Joint Committee representing the different classes of utilities in interest and recommended to The Public Service Commission of the Commonwealth of Pennsylvania for adoption. *Philadelphia, 1915.* Gift of Paul Spencer.

Standard Specifications for Hydrated Lime Adopted in 1915 by the American Society for Testing Materials, "Pamphlet H," October, 1915. Gift of National Lime Manufacturers' Association, Hydrated Lime Bureau.

Steel Construction, Henry J. Burt. *Chicago, 1914.*

Smoke Abatement and Electrification of Railway Terminals in Chicago. Report of the Chicago Association of Commerce Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals. *Chicago, 1915.* Gift of Chicago Association of Commerce.

Technique of Modern Tactics, P. S. Bond and M. J. McDonough. ed. 2. *Menasha, 1915.*

Telephone Appraisal Practice, J. C. Slippy. *Pittsburgh, 1915.*

Thayer School of Civil Engineering. Dartmouth College. Annual for 1915. *Hanover, N. H., 1915.* Gift of Dartmouth College.

Theoretical Elements of Electrical Engineering, C. P. Steinmetz. ed. 4. *New York, 1915.*

Theory of Structures, Charles M. Spofford, ed. 2. *New York, 1915.*

Thomas' Register of American Manufacturers. ed. 7. 1915. *New York, 1915.*

Tramway Track Construction and Maintenance, R. B. Holt. *London, 1915.*

Treatise on the Theory of Alternating Currents, A. Russell, vol. 1. ed. 2. *Cambridge, 1914.*

Van Nostrand's Monthly Record of Scientific Literature. Vols. 7-9; 16-21; 25-30; 31, nos. 1, 3, 6-7, 9, 11; 32, no. 9, 10, 12. *New York, 1878-81; 1887-93; 1897-1911.* Gift of Edward Caldwell.

Ventilation for Dwellings, Rural Schools and Stables, F. H. King. *Madison, Wis., 1908.*

Watch and Clock Makers' Handbook, F. J. Britten. ed. 11. *London-New York, 1915.*

Waterproofing Concrete with Hydrated Lime. "Pamphlet F." 1915. Gift of National Lime Manufacturers Association, Hydrated Lime Bureau.

Welding and Cutting Metals by the Oxyacetylene Process, a text book. *Minneapolis.*

Wireless Time Signals. Issued by the Paris Bureau of Longitudes. *London-New York, 1915.*

GIFT OF NATIONAL CHILD LABOR COMMITTEE

Annual Conference (10th). Federal Child Labor Bill. Child Labor Bulletin, Feb. 1914.

Child Labor and the Republic. Proceedings of the 3d Annual Meeting. *New York, 1907.*

Child Workers of the Nation. Proceedings of 5th Annual Conference. *New York, 1909.*

Clinker and Some Other Children. *1914.*

GIFT OF ERNEST L. JONES

Aero, v. 1, no. 1-2, 4-19, 21-32, *1909;* v. 2, nos. 33-43, 45-54, 56-57, *1910;* v. 3, nos. 61, 67-68, 70, 73-77, 79, 83-84, *1910;* v. 4, nos. 85-89, 91-93, 95-96, *1911;* v. 5, nos. 97-105, *1911;* v. 6, nos. 106-117, *1912;* v. 7, nos. 118-122, *1913.*

Aeronautical journal, v. 11, nos. 41, 43-44, *1907;* v. 12, nos. 45, 47-48, *1908;* v. 13, nos. 51-52, *1909;* v. 14, nos. 53-56, *1910;* v. 15, nos. 57-60, *1911;* v. 16, nos. 61-64, *1912;* v. 17, nos. 66-68, *1913;* v. 18, nos. 69, 71-72, *1914;* v. 19, no. 74, *1915.*

Aeroplane, v. 2, nos. 35-44, 46-54, 56, *1912;* v. 3, nos. 2-4, 6-7, 10-11, 13-23, 25-26, *1912;* v. 4, nos. 1-7, 9-26; *1913;* v. 5, nos. 1-2, 4-9, 11-16, 18-22, 24-26, *1913;* v. 6, nos. 1, 3-6, 8-12, 14-22, 24-26, *1914;* v. 7, nos. 1-10, 12, 15-17, 19, 23-26, *1914;* v. 8, nos. 4-5, *1915.*

Aircraft, v. 5, no. 11, *1915.*

Automobilia, Jan., May-Dec., *1908;* Jan., Mar., May, Oct.-Dec., *1909.*

Avia, nos. 5-6, 8-9, 11-17, *1913;* nos. 1-8, 11-15, *1914.*

Deutsche zeitschrift für Luftschiffahrt, v. 14, nos. 1-26, *1910;* v. 15, nos. 1-6, 8-17, 19-26, *1911.*

Deutsche Luftfahrer zeitschrift, v. 16, nos. 1-2, 4-6, 8-22, 24-25, *1912;* v. 17, nos. 1-8, 10-20, 22-26, *1913;* v. 18, nos. 1-6, 8-15, *1914.*

Encyclopédie de l'aviation, v. 1, nos. 1-9, *1909;* v. 2, nos. 10-19, *1910;* v. 3, nos. 20-24, *1911.*

Flight, new series, v. 1, nos. 1-14, 16-35, 38-52, *1909;* v. 2, nos. 53-65, 67-79, 81, 84, 87-88, 90, 93-105, *1910;* v. 3, nos. 106-137, 139-154, 156-157, *1911;* v. 4, nos. 158, 160-171, 173-183, 185-195, 197, 207, 209, *1912;* v. 5, nos. 210-214, 217-261, *1913;* v. 6, nos. 262-290, 300, 304-311, 313, *1914;* v. 7, nos. 314-329, 331-334, 336-352, *1915.*

Flug-u. Motor-technik, v. 3, nos. 20-32, *1909;* v. 4, nos. 1-7, 9-24, *1910.*

Flugsport, v. 1, nos. 14-22, 24-26, *1909;* v. 2, nos. 1-7, 9-20, 22-24, *1910;* v. 3, nos. 1-9, 11-27, *1911;* v. 4, nos. 1-15, 17-24, 26, *1912;* v. 5, nos. 1-4, 6-26, *1913;* v. 6, nos. 1-6, 9-26, *1914;* v. 7, nos. 2-11, 13-18, *1915.*

Illustrierte aeronautische mitteilungen, v. 10, no. 12, *1906;* v. 11, nos. 5, 7-12, *1907;* v. 12, nos. 1-8, 12-26, *1908;* v. 13, nos. 1, 3-15, 17-26, *1909.*

L'aéro-mécanique, v. 1, nos. 1-6, 8-11, *1908;* v. 2, nos. 1-10, *1909;* v. 3, nos. 1-2, 5-9; *1910;* v. 4, nos. 1-5, 7, 10, 12, *1911;* v. 5, no. 3, *1912.*

L'Aero-revue, v. 1, nos. 6-12, *1907;* v. 2, nos. 1-6, *1908.*

L'aeronautique, v. 6, nos. 22-24, *1907;* v. 7, nos. 25-26, 28-29, *1908;* v. 9, no. 1, *1911;* v. 10, nos. 4-5, *1912.*

L'Aerophile, v. 13, nos. 3, *1905;* v. 14, no. 5, *1906;* v. 15, nos. 8, 12, *1907;* v. 16, nos. 1-2, 4-24, *1908;* v. 17, nos. 1-16, 18, 20-24, *1909;* v. 18 and v. 19 complete, *1911,* v. 20, nos. 1-11, 13-17, 19-24, *1912;* v. 21, nos. 1-2, 4-8, 10-12, *1913;* v. 22, nos. 3, 11, 13-15, *1914;* v. 23, nos. 7-8, 11-14, *1915.*

L'Aérostation, v. 4, nos. 10-12, *1907;* v. 5, nos. 15-17, *1908;* v. 6, nos. 18, 20-21, *1909;* v. 7, nos. 22-25, *1910;* v. 8, nos. 26-27, 29, *1911;* v. 9, nos. 30-34, *1912;* v. 10, nos. 35-37, *1913;* v. 11, nos. 38-39, *1914.*

L'Aviation illustrée, v. 1, nos. 6-18, 20-37, *1909;* v. 2, nos. 38-41, 43-52, 56, 58, 61-64, *1910.*

La Conquête de l'Air, v. 10, nos. 2, 4-21, 23-24, *1913;* v. 11, nos. 1-14, *1914.*

La Ligue Nationale Aérienne, v. 1, nos. 1-2, 4-10, *1909.*

La revue aérienne, v. 3, nos. 30-52, *1910;* v. 4, nos. 54-76, *1911;* v. 5, nos. 78-100; *1912;* v. 6, nos. 102-114, *1913;* v. 7, nos. 138-139, *1914.*

La revue aéronautique et automobile, v. 2, nos. 14-15, *1913;* v. 3, nos. 4-13, *1914.*

La Revue de l'Aviation, v. 2, nos. 5-11, 13, *1907;* v. 3, nos. 17-18, 20-25, *1909;* v. 4, nos. 26-36, 38-47, *1910.*

La technique aéronautique, v. 5, nos. 38-48, *1911;* v. 6, nos. 49-63, 65-68, 70-71, *1912;* v. 7, nos. 73-84, *1913;* v. 8, nos. 86-94, 96, *1913;* v. 9, nos. 97-108, *1914;* v. 10, nos. 109-112, *1914.*

De Luchtvaart, v. 4, nos. 13, 19-24, 26, *1912;* v. 5, nos. 1-7, 9-11, *1913.*

Die Luftflotte, v. 3, nos. 4-7, *1911;* v. 4, nos. 1-12, *1912;* v. 5, nos. 1-4, 7-11, *1913;* v. 6, nos. 1-12, *1914.*

Mitteleuropäischen Motorwagen-Verein Zeitschrift, v. 10, nos. 1, 8, 11, *1911;* v. 11, no. 8, *1912.*

Osterreichnische flug-zeitschrift, v. 5, nos. 1-17, 19, 21-24, *1911;* v. 6, nos. 1-22, 24, *1912;* v. 7, nos. 1-16, 18-21, 23-24, *1913;* v. 8, nos. 1-9, 11-15, 17, 24, *1914;* v. 9, nos. 5-8, 13-16, *1915.*

Rendiconti degli studi ed esperienze, v. 1, no 1, *1911;* v. 2, nos. 2-4, *1912;* v. 3, nos. 7-8, *1913;* v. 4, nos. 10-12, *1914.*

Répertoire de l'Aéronautique, nos. 1-4, *1911;* nos. 5-8, 10-13, *1912;* nos. 15-23, *1913;* nos. 24-27, *1914.*

Revista de locomocion aérea, v. 1, nos. 2, 4-5, *1909.*

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Zeitschrift für Flugtechnik und Motorluftschiffahrt, v. 1, nos. 1-2, 5, 17-21, 23, *1910;* v. 2, nos. 1-6, 8-24, *1911;* v. 3, nos. 1-22, 24, *1912;* v. 5, no. 2, *1914.*

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ENGINEERING SURVEY

At the beginning of the present war there used to occur considerable delays in the delivery of foreign periodicals to the library of the Engineering Societies, due, as explained at the time, partly to the disorganization of the ocean mail service and partly to irregularities in the issue of periodicals themselves. Then for a time foreign periodicals, not excepting German and Austrian ones, used to come with a fair regularity. Of late, however, there has begun to occur again great delays, so that some of the important periodicals, especially from the Central Empires, practically stopped coming. Attention is called to this fact to explain the comparatively small number of articles reported from periodicals in the German language.

This Month's Articles

An illustrated abstract of an article on the utilization of exhaust heat from internal combustion engines is given, of interest because it refers to methods of utilizing this exhaust heat in prime movers.

In the section Machine Shop Processes is given an abstract on an article on the production of die-pressed castings. Other abstracts refer to the manufacture of brass cartridge cases.

The Machine Tool section deals mainly with machinery for shell manufacture, a subject to which particular attention is paid in Canadian trade papers. Two abstracts of properties of materials are given. One on the recrystallization of cold worked brass on annealing, of particular interest because of the insight which the experiments described give on these variations in the structural constitution of brass. The article on the rusting of iron and steel describes interesting experiments which may help to make clear the still uncertain processes which take place when iron and its alloys "rust."

In the section Mechanics are reported several articles to which particular attention is called. F. L. Fairbanks, in a paper on the lubrication of bearings and cylinders, discusses some of his experiences in the design of bearings, cylinders, and pistons, expressing rather novel views on what actually occurs between two surfaces in friction with one another supposedly protected by a film of oil. A mathematical article on the bending of a shaft having two bearings is reported from a French paper, while in another article is discussed the problem of the centrifugal action as it affects helical springs.

In the section on Power Generation and Transmission is reported a suggestion made by Dugald Clerk concerning a turbine driven by gas through a hydraulic medium, and the question of comparative costs of compressed air and electricity in mine stop haulages is discussed, as well as that of the comparative merits of geared turbine and turbo-electric means for marine propulsion. In the last of these abstracts is given a formula for a power constant by which the performance of gears may be compared.

In the section Steam Engineering are abstracted two articles, one on the discovery of leaks in surface condensers by chemical and electrical means, and the other on the design and use of steam engines with very high back pressures up to and perhaps over 60 lb.

In this article, by the way, the author calls attention to the unfortunate practice, still adhered to in many cases, of letting the consulting engineer design the power plant and then connecting up in a "traditional" way the appliances using live and exhaust steam in the various manufacturing processes carried in the plant. He shows further how much better results can be obtained when the entire plant is treated, as it ought to be, as a unit, and the power end designed with a clear understanding of what the exhaust steam is to be used for.

In the same article the matter of waste cylinder condensation, with special reference to engines working with high back pressures, is discussed in detail.

The question of pipe couplings with special reference to their use on gas line is taken up in an article abstracted from the *Natural Gas Journal.* Among other things is described a new type of a pipe coupling in which the outer flange is entirely done away with, and the ring is arranged in such way that it cannot bend between the bolts.

A plant in Brooklyn, N. Y., is described, where the entire feed water for the boilers and water for bathing and washing purposes is treated by the Permutit process. The installation is of interest especially because a capacity of about 500 cu. ft. takes care of 60,000 gallons per day of very hard well water, and only about 2000 gallons of brine (common unrefined salt) is used to treat it.

From a German publication is abstracted a paper on economic methods of packing metal shavings. The day is not far away when a lathe hand used to be proud of getting a shaving of record-breaking length. Now the problem is how to make it as short as possible, and the paper describes a number of ways, some apparently of proven practicability, of achieving this result.

The question of railway electrification as a solution of the smoke problem in Chicago is referred to in the last abstract. It is noteworthy in this connection that after a very thorough investigation, including an examination of a recent Diesel engine locomotive in Switzerland, no type has been found that could, even at a higher cost of operation, take the place of the

SUBJECTS OF ARTICLES

Utilization of Exhaust Heat from Diesel Engines in Turbines.
Brass Cartridges for 18 Pdr. Shells.
Brass Cartridge Cases.
Die-Pressed Castings.
Herbingbone Gear Hobbing Machine.
Tools and Devices for Shell Making.
Cutting-off Machine for Shell Work.
Expanding Chuck.
Waving and Band Cutting Fixture.
Nosing Presses.
Mechanical Plug Wrench.
Painting Machine.
Recrystallization of Cold Worked Brass.
Rusting of Iron and Steel.
Bending of a Shaft with Two Bearings.
Lubrication of Bearings and Cylinders.
Equations of Plotted Curves.
Helical Springs Under Centrifugal Action.
Gas-Water Turbine.
Farm Engines.
Geared Turbine.
Power Constant of Gears.
High Pressure Exhaust Steam.
Leaks in Surface Condensers.
Pipe Couplings.
Permutit Water Softening.
Packing Metal Shavings.
Smoke and Railway Electrification in Chicago.

steam locomotive in work as heavy as that in the Chicago terminal zone.

Internal Combustion Engineering

Utilization of Exhaust Heat from Internal Combustion Engines, W. Gentsch

The problem of utilization of the exhaust heat from internal combustion engines has become of importance especially in connection with the introduction of Diesel engines for ship propulsion. It must be also remembered that in many cases a mixed Diesel engine and steam propulsion has been found advisable. Thus Thornycroft, on torpedo boat destroyers, have found it convenient to drive both screws by Diesel engines during maneuvering with about 1200 h.p., while in straight runs 15,000 h.p. are supplied to the shafts by steam turbines.

It is fairly clear that the exhaust gases cannot well be directly utilized in a turbine, since the driving medium possesses low specific gravity and comparatively low velocity, in addition to which, because of its low initial pressure, the velocity of the exhaust gases varies only very little.

An arrangement proposed by A. Burdin and M. Mutel is shown in Fig. 1 A and B. An explosion engine with rotary cylinders, and a turbine in series with it, rotate about a rigidly held shaft, and the exhaust valves of the cylinder are arranged in such a manner that the exhaust gases are discharged after each two revolutions of the cylinder during the period of ½ of one revolution. The purpose of this arrangement is that during the slow run of the pistons the exhaust gases still possess a sufficient power of expansion to drive the turbine directly, without the use of a superheater or similar device. The arrangement is shown in detail in the figure. Each of the working cylinders E rotating about the axis B is provided with an exhaust passage m governed by a valve M. In a disc C rotating together with the cylinder is provided a passage m', which forms the continuation of the passage m. The turbine P is provided with blades a only over one half of its circumference. Since the engine works on the four stroke cycle, the exhaust gases from each cylinder can flow to the blades a only during one half of one revolution. The valves A are governed by the toothed wheel N. On the two opposite points of the disc C are rotatably located two other geared wheels N' and N'', each of which has twice as many teeth as the wheel N with which they are in engagement, so that when the working cylinder makes two revolutions, they make one revolution. The two wheels N' and N'' have a roller n which during one quarter of a revolution of the geared wheels N and N'' (that is during one half of a revolution of the rotating working cylinder) acts on the guide N' of a guiding frame, lifts it and thereby opens the exhaust valve M connected with it. The roller n operates in such a manner that the exhaust valves are alternately opened during one half of one revolution of the working cylinder, and during each complete revolution of the latter these exhaust gases are once directed towards the turbine blades a.

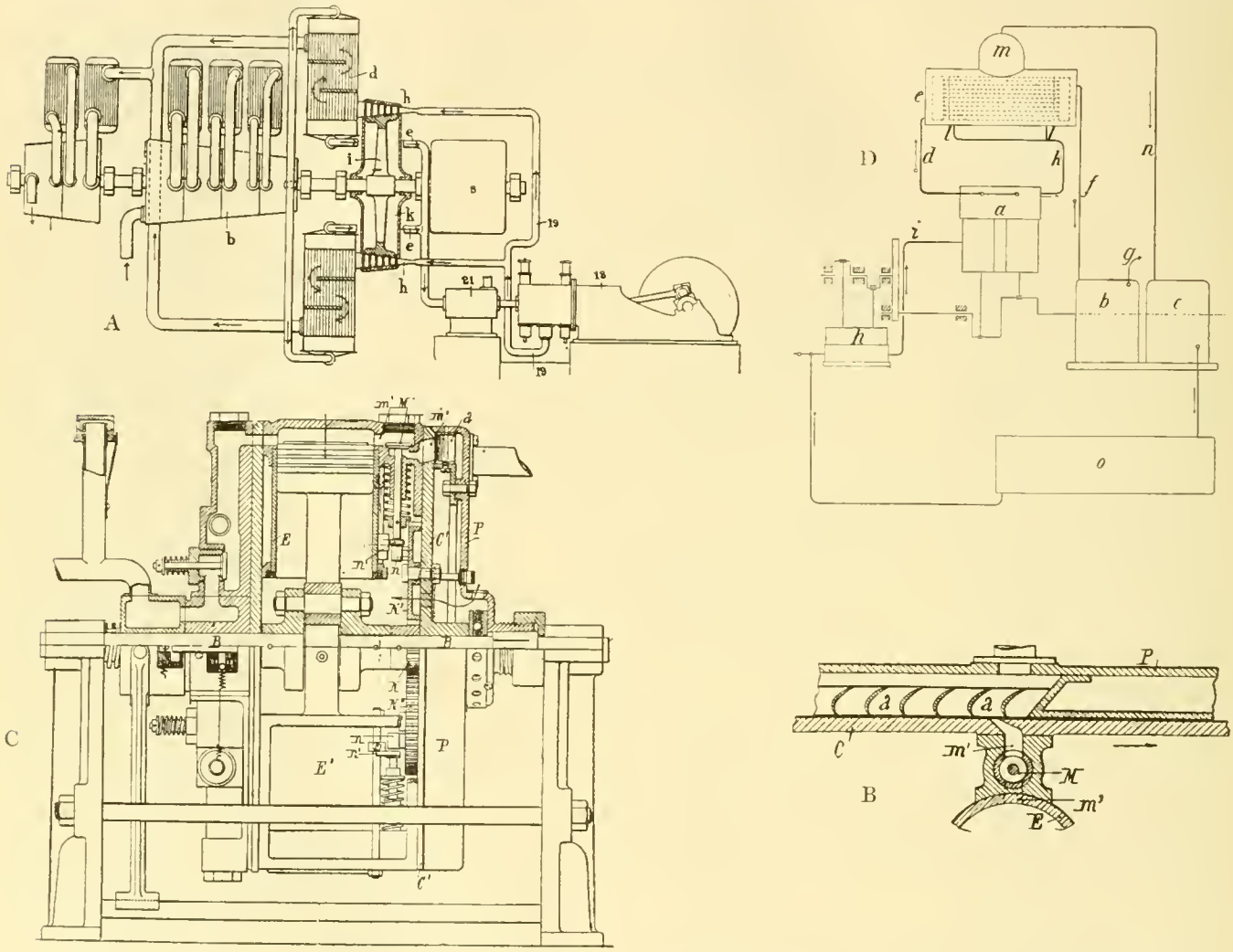


Fig. 1 Apparatus for Utilizing Exhaust Heat from Internal Combustion Engines in Prime Movers

In the design proposed by H. Grünewald (Fig. C), stationary cylinders working on the four stroke cycle are used, the shaft of which rotates a ring *a* provided with curved parts. This ring, in its turn, operates the cocks *v* through which fresh mixture is delivered by suction into the cylinder and the exhaust gas is liberated during the last stroke. During this delivery of the exhaust gas the fresh mixture which still remains in the cocks is ignited so that the gases still having a certain amount of energy are delivered into the running wheel of the turbine.

It is, of course, entirely feasible to utilize both the waste heat of the cooling jacket and the heat from the exhaust gases, and this may be done separately, so as to have both sources of waste heat connected, so to speak, in parallel. Fig. D shows diagramatically such an arrangement proposed by C. H. J. Stuart, in which the heat carriers, steam from the cooling water and gases work separately in the turbines, but previous to the delivery of the work there occurs between them an exchange of heat. The reciprocating engine *a*, the gas turbine *b*, and the steam turbine *c* work on the same shaft. The exhaust gases from the reciprocating engine *a* go through piping *d* into the heater *e* and from there through pipe *f* into the turbine *b*, from which they finally exhaust through pipe *g*. The pump *h* through pipe *i* delivers water into the cooling jacket of the reciprocating engine, which this water leaves, partly mixed with steam and material heated up, through pipe *k* and from there enters in the form of a spray the heater *e* through nozzles *l*. Here a complete vaporization of this water takes place, accompanied by a cooling down of the exhaust gases, this occurring in such a manner that the superheated steam flows through pipe *n* to turbine *c*. The exhaust of the latter goes to the condenser *o* out of which the pump *h* delivers it as water of condensation back to the cooling jacket. These three sets of machinery may be distributed between ship shafts in such a manner that the middle shaft is driven by the reciprocating engines while the two turbines drive the side shafts. This arrangement has the advantage that each working medium operates under conditions most suitable for it, but its disadvantage lies in the complicated arrangement which materialy increases the prime cost as compared with the gain in heat efficiency. (*Über die Verwertung der Abwärme von Verbrennungsmaschinen in Turbinen*, Wilhelm Gentsch, *Zeitschrift für das gesamte Turbinenwesen*, vol. 12, no. 33 and 34, pp. 385 and 397, November 30 and December 10, 1915, 8 pp., 14 figs. *d.*)

Machine Shop Processes

Manufacturing Brass Cartridge Cases for 18 Lb. Shells

When the problem of producing brass cartridge cases first came before Canadian manufacturers, one of the chief drawbacks to immediate output was the inability to secure the necessary equipment. The existing machinery of plants had to be adapted to the purpose, with eminent success in some cases, one of which is described here.

The work of producing brass cartridge cases for 18 lb. shells is characterized by some interesting drawing operations which with the annealing processes constitute the greater part of the work, especially in view of the fact that the metal from which these cases are made has to conform to close physical specifications after being worked and the finished case has also to pass a rigid inspection and answer to very exacting requirements. The article describes the processes of cupping, annealing the shells, first and second redrawing operations, first indenting, third and fourth redrawing and second indenting, fifth redraw and preliminary trimming, final trimming, heading the cases, annealing and tapering, machining the headed end, and inspection at the various stages of manufacture. The interesting feature of the manufacture described is that it is done not on special tools but with the usual equipment of a well-found machine shop. (*Canadian Machinery*, vol. 14, no. 27, p. 595, December 30, 1915, 6 pp., 17 figs. *dp.*)

Making Cartridge Cases on Bulldozers and Planers, Douglas T. Hamilton

The manufacture of cartridge cases on bulldozers and planers is described in detail step by step. A very interesting table is also given covering such data as the character of each operation, the sizes, type of machine used, type and temperature of furnace used, bath, scleroscope reading, and production per hour. The description and sizes refer mainly to the 18 lb. British cartridge case, but would be of equal interest for articles of approximately the same sizes with suitable modifications in the dies. (*Machinery*, New York, vol. 22, no. 5, p. 386, January 1916, 5 pp., 13 figs.)

The Production of Die-Pressed Castings, Edward K. Hammond

The production of die-pressed castings is a comparatively recent method of manufacture. Until recently, the production of many machine parts was limited practically to one of two methods: either turning the pieces from bar stock, or casting them in sand molds. The disadvantage of the former method lies in the large proportion of the material that is converted into scrap, while castings produced in sand molds are apt to be defective from several causes. The method of making die-pressed castings gives castings which can be brought extremely close to the required dimensions of the part with a smooth surface and uniform structure of the metal, and still be free from such defects as blow holes, pin holes, etc. Brass, bronze, copper, aluminum, nickel and other metals lend themselves to this treatment.

The article describes in considerable detail the dies used for this method and gives many suggestions in regard to the design of the dies, such as methods for determining the unit pressure which the die will be called to resist. It discusses also the design of dies made in halves for the case where the metal is completely enclosed.

Tungsten steel is the material best adapted to the requirements of making dies for pressing hot metal, but on account of its cost the expedient has been adopted of making the inner part of the die of tungsten steel and shrinking one or more machine steel collars around it to give it the required strength.

The type of power press used for applying pressure to the dies is further discussed. The author particularly recommends the "percussion" type of power press for use in the manufacture of die-pressed castings and describes certain types used in Germany and recently introduced into this country. The importance of performing pressing operations at a suitable speed is emphasized.

In this connection the author calls attention to the interesting fact that the lead of the driving screw does not govern the force of the blow which is delivered by the ram. By reducing the lead of the screw the speed of the ram and the value of its kinetic energy are correspondingly reduced, but this loss of power is offset by the fact that the screw of more gradual lead has a greater mechanical driving power. In practice the presses are designed to take advantage of the maximum mechanical driving power which can be obtained from the screw, and so the lead is made as small as possible, the limiting con-

dition being that point where the inclination of the thread is so gradual that the screw will tend to bind in the nut.

The raw materials of the industry are further discussed and a shop equipped for making die-pressed castings is described. (*Machinery*, New York, vol. 22, no. 5, p. 363, January 1916, 8 pp., 16 figs. *d.*)

Machine Tools

The Largest Herringbone Gear Hobbing Machine, E. K. H.

Description of a special machine designed and built by the Falk Co. of Milwaukee, Wisconsin, for generating herringbone gears of the Wuest type.

For a description of the Wuest type see Transactions, Volume 33, page 681. The machine is equipped with two hubs carried by heads located at opposite sides of the table on which the work is mounted. (*Machinery*, vol. 22, no. 5, p. 396, January 1916, 3 pp., 7 fig. *d.*)

Typical Tools and Devices from Canadian Shell Shops

The Canadian Pacific Railroad Angus Shops have developed a method for milling the back ends of the shell forging on a vertical milling machine by means of a special fixture not fully described. It requires about two minutes to complete one base and the operation is practically continuous as finished shells can be removed and rough ones put in place while the machine is running.

The Montreal Locomotive Co. is using a planer for facing off the bases of 4.5 shells. A heavy forging having a series of V's or notches cut in it is clamped to the planer bed. The shells are placed in the V's, three shells to each, and are gaged for length by having the noses "butt" against the bar fastened to the inside edge of the forging. They are then securely clamped by a heavy bar extending along the top. In machining the bases the side-head with vertical feed is used.

The Toronto Structural Steel Works use an interesting design of centering jig. It consists of an upright arbor fastened to a block which slides in V's formed on the table of the drill press. A bushing shaped to conform to the rough bore of the forging near the base slides on the arbor and is maintained in position near the top by means of a spring resting upon a shoulder formed by the lower part of the arbor. There is also provided another bushing which is made a sliding fit for the lower part of the arbor and is also held in its highest position by means of a spring. This bushing is made with a suitable taper so as to rest half way into the open end of the forging. When the rough forging is placed over the arbor it centers itself on the two bushings which compresses the springs until the weight of the forging is taken by two stop pins. The centering proper is done by a combination drill and center.

A number of expanding mandrels have been devised for shell manufacture. The Canadian Ingersoll-Rand Co. uses on an engine lathe a mandrel operated by air. A hollow arbor has a tapered shank to fit the lathe spindle. A plug screwed into the end of the arbor acts as a locating stop. Two sets of jaws are operated by means of a hollow sleeve and shaft. These sets of jaws are operated by a small air cylinder placed on the end of the lathe. When the air is turned on, the piston is forced back in conjunction with the shaft and sleeve. The tapered portions on the end of these engage with the taper jaws, forcing them out against the wall of the shell. E. T. Spidy has designed a mandrel to average up the hole, to take care of cases when a long hole is not perfectly straight. (*Canadian Machinery*, vol. 14, no. 27, p. 650, December 30, 1915, 5 pp. *d.*)

New Machines and Appliances Evolved by Canadian Firms

Description of new machines and appliances evolved in Canada mainly in connection with the manufacture of shells.

John H. Hall & Sons have redesigned their cutting-off machines so as to adapt them to shrapnel and high explosive shell work. The bed of the machine is heavily constructed and to it is bolted the head stock. The spindle rests in ample bearings, the whole being entirely inclosed by a cast iron cover. The cut-off slide is provided with two tools working in opposite directions, and power feed. Longitudinal travel of the tool slide is obtained by means of a screw and star wheel located at the end of the machine.

The Hamilton Gear and Machine Co. have also redesigned their cutting-off machine. An annular chuck with automatic jaws grips the shell body leaving both ends exposed. Two tool slides are provided, one on each side of the chuck, the slide at the back carrying a tool which removes excess metal from the shell base, while the front slide carries a cutting-off tool which trims the shell to correct length.

The R. McDougall Co. makes an expanding chuck with the hand wheel fitted to a rod which extends through the hollow lathe spindle. Two sets of three jaws expand and tighten against the shell, which is pushed on the chuck until the end of the lathe which acts as a stop, comes in contact with the bottom of the shell. The jaws are caused to expand by two tapered lengths of the central spindle of the chuck. First, a stiff spiral spring which acts as a means of adjustment, is placed between the two tapered portions. As the small pair of jaws is designed to seize just before the larger, the spring allows the tapered portion of the spindle to continue to tighten the larger jaws. Flat steel springs withdraw the jaws from the work when the hand wheel is turned.

John Bertram & Sons Co. have designed a waving and hand-cutting fixture which may be attached to any style of lathe. A triple faced cam is attached to the face chuck holding the shell. The tool holders are bolted to the ways of the lathe, the front holder supporting the waving tools and the rear holder the under cutting tools, cams imparting an oscillating motion and giving a wave to the ribs. A stop in the center of the fixtures regulates the depth of cut for all the tools.

Two new nosing presses have been put on the market, one by the Brown-Boggs Co., a standard gear straight side press with a heavy nosing die attached to the end of the ram, and the other by the Canadian Locomotive Company, who found a way to convert their banding press into a nosing press simply by inserting a steel plug in the center of the machine. This plug is provided with a shank which extends down and rests on top of the piston from whence it gets its motion. The nosing die is held in a fixture mounted on the center of the machine. The shell is placed on the plug and moved upward, the nose coming in contact with the die which forms it to the desired shape.

A machine of novel design is the mechanical plug wrench developed by the Holden-Morgan Co. for screwing home the plugs in the bases of the shells. The bed of the machine is a hollow iron casting supporting two spindle bearings and a table for the vise. A large spur gear is keyed to the end of the spindle and is driven by a pinion on the clutch shaft placed at the side of the bed. The chuck on the spindle is made to take the square end of the base plug.

The Canadian Locomotive Company has also designed an

interesting type of painting machine in the shape of a huge drum on the top of which is mounted a circular table resting on five rollers, three of which are made of laminated leather and impart a revolving motion to the table. Mounted around the outer edge of the table of the machine are sixty hinged bolts. The brass sockets which are screwed into the shell nose are then slipped over the bolts, nose down. A bracket to carry the paint can be slipped over the central stationary spindle of the machine and can be moved around to any desired position. The operator swings the shell inward upon the hinged bolts and this causes the beveled surface of the brass casting in the shell nose to come in contact with the large central revolving disk. The shell is thus rotated and the paint applied with great ease. Steam coils are placed in the center of the machine which permits the shell to be dried very quickly. (*Canadian Machinery,* vol. 14, no. 27, p. 641, December 30, 1915, 3 pp. *d.*)

Materials of Construction

Recrystallization of Cold-Worked Alpha Brass on Annealing, C. H. Mathewson and Arthur Phillips

The paper is devoted to a limited report of some tests on the mechanical properties and micro-structure due to annealing under uniform conditions of certain types of commercial rolled brass. Since these experiments were conducted with the active coöperation of the Bridgeport Brass Co., involving free use of its product, and have thus furnished information which is characteristic of some of its special mixtures, the author does not consider justifiable the full publication of the numerical relationships and comparative results encountered. The present paper reports, therefore, only some of the general features of the work done, especially the characteristics of recrystallization as related to the degree of hardening by strain and the ordinary annealing variables.

The paper reports fully the results obtained by the French engineer, Grard, in 1909, as well as the experiments of Bengough and Hudson in 1910. It also describes the various methods used in the present tests.

The author states that the precise nature of the changes which take place in worked metal as a result of exposure to very moderate temperatures or even spontaneously is not understood. Any attempt to study these changes with the aid of the microscope is certain to fail because the accompanying structural alterations are too minute or too indefinite to be followed. Since no alteration of structure can be associated with these effects they must be of a mechanical nature (Heyn) or must be due to some reorganization of the particles which does not suffice to change the etching characteristics of the metal.

As reported in the paper, the investigation covered, in the first place, the determination of the time required at a number of different temperatures between 225 deg. cent. and 325 deg. cent. to produce a drop of three points in scleroscopic hardness in the case of 70/30 brass which has received a 40 per cent reduction by rolling after a dead soft anneal in the mill. The author calls attention to the fact that from a practical standpoint, if we are to speak of a critical temperature at which softening will begin in any particular mixture that has been given a stated reduction by cold working, certain qualifications have to be considered. Any set of curves giving the physical properties of a commercial mixture having anneal for a fixed period of time following a given reduction by cold working, requires that a stated period of anneal be rigidly adhered to within the critical range of incipient effects, in order that the results of the test may be properly duplicated. At high temperatures approximate equilibrium values are reached in comparatively brief periods of time. Thus in the case of cartridge brass (70/30 + 3) which has received a heavy reduction, at all temperatures above 325 deg. cent., variation of the annealing period between ½ hour and 1 hour will not bring about any material change in properties.

As regards the earlier stages of recrystallization in material which has received a high degree of reduction by cold work, microscopic examination under high power is necessary as the first visible elements of recrystallization are extremely minute. The intergranular secondary construction due to deformation consists in the main of groups of curved or wavy lines which possess the same general direction in each grain or homogeneous portion of a twinned grain and increase in number and prominence with the degree of reduction. It appears that in the squeezing of the grains between the rolls, the most destructive movements affecting the integrity and homogeneity of the grain-substance have occurred chiefly along the gliding planes which in any grain are nearest at right angles to the direction of elongation. The author calls them lines of deformation.

In a recrystallized structure free from mechanical alteration each homogeneous member or grain shows its individuality on etching by reason of its directional properties which determine selective etching with boundary distinction or selective reflection with contrasting effects. When the grains are strained beyond the limit of elasticity their temperature range of existence without visible change of form is restricted, and on heating to a high enough temperature they appear to disintegrate into smaller grains. An increase in surface energy due to "spontaneous" disintegration must have developed as a result of the strain, that is, in the form of inner surfaces between blocks or groups of the grain substance, but this mechanical dislocation of the grain substance is not indicated in any way by etching except in cases of severe strain. We cannot see the inner surfaces, all we can do is to speculate as to their nature; in fact, a sample of brass which has been heated to 750 deg. so as to develop a coarse grain and then strained so as to show numerous slip bands on the polished surface gave little or no evidence of recrystallization after annealing at approximately 600 deg.

On the whole, after a heavy reduction of metal by rolling, recrystallization begins in the more severely strained areas at low temperature the exact values of which in any case depend upon the degree of reduction and time of exposure. As the temperature of anneal increases under otherwise uniform conditions, additional etch bands break down or granulate, the existing recrystallization units coalesce and grow and at no very elevated temperature the entire pre-existing grain structure becomes replaced by a secondary refined structure.

A few special experiments were made for the purpose of revealing the characteristics of recrystallization in metal which has received very light reduction. From the standpoint of potential recrystallization the chief distinction between metal which has received a heavy reduction and metal which has received a light reduction lies in the vast difference between the number of inner surfaces which have developed in the two cases. These inner surfaces cannot remain permanently in existence under changing conditions and as the temperature is raised they give way to more stable configurations in accordance with equilibrium requirements which take into account their number, character and distribution along with the other variables encountered. Two neighboring particles with separate surface boundaries will tend to flow together under the

influence of forces which operate to reduce the surface area and surface energy to a minimum.

This tendency is opposed by forces which bring about a certain degree of rigidity of the grain-substance or determine directional properties which each particle tends to retain. In this way there tends to be established a condition of equilibrium beyond which further decrease of surface area is effectively opposed by the forces in question. This form of equilibrium renders the size of particles of a number of inner surfaces chiefly a function of the temperature. In order that reorganiaztion within the grain-substance may proceed at a low temperature, there must be a high order of development of inner surfaces, but where the metal has received a light reduction there are no inner surfaces of this order and the first units to recrystallize will be comparatively large.

As to the principal relations between deformational treatment and structural characteristics after anneal, the author states that no direct indication of the size or shape of the ultimate secondary units can be obtained and as far as direct observation goes these new structural elements are latent only. In order that the annealing effect may be felt at the given temperature, the mechanical destruction of the original grain must have been sufficiently pronounced to produce fragments inferior in size to the recrystallized grain characteristic of this temperature. In general the grain fragments produced by deformational processes will vary widely in size, so that certain of them will be able to coalesce below the given temperature, while others will remain unaffected, the particular factors which apply in any given deformational process will combine to determine a curve of fragmental resolution of grains for this particular process in which the cumulative percentage of fragments below a given size appears as a function of the size of the fragments.

As the degree of deformation increases through mechanical working, the curve of fragmental resolution recedes in the direction of maximum resolution, a specific condition for each metal or alloy beyond which further destruction of grain will bring about fracture. There is for each metal or alloy a minimum temperature at which recrystallization will start from a condition of maximum resolution into fragments of minimum size. On the other hand, in metal which has received very light deformational treatment, the curve of fragmental resolution assumes a form in which the percentage of coarse fragments will very likely exceed the percentage of fine fragments. It must be borne in mind, however, that the curves of fragmental resolution are purely hypothetical. The precise form of any curve will be determined by the nature and intensity of the deformation sustained by the metal.

The paper contains an interesting discussion of the structural changes developed in 70/30 cartridge brass by uniform anneal at six different temperatures within the range 350 to 800 deg. cent. after reductions of 2, 4, 8, 12, 15 and 25 per cent respectively. The characteristics of rolled structures are illustrated by photomicrographs. (*Bulletin of the American Institute of Mining Engineers,* no. 109, p. 1, January 1916, 50 pp., 4 figs and 11 plates. *etA.*)

Rusting of Iron and Steel. James Scott

Discussion of the subject of rusting of iron and steel based on observations made on iron fixed so that the surface rust can develop undisturbed.

Invisible globules of moisture falling upon iron react with the particles in their vicinity. Should several of these globules run together they form a small pool in which the specks of rust are so deposited that when all parts are dry there is an elevation inside the crater resembling a minute exhausted volcano. (Fig. 2.) When iron oxidizes, it increases in bulk so that it becomes capable of forcing any covering off. Particles of rust may emerge from invisible cracks in an apparent protective coating. The continuous spreading of the rust causes the paint to peal away, giving rise to the opinion that this latter substance is at fault. Actually iron expands and contracts according to temperature, and unless the paint which covers it has the same elasticity it will split at various points and thereby enable the globules of steam to settle down on the granules of the metal; if neglected the final result will be disastrous.

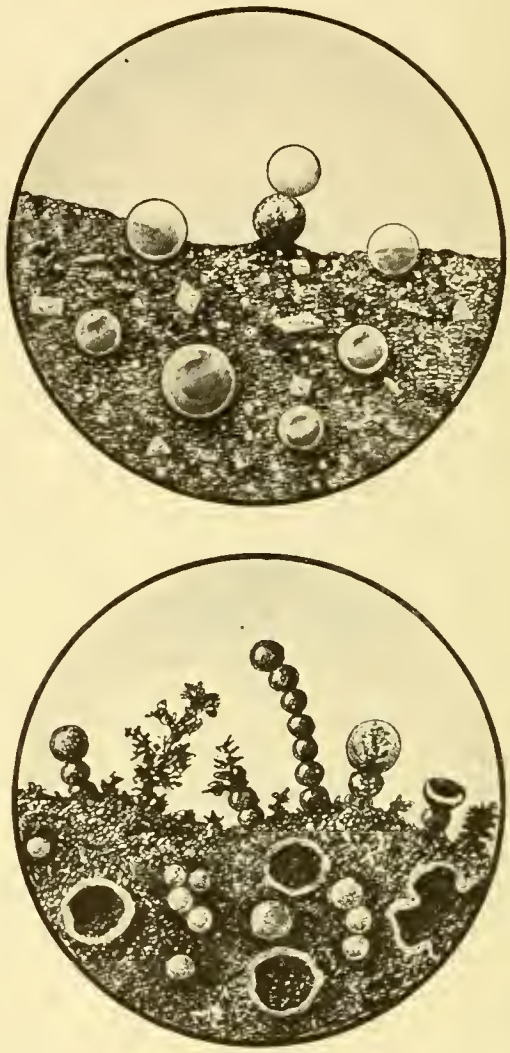


Fig. 2 Magnified Globules of Rust on Iron and Steel

The less disturbed the metal is, the more perfect become the rust spheres and "necklaces." The inside of the eye of a rusty needle, for instance, where the substance is shielded from dislodgment, will generally present a series of elevated necklaces and the same objects can be purposely obtained within a few days on any kind of iron.

It is usual to refer to the wet rust as ferric hydroxide and to dry rust as ferric oxide. The author claims that when iron rusts it has first to pass into a ferrous condition (green in color) which then rapidly oxidizes to the red or ferric condition. These changes can be watched by immersing a strip of iron for a few days in a small jar of water the upper portion being allowed to project.

A very beautiful experiment may be undertaken to empha-

size the electrolytic theory. Soften some pure gelatine, such as agar-agar in hot distilled water. Exactly neutralize the solution with 1/100 normal caustic potash, meantime using phenol phthaleine as an indicator. Then add a few drops of potassium ferrocyanide to the jelly and pour a layer of the compound in a shallow dish standing in ice water, which will rapidly stiffen it. Lay a strip of clean iron in the jelly and cover some more over it so as to wholly immerse the metal. Keep the whole in a cool, dry place; the moisture in the gelatine will be sufficient to induce oxidation.

Within a short time the electric action will begin. Dark blue patches of color in the form of spheres and ellipsoids (Fig. 3) will appear and indicate the positive poles, while dark pink zones somewhat hazy and glistening will denote the negative poles. The blueness is caused by the combination of ferros iron with the ferrocyanide, making what is practically Prussian blue. The pink is the infused oxide rendered delicate by the presence of the gelatine. The blue areas gradually become red owing to the deposition therein of the true ferric oxide. The changes in color will continue until exhaus-

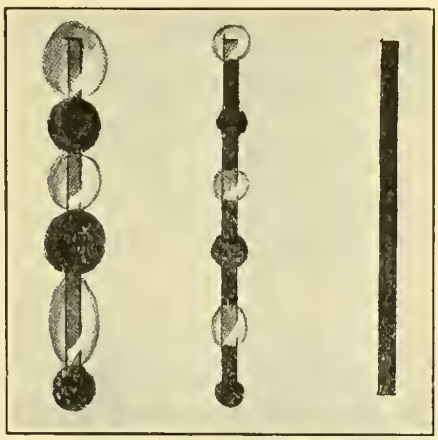


Fig. 3 Spheres and "Necklaces" of Rust

tion sets in. The less pure the iron is the sharper will be the definition. (*Railway Engineer*, vol. 36, no. 431, p. 329, December 1915, 3 pp., 3 figs. *et.*)

Mechanics

Bending of a Shaft Having Two Bearings, J. Cabrol

Assume a shaft of any shape whatsoever, subject to a certain number of vertical loads, P_1, P_2, etc., distributed in any manner whatsoever, and producing counter reactions V_1, V_2, etc. The supports are assumed to be free. We use the following notation:

x, abscissa of a section X measured from the axis of the left bearing,

y, deflection of the shaft from the lead-line of that section,

M, moment of bending,

I, moment of inertia of the section.

Then
$$\frac{d^2y}{dx^2} = -\frac{M}{EI} \quad \ldots \quad [1]$$
where E is the modulus of elastiicty of the metal of the shaft. The calculation of the shaft reduces itself therefore to the integration of this differential equation of the second order in which the second member is a function of x. This is usually done either graphically or by successive differentiations, but the author gives a method which simplifies it to a certain extent. $\frac{M}{EI}$ or $\frac{M}{I}$ is a function of x, and, as shown in Fig. 4, is of quite irregular shape. We can, however, consider it as a first half-period of a periodic function (period $2l$), and as such develop it into a Fournier series. There is nothing to prevent us from assuming that the second half-period will be similar to the first one, and hence the developed series will contain only odd harmonics. We have, therefore:

$$\left.\begin{aligned} -\frac{M}{I} = A_1 \sin\frac{\pi x}{l} + A_3 \sin\frac{3\pi x}{l} + A_5 \sin\frac{5\pi x}{l} + \ldots \\ + B_1 \cos\frac{\pi x}{l} + B_3 \cos\frac{3\pi x}{l} + B_5 \cos\frac{5\pi x}{l} \end{aligned}\right\} \ldots\ldots [2]$$

In this equation, by the way, the cosine terms will disappear only when the curve $\frac{M}{I}$ is symmetrical to the perpendicular section of the shaft through its support, which is an exceptional case. But, from equation [1]

$$\frac{M}{I} = -\frac{Ed^2y}{dx^2}$$

By integrating it twice we get

$$\left.\begin{aligned} y = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \Big[A_1 \sin\frac{\pi x}{l} + \frac{A_3}{9}\sin\frac{3\pi x}{l} + \frac{A_5}{25}\sin\frac{\pi x}{l} + \ldots \\ B_1 \cos\frac{\pi x}{l} + \frac{B_3}{9}\cos\frac{3\pi x}{l} + \frac{B_5}{25}\cos\frac{5\pi x}{l} + \ldots \Big] + Cx + D - \end{aligned}\right\} \ldots [3]$$

C and D are constants of integration. To determine them, we take that y becomes zero when $x = 0$ and when $x = l$. This gives us:

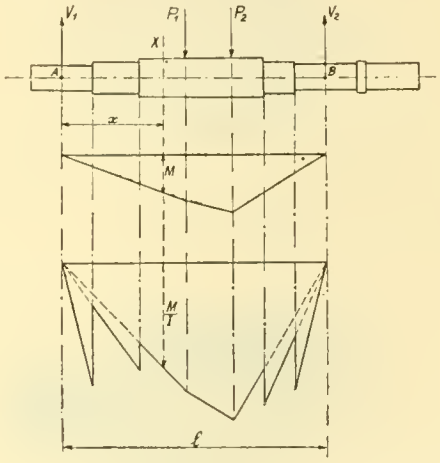


Fig. 4 Curves of M/EI and M/I for a Shaft Having Two Bearings

$$0 = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[B_1 + \frac{B_3}{9} + \frac{B_5}{25} + \ldots \right] + D$$
$$0 = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[-B_1 - \frac{B_3}{9} - \frac{B_5}{25} - \ldots \right] + Cl + D$$

and hence

$$D = -\frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[B_1 + \frac{B_3}{9} + \frac{B_5}{25} + \ldots \right]$$
$$C = -\frac{2D}{l}$$

If we substitute these values into equation [2], we obtain:

$$\left.\begin{aligned} y = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \Big[A_1 \sin\frac{\pi x}{l} + \frac{A_3}{9}\sin\frac{3\pi x}{l} + \frac{A_3}{25}\sin\frac{5\pi x}{l} + \ldots \\ - B_1\left(1 - \frac{2x}{l} - \cos\frac{\pi x}{l}\right) - \frac{B_3}{9}\left(1 - \frac{2x}{l} - \cos\frac{3\pi x}{l}\right) - \\ \frac{B_5}{25}\left(1 - \frac{2x}{l} - \cos\frac{5\pi x}{l} - \ldots\right) \end{aligned}\right\} [4]$$

If we take $x = \frac{l}{2}$ we have an expression for the flexure at equal distances from the supports which is particularly simple and, in general, sufficiently close for all practical purposes to the value of maximum deflection:

$$f = \frac{1}{E}\left(\frac{l}{\pi}\right)^2 \left[A_1 - \frac{A_3}{9} + \frac{A_5}{25} - \frac{A_7}{49} + \ldots \right] \ldots\ldots [5]$$

The terms with B disappear entirely. It is therefore after all a problem of resolving a periodic curve into its harmonies which can be done in several ways which the article discusses. *Méthode de calcul de la flèche d'un arbre reposant sur deux tourillons,* J. Cabrol, *La Lumière Electrique,* vol. 37, no. 49, p. 265, 3 pp., 1 fig. *m.*)

Lubrication of Bearings and Cylinders, F. L. Fairbanks

The author discusses some of his experiences in the matter of lubrication of bearings and cylinders and describes what he considers the correct methods of design of bearings. He also reports certain experiments with various kinds of lubricating oils.

In the first place, he tried to determine the probable thickness of the film of oil under a joint or piston. He found that under normal running conditions the average film of oil under the shaft was from 0.002 to 0.003 in. and that the thickness of the film depended considerably upon the rotative or circumferential speed, the thickness increasing with the speed probably because more oil is pumped or pulled in between the journal and the bearing as the speed increases. As a result of this experiment the plant with which the author is connected gives the average journal 0.005 in. clearance and to eliminate hand work, machines the bearings 0.005 large and then takes out the shims that are placed between the cheek pieces and the upper and lower shell after the machining. This gives a shape of bearing almost identical with the hand shaped bearing.

The author objects to the use of the usual type of oil grooves in bearings. He says that several babbitted bearings which ran warm did not begin to run cool until after they started the babbitting and filled the oil grooves. He believes that the average oil grooves are of comparatively little value because they represent usually a journal with square edges.

To make the groove more efficient the author decided to cut it as shown in Fig. 5 A so as to get rid of the corner at the edge of the groove and obtain a wedge shaped opening from either side down.

In experiments with oils of approximately the same "tensile strength" (viscosity), different results were had, which indicates that there are two qualities that represent the lubricating properties of oil, *viscosity* (which the author calls also "tensile strength") and *adhesiveness to the metal surfaces.* As animal oil is more adhesive it, instead of slipping on the surfaces, is carried under the shaft, but beyond a certain temperature point animal oils lose their viscosity faster than the mineral oils. Russian oil was found to be more viscous and hence preferable to American oil.

The author describes how the bearings are made and calculated in his plant. To further insure safety, all of his bearings now have a special bronze with diagonal babbitt inserted (Fig. B). He takes a bottom shell and runs diagonal strips of babbitt, the idea being that these strips will wear usually under the surface of the bronze as the oil apparently has a greater affinity for a good babbitt than for brass. Besides if an oiler through carelessness allowed the bearings to run dry or with too little oil to carry the film around the shaft these diagonal inserts of babbitt would melt and immediately become a lubricant. Incidentally they raise the shaft and protect it from the bronze bearing. In this connection the author describes the particular case of babbitt melting through the fact that an oiler apparently dropped a piece of waste into the hole on a bearing of a 1000 ton compressor before replacing the strainer.

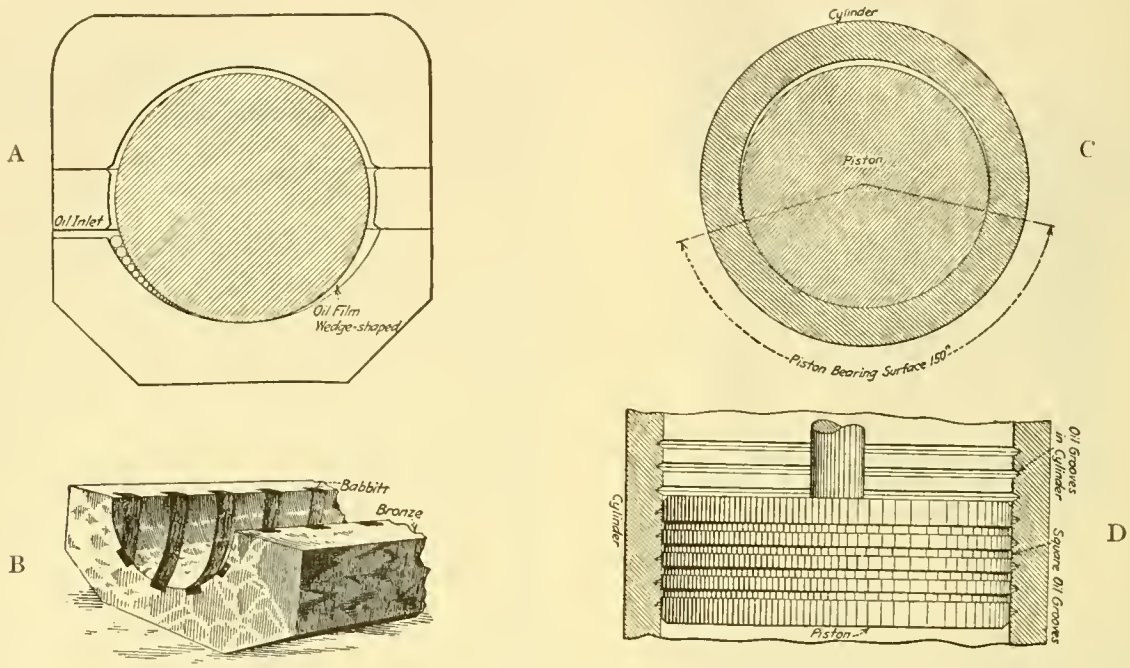


Fig. 5 Lubrication of Bearings and Cylinders

The author describes also an interesting case where kerosene added to the lubricant caused serious trouble. The oiler held that an engine running constantly will get "gummed up." He thought it a good idea to put in kerosene and wash out the bearings which he did by pouring in a pint to the center crank pin bearing with the compressor working at 200 lb. pressure. The engine soon stopped and on inspection it was found that every bit of babbitt in that center crank pin was wound around the shaft. The bearing looked worse than if the box had been filled with gravel, but after the babbitt was filed off there was hardly a scratch under it. The author thinks, therefore, that the babbitt is the best safety valve for friction that he knows of.

The question of cylinder lubrication has been also treated

in the same manner. The author had a 60 in. low pressure cylinder, out of which hardly ever more than three months' use was obtained. The cylinder carried a very heavy piston weighing 3 to 5 tons with its portion of the rod. The average engine builder carefully bores out cylinders, in fact, some grind them, and then turn up the pistons with 1/32 to 1/16 in. clearance which gives a circle within a circle, and as both elements are cylinders, the weight is borne on a line. The result is that the builder has anywhere from a few pounds to 5 or 6 tons per sq. in. projected area and it is the distortion of the cylinder that really helps, by increasing slightly the bearing surface. As the cylinder approaches the original temperature of the casting it goes back to the original shape, the distortion being proportional to the difference in temperature and dependent upon the construction of the cylinder. If this is true why waste time grinding cylinders?

Instead the shop turned the piston which was 0.003 to 0.004 in. larger than the cylinder, jacked it off center and relieved it as in Fig. C, giving the maximum of 150 deg. The old piston has a little over 7 sq. in. of bearing. With a new piston nearly 9 sq. ft. were obtained.

On investigation the author found that the average low pressure cylinder is running in water. That is, there is water between the piston and the cylinder. He found that there is a film of water anywhere from ¼ to ½ in. in depth being pushed ahead of the piston. If this is true the oil must be on the surface and is not lubricating the point between the piston and the cylinder. To prevent this condition the cylinder was bored out leaving tool marks with 16 threads to the inch and looked something like Fig. D. A 60 in. piston was put in and has been running for the last nine years. To-day these tool marks are black and the piston and cylinder do not touch as the former runs on an oil film. The junk ring carries one ring of packing in the center as black as can be; where it overruns the packing ring the oil is gummed as it is on the back of a Corliss valve. The same principle is used on ammonia machines with 24 threads to the inch.

It was found that viscosity is lower in summer than in winter. The oil systems are logged every hour and once in 24 hours the viscosity and the gravity are taken. The reports come to the office every morning and are filed, the engineer being notified of every drop in gravity of one degree and a drop in viscosity of 10 points. This gives quite valuable information. The viscosity of oils are measured at 100 deg. which is taken as a standard temperature. By testing the viscosity of each oil at temperatures near or up to the working temperature it was found in the case of two oils that up to 350 deg. fahr. the viscosity of both the oils was the same but at a slightly higher temperature the viscosity of one of them dropped 40 points behind the other. (*The Isolated Plant*, vol. 8, no. 1, p. 21, January 1916, 4 pp., 4 figs. *ed.*)

Fitting Equations to Plotted Curves, Assistant Professor J. B. Kommers

The paper describes methods intended as an assistance for determining the equations which will fit curves obtained from experimental work.

The author begins by simple curves having no constant terms, parabolic, hyperbolic, and logarithmic, and shows how such curves can be converted into straight lines by plotting them on logarithmic or semi-logarithmic paper. He proceeds then to the consideration of equations of the same types but having one or more constant terms. Such equations, when plotted on logarithmic or semi-logarithmic paper, do not result in straight lines, and for handling them, the author suggests the *method of selected points* which makes use of as many sets of co-ordinate points on the curve as there are constants in the equation. Solving the simultaneous equation obtained by substituting these values, gives the complete trial equation which should then be tried for various values of x to see if it fits the other points on the curve. If say three sets of points are chosen, they should be taken from the beginning, middle, and end of the curve so as to cover the whole range fairly well. The author gives several examples to show the application of the method of selected points to experimental curves taken from various publications and therefore typical of the kind that are met with in practical work. (*The Wisconsin Engineer*, vol. 20, no. 3, p. 106, December 1915, 11 pp., 6 figs. *p.*)

Helical Springs Under Centrifugal Action, John S. Myers

Investigation of a speed-limit device under conditions of operation where the weight of the spring is an important factor.

Most high speed machinery is now equipped with speed-limiting devices, the action of which usually depends on a

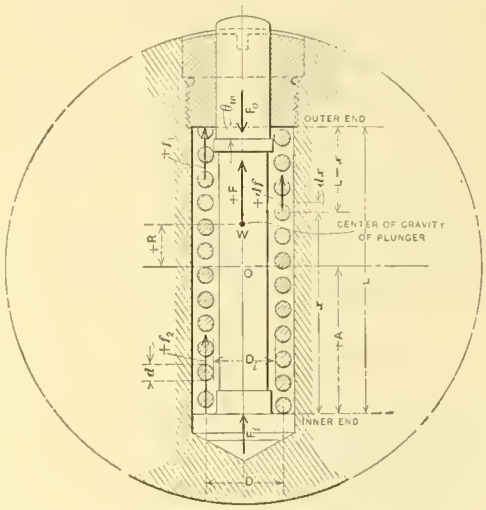


Fig. 6 Safety Speed Limit Device Where Spring is Acted Upon by Centrifugal Force

spring being deflected by the centrifugal force of a rotating weight; since the centrifugal force of the spring due to its own weight varies as the square of the velocity, the weight of the spring becomes of considerable importance at even moderately high speeds. The article presents a mathematical investigation of this matter and derives the following formula for the total centrifugal force of the spring (Fig. 6):

$$f = KwN^2(\tfrac{1}{3}L - \tfrac{1}{2}A) + KwN^2(\tfrac{1}{6}L - \tfrac{1}{2}A)$$

$$f = KwN^2(\tfrac{1}{2}L - A)$$

Where K = centrifugal force constant = 0.0000284; w = weight of spring; N = r.p.m. of devices about center O; L = length of spring in place under its initial strain; A = distance from the center of rotation to inner end of spring as shown in Fig. 6.

In this equation $(\tfrac{1}{2}L - A)$ is the distance from the center of rotation to the center of gravity of the spring. The author also discusses other forces acting on the spring, as well as gives an equation for the deflection of the spring. He proceeds then to a statement of the usual method of handling the designing of a spring and gives a numerical example illustrating it. (*Machinery*, vol. 22, no. 5, p. 400, January 1916, 4 pp., 2 figs.)

Power Generation and Transmission

Reciprocating and Rotary Principles in Prime Movers, Dugald Clerk

The paper is a reproduction of one of the Thomas Hawksley lectures, this time on the world supply of fuel and motive power. Among other things the author expresses an opinion that as far as he can see there is no hope of an indefinite increase in power using reciprocating pistons in internal combustion engines. Something must be done to introduce the rotary principle. So far the gas engine has not proved to be a success, but other methods of dispensing with the reciprocating piston and cylinder are quite practicable. The large Humphrey engine dispenses with pistons, but is necessarily heavy for a given power. It appears, however, possible to use water in another manner by filling a chamber, exploding a compressed mixture above the water, and forcing the water through a jet to operate a turbine of the Pelton type. Arrangements would be made to allow for the varying velocity of the water due to the falling of pressure by expansion, and it would be quite possible to obtain an efficiency between the explosion chamber and the Pelton wheel of about 80 per cent. Such a turbine could be made to work using the same water repeatedly and high efficiency combined with light weight is possible. A brake efficiency of 30 per cent is possible, but before such engines could compete for the highest power reached by the steam turbine, gas producers must be considerably modified and improved. Producers will require to be designed which avoid the huge scrubbing plant required now in all bituminous producers.

The author gives the following interesting table showing the progress in the work of the engineer during the nineteenth and twentieth centuries.

INDICATED THERMAL EFFICIENCY OF STEAM AND INTERNAL-COMBUSTION ENGINE.

Steam.	Indicated Efficiency. Per Cent.
Boulton and Watt Condensing Low-Pressure, about 1820	3.8
Cornish Engine, about 1850	9.0
Triple Expansion, about 1910	17.0
Parsons Turbine, about 1914	23.0
Internal-Combustion.	
Lenoir, about 1860	4.0
Compression-Constant Volume (two or four stroke):	
1876	16.0
1905	35.0
Compression-Constant Pressure (Diesel), 1910	40.0

The indicated efficiency refers to the proportion of the total heat of the steam of working fluid given to the engine converted into indicator work. (Thomas Hawksley Lecture. The World's Supply of Fuel and Motive Power, Dugald Clerk, *The Journal of the Institution of Mechanical Engineers, Part* I (1), December 1915, 34 pp. *g.*)

Some Notes on the Comparative Costs of Compressed Air and Electricity for Use in Mine Stop Haulages A. E. Middleton

While admitting the superior economy of electricity over compressed air for use on main and auxiliary underground haulages, the author questions the economy of electric drive on winches. He believes that although a considerable field is open for electrically driven winches in the flat mines on the eastern Rand, the heavy cost of cables is the chief adverse factor as regards their adoption. An electric coal cutter uses about the same horse power but works for longer hours, displaces expensive hand labor and can therefore carry a much higher first cost for cables. A substitute for the present safe and efficient, but expensive, paper or bitumen armored cable is highly desirable. The cost of power is decidedly in favor of electricity, but the first cost is likely to be in favor of air. The air has to be carried long distances to the working faces and the extra length and cross section required at any point for a winch is practically negligible, while apart from pumps and haulages generally situated on the main arteries of the mine, no electric power is available and the cost of extra cabling has to be debited entirely to the electric winch. (*The Transactions of the South African Institute of Electrical Engineers,* vol. 6, Part 8, p. 254, October 1915, 4 pp. *cp.*)

Farm Machinery Exposition

Description of the Exposition of the Smithfield Club at the Royal Agricultural Hall in Islington.

The Smithfield Club is mainly an agricultural organization, but at its Annual Shows farm machinery, tractors, and prime movers are exhibited. Among the machines shown this year, attention is called to the 3 to 4 ton gasoline wagon built by Clayton and Shuttleworth. The engine is a four cylinder machine developing 45 b.h.p. when running at a speed of 1000 r.p.m. The worm reduction gear is of the friction type. Power is transmitted from the propeller shaft by means of a worm and worm wheel to the differential casing. The propeller shaft is enclosed in a steel tube having ball joints at the rear end of the gear box thus relieving the springs of all driving strain. This tube takes the whole of the torque or drive of the rear axle. Roller and ball journals and thrust bearings are used throughout. Another of Clayton and Shuttleworth's exhibits is a five ton steam wagon fitted with rubber tires. The makers claim that in designing this vehicle special attention has been paid to steering capacity, the proportioning of parts and the distribution of load.

Ruston, Proctor & Co., Ltd., show among other things a ten b.h.p. engine for working with paraffin. It is one of the so-called convertible engines. It is fitted with a magneto and sparking plug and is started with gasoline. No starting torch is used. The engine may readily be converted to work with fuels such as benzole, gasoline, kerosene, producer and town gas.

Petters exhibited a light agricultural tractor for general farming work. The engine which starts on gasoline and afterwards runs on kerosene, is an 8 to 10 h.p. machine and can be fitted with a pulley for driving stationary machinery. Battery ignition is used for starting purposes. (The Smithfield Club Show, *The Engineer,* vol. 120, no. 3128, p. 550, December 10, 1915, 3 pp., 7 figs., articles not finished. *d.*)

The Geared Turbine and the Turbo-Electric Systems of Marine Propulsion, John H. Macalpine.

Data on design of transmission gears in geared turbine marine propulsion systems and a discussion of the comparative merits of the geared turbine, and turbo-electric ship drives.

The author derives what he calls the Power Constant by which the performance of gears should be compared. It is

$$C = \frac{1000\ P}{D^3\ R}$$

where C = power constant, P = horsepower transmitted by the gear, D = diameter of pinion in inches, R = revolutions per minute of pinion. The factor 1000 is introduced to make C fall, usually, between unity and 10. In similar gears loaded at corresponding points to the same intensity of stress the value of C is constant and with similar gears on a turbine of given power and speed, the weight per horsepower is inversely proportional to the value of C; hence the higher the value of C which can safely be carried the better the design or type of the gear and the more advantageous for adoption on board ship.

The "floating frame" was introduced to raise the safe value of C by producing and automatically maintaining very uniform distribution of pressure between the teeth and thus preventing great local rise of stress through slight errors of alinement of the gear and pinion. With the floating frame, errors of alinement unless far outside the limits which would ever be allowed to occur in practice, produce no sensible effect. The Westinghouse Machine Co. gradually raised this constant until $C = 4$ is regarded as a proper value for marine work. Then by reducing the pitch diameters of the Neptune's pinions to 7 in., C was raised to over 5 with complete success. It is worth remembering that the highest result for rigid gears is about 3 on the S.S. Vespasian. For a given power, the high value of C allows either a much smaller and lighter gear for a given ratio of reduction or, with a given diameter—of large gear, of a greater ratio of reduction, reducing the speed of the propeller or increasing the speed and consequently reducing the size and the weight of the turbine, and thus increasing the efficiency of the installation. (*International Marine Engineering*, vol. 21, no. 1, p. 4, January 1916, 5 pp., 2 figs. *dc.*)

Steam Engineering

Application of High Pressure Exhaust Steam to Manufacturing Purposes, James M. Taggart

The article compares the application of high pressure and of low pressure exhaust steam to manufacturing purposes from the point of view of safety and economy and describes a plant in which exhaust steam is used at a pressure of 60 lb. per sq. in.

The necessity for the use of high pressure steam in various manufacturing processes is due to the need of high temperatures. As examples may be cited the boiling down of certain liquids, melting of solids such as asphaltum, vulcanizing, drying, and rapid evaporation. Among the objections raised to the use of high pressure exhaust have been, first, that the increase in initial pressure would increase the cost of equipment; second, that the higher initial pressure would result in lower boiler efficiency and greater loss through radiation in the piping; and third, that the higher pressure involves an increased danger of accident or breakdown.

These objections are answered somewhat as follows: The increased cost of the equipment installed would ordinarily be more than offset by the reduction in size of the equipment required; because of the reduced size of piping the total loss would probably be no greater; as regards the increased danger of accident, at the present time the use of higher pressure has already led to the development of construction fully meeting the conditions and in a high pressure plant accidents may be as rare as in a low pressure plant. In fact, the purer condition of feed water in high pressure plants has often resulted in the decrease of accidents because of the practical elimination of scale.

It seems to be the common practice where steam for manufacturing purposes is required at a pressure of 40 lb. or more to use live steam direct from the boilers while the engine exhaust is run to the air or to a condenser. This is probably due to the usual separation of power design from the design of factory equipment. The consulting engineer is often retained to design the power house, and his duty ends with running a steam line to supply live steam for the factory, then the various appliances are connected up according to standard practice for the industry involved.

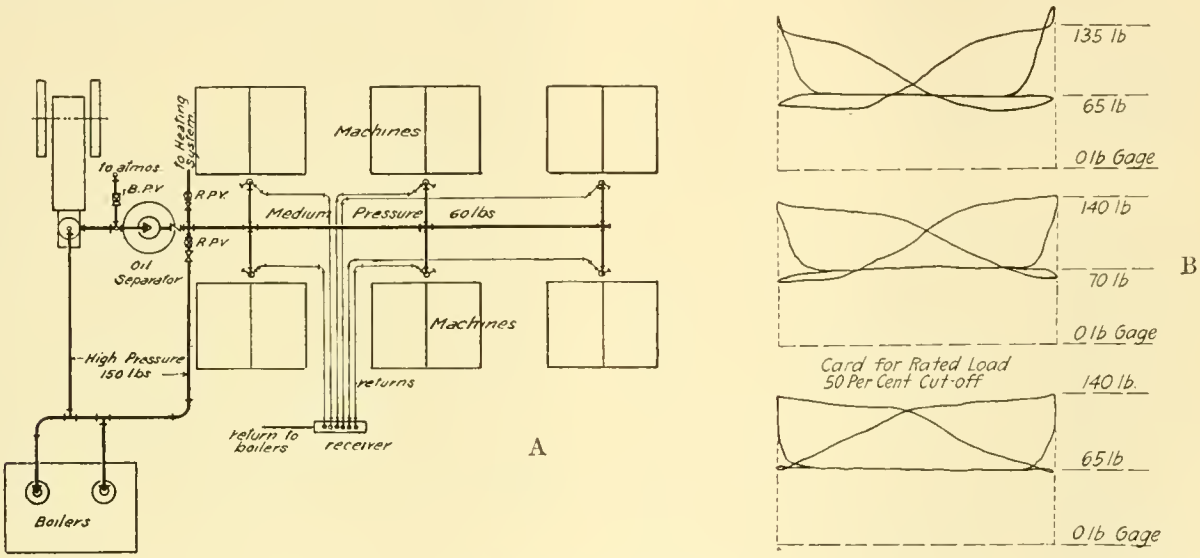


Fig. 7 Layout of a Plant Using Exhaust Steam at 60 Lb. Pressure, and Copies of Indicator Cards Taken at 60 to 70 Lb. Back Pressure

The author had a case in which the manufacturing conditions apart from the engine required steam at a pressure of 60 lb., the amount of steam used in the processes being normally twice what would be needed for power. The computation showed that all the exhaust could be easily utilized provided the initial pressure was not lower than 140 lb. per square in. At that time the investigation failed to disclose any instance where such back pressure had been used.

The installation was made as proposed and worked in practice as anticipated, in fact, with the cylinder condensation even lower than expected. The engine used was of the high speed automatic balanced slide valve type and the general arrangement of the plant is shown in Fig. 7A.

Fig. B shows some copies of indicator cards taken from the engine at various loads and at 65 to 70 lb. back pressure. At the lower loads the expansion line falls below the back pressure lines but flattens out when 10 to 12 lb. below. It was found that this point, namely 10 or 12 lb. below the back pressure, was about the limit to which the expansion curve fell no matter how light the load. It seems that the pressure must have been held up by evaporation, as the engine was tested for leakage.

The article gives a table showing the various quantities computed from the tests and fully discusses the methods of computation. The matter of waste cylinder condensation is carefully considered on the basis of tests made at the Sheffield Scientific School of Yale University in December, 1914, by Prof. F. P. Breckenridge and Prof. E. H. Lockwood, as well as the tests made by Callender and Nicholsen. The author figured the weight of condensation on the actual weight obtained per h.p. because seemingly the inefficiency of the engine or the steam used per hp-hr. should not affect the condensation due to radiation for similar sized cylinders and similar power development.

In table 1 the quantities computed are, for convenience, all based on the assumption that $V N$, or the volume of the cylinder times the number of revolutions, is equal to 100. For any special use, the quantity in the table multiplied by the respective $V N$ and divided by 100 will give the equivalent quantity (*Steam*, vol. 17, no. 1, p. 7, January, 1916, 5 pp., 3 figs. *ed.*)

TABLE 1. VALUES FOR $VN=100$

Initial pressure, lb. per sq. in.	Exhaust pressure, lb. per sq. in.	Cut-off in per cent of stroke	Mean effective pressure, lb. per sq. in.	Indicated horsepower	Steam per hp-hr., lb.	Thermal efficiency of system, per cent	Cost per hp-hr., lb.
200	20	19.5	78.3	68.3	20.5	64	0.49
200	40	28.0	81.8	71.2	27.1	63	0.50
200	60	37.0	83.1	72.5	33.8	62	0.51
200	80	47.0	79.5	69.3	42.8	61	0.52
180	20	19.5	74.1	64.7	21.7	65	0.49
180	40	30.0	76.0	66.3	28.9	64	0.50
180	60	43.0	75.2	65.6	37.3	62	0.51
180	80	53.0	69.3	60.5	48.7	61	0.52
160	20	25.0	69.4	60.6	22.7	65	0.49
160	40	33.5	69.2	60.3	31.5	64	0.50
160	60	48.0	66.7	58.2	41.5	62	0.51
160	80	59.0	58.2	50.8	57.3	62	0.52
140	20	29.0	64.0	55.8	24.3	66	0.49
140	40	39.0	61.8	54.0	34.7	64	0.50
140	60	54.0	56.9	49.6	48.1	63	0.50
140	80	65.0	45.8	40.0	71.8	62	0.51
120	20	33.0	57.8	50.3	26.6	66	0.48
120	40	44.0	53.3	46.5	39.9	65	0.49
100	20	39.0	50.5	44.1	29.9	67	0.48
100	40	52.0	43.2	37.7	48.4	66	0.49

Hunting for Leaks in Surface Condensers, Otte

The development of the steam turbine has led to an increased use of surface condensers instead of the formerly more extensive use of jet condensers. One of the great difficulties which is encountered in the use of surface condensers is that of keeping the condenser space watertight with respect to the cooling water, since with even a few leaky places quite considerable amounts of cooling water may penetrate into the water of condensation. This entails the following undesirable consequences:

1. The condenser pump is loaded higher than it should be, since, in addition to the water of condensation, it has also to take care of the inleaking cooling water.
2. The air pump also is required to carry an extra load because the cooling water leaking into the condenser usually carries much air.
3. The vacuum is reduced because of the overload on the pump handling the water of condensation, and on the air pump. In addition to that the steam side of the cooling surface is soiled by deposits from the cooling water and the cooling action is thereby considerably impaired, especially because of the fact that its cleaning is difficult.
4. The water of condensation is contaminated by the addition of cooling water and becomes unsatisfactory for boiler feeding purposes; if the cooling water is hard, scale is formed, and if it is salty (sea water), carrying over of water by the steam is apt to occur.
5. The determination of steam consumption by measuring the amonnt of water of condensation becomes unreliable as the apparent steam consumption is higher than the actual one.

There are several ways of testing the watertightness of surface condensers. The simplest way is to start the condenser installation working while the turbine is shut off. If the condenser pump continues to deliver water, that shows that there is a leak. In most cases, however, it is desirable to be able to test the watertightness of the condenser plant without stopping the steam turbine. Most of the methods suggested for this purpose are based on the assumption that as the steam is clean, the water of condensation coming from a perfectly watertight condenser may be considered as distilled water, and any leakage of cooling water into it will cause chemical and physical changes, the magnitude of which may be used for indicating the amount of leak.

One of the chemical properties of cooling water which is often used for discovering leaks in condensers is its contents of dissolved calcium and magnesium salts. The hardness of water may be determined, for example, by the Clark method, which consists in adding to the water being investigated, while well shaken, a solution of soap in alcohol of known strength. A deposit of insoluble calcium and magnesium soaps is then formed and its amount indicates the contents of the salts in the water.

This is a very simple process, but not always sufficiently precise. A more reliable method is that of Prof. C. Blacher, in which the hardness of the water is determined by titration with sodium palmitate. The amount of cooling water leaking into the condenser per hour may be determined from the following formulae:

$$K = Q \cdot \frac{h}{H} \text{ and } D = Q - H$$

Where Q = the amount of gases in the water passing per hour through the condenser pump, including the cooling water which has leaked in; K = the amount of cooling water which leaks in per hour; D = the amount of steam condensed per hour; H = the degree of hardness of the cooling water (one degree of hardness means one milligram of CaO in 100 cm³ of water), h the degree of hardness of the mixture Q.

For example, the apparent amount of water of condensation per hour of a 15,000 kw. turbine with a load of 5000 kw. amounted to 40 metric tons or 8 kg. (17.6 lb.) per kw-hr. The hardness of the cooling water was 20 deg. while the hardness of the water delivered by the condenser pump was 1.5, hence from the above formula the amount of the leak of cooling water was $40 \times \frac{1.5}{20} = 3$ m³. The real consumption of steam of the turbine was, therefore, 37 metric tons or 7.4 kg. per kw-hr.

If sea water is used for cooling in a surface condenser, the leak may be discovered through the difference in specific gravity by means of hygrometers. The German Navy employs such instruments which permit of reading the sea water content in the water of condensation directly in percentages.

The English house, Digby & Diggs, have placed on the market a device for determining the quantity of salt solutions in water by measuring the electrical resistance of the liquid. This method has these disadvantages, first, that correction must

be made for the temperature of the solution, and, second, that errors are apt to occur because of polarization phenomena at the electrodes of the measuring apparatus.

Some such tests ought to be made in well conducted plants at least once a day. (*Die Feststellung von Undichtigkeiten an Oberflächenkondensatoren,* Otte, *Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 38, no. 48, p. 393, November 26, 1915, 2 pp. *p.*)

Varia

Pipe Couplings, R. S. Lord

The paper discusses the question of pipe couplings with particular regard to their use on gas lines.

The essentials of a good pipe coupling are tightness, flexibility, allowance of expansion and contraction, strength, and rigidity. The apparent contradiction between the requirements of flexibility and rigidity is due to the fact that while the ability to make bends easily is a very important matter to a pipe line builder, the degree of flexibility must be controlled by something in the joint itself, or by proper anchorage. In the matter of strength, present day demands require a very high standard as in natural gas pipe lines pressures run in some cases up to 1200 or even 1400 lb. Fortunately these extreme pressures are never carried any distance from the well, or for any length of time without natural reduction due to expansion into the large space of a big pipe line.

The fluids to be carried have an important bearing on the requirements of a pipe coupling. Natural gas has no appreciable effects on rubber gaskets used on plain end pipe unless it be saturated with oil or gasoline. Artificial gas is also practically harmless when dry, but the coal distillate known as drip oil and often found in it, is even worse than gasoline in its effect on coupling gaskets.

In the use of cast iron pipe only three classes of joints are common, bell and spiggot, flanged, and machined or universal. The bell joints depend upon cement or a soft metal such as lead for sealing. Cement does not permit of any variation from the alinement given the pipe when laid and this may cause strain sufficient to break the pipe. The weakness of lead lies largely in the fact that when once compressed or forced out of position it lacks any elastic power that would tend to return it to its position. In recent years lead wool has been hammered into bells to form a more solid packing than that made by pouring molten lead and then caulking the face.

The joints in use on wrought iron pipe have until recent years been threaded. The author vigorously opposes the statement often made that a properly laid screw line will not leak. He believes that it will.

The article describes in some detail the following joints: Van Stone, E. C. Converse, H. Sellers McKee, and the Matheson.

As regards rubber packed couplings, the author divides them into two general classes, those intended to be packed by the pressure of fluid carried, and those packed by force applied externally working against the pressure within. The author also describes the Gillespie and the Custer pipe couplings as well as the design placed on the market by the Hammond Coupler Co., in which the outer flange is entirely done away with, the bolts holding themselves on by a hook at the head and a clip at the nut end. The bolts rest directly against the broad band of the ring in semi-circular notches made for the purpose of locating them. The hooks coming behind these rings make the pull as direct against the gasket as it is possible to get it. The strength of the ring is made in the direction of this pull of the bolts so that it cannot be bent between the bolts. The author discusses also the plain end pipe coupling and the gaskets used in that connection. (*The Natural Gas Journal,* vol. 9, no. 12, p. 556, December 1915, 6 pp. *cd.*)

Water Softening by Permutit

Description of the isolated plant of the new Central Y. M. C. A. in Brooklyn, N. Y. An interesting feature of the plant is the Permutit plant for water softening. The water comes from an Artesian well and is very hard having a content of lime and magnesium 270 parts to the million. It was, therefore, quite unsuitable for boiler feed and even for bathing purposes inasmuch as it would not form soap lather to any extent. It did not readily lend itself to the lime-soda method of treatment either. The high content of magnesium salts in the water would require a tremendous excess of lime and soda ash and a time of reaction of from 4 to 6 hours. In addition to that, as the salts formed in the lime soda method of treatment are partially soluble in water at ordinary temperatures, there would always remain in the treated water besides an excess of chemicals a certain hardness expressed as calcium carbonate, and in the boilers this would be precipitated and the result would be a bad scale in the heating coils, heaters, pipe lines, and boilers themselves. Furthermore a huge settling tank of about 3500 cu. ft. would be required for the lime-soda softener.

Instead of that a small compact Permutit plant of about 500 cu. ft. was installed. The filtering medium is an artificial silicate which has the property of absorbing all of the calcium and magnesium salts from the water passing through it and substituting for them its sodium base. When the total amount of zero water for which the plant is designed is realized the filters are restored to their original softening efficiency by introducing a solution of unrefined salt (sodium chloride). This solution is allowed to remain in contact with the Permutit for a period of 10 hours, it is then washed directly into the sewer and the filter is again ready for the next day's run.

The plant installed is capable of handling 60,000 gal. per day of the very hard well water. This capacity is divided between two filters. After 30,000 gal. have been filtered through, each filter is regenerated by passing about 1000 gal. of brine through it. (Model Plant in Brooklyn Y. M. C. A., *The Isolated Plant,* vol. 8, no. 1, p. 3, January 1916, 2 pp., 2 figs. *d.*)

Economic Methods of Preparing Metal Shavings for Packing, R. Philipp

A paper read before the Lower Rhine Section of the Verein deutscher Ingenieure on the economic methods of handling metal shavings with special regard to the best ways of preparing them for packing.

One of the great difficulties in the shipment of metal shavings is that unless they are mixed with a sufficient amount of very fine material, they occupy a volume out of proportion with their weight which naturally increases freight charges, sometimes to a prohibitive extent, or in any case materially reduces the price which a shop can get for its waste metal.

Of late (for about six years) serious efforts have been made to prepare the shavings at the plant for economic shipment. Jones and Lamson of Springfield, U. S. A., have provided on their turret lathes an arrangement for breaking up the shaving as it originates. This device consists of a little bridge over which the shaving has to run; at the end of it the shaving is sharply deflected into another direction and broken thereby. This device did not prove practical.

Another attempt was to arrange the cutting itself in such a manner as to prevent the formation of long shavings. This

may be done by giving the tool a peculiar shape such as spoon shape, which prevents the cutting from coming out in a smooth ribbon, prevents it from twisting, and forces it to run in a plane. This gives the shaving bends which with many kinds of steel make it brittle. This process has only a very limited application.

Another proposal belonging to the same class was to set the cutting edge of the tool at right angles to the axis of rotation. For heavy work and for many kinds of steel this is not adaptable because it increases the power consumption and does not prevent the formation of long, strong shavings. It was attempted to destroy the elasticity of the shavings by annealing and hardening them which would make them brittle, but this process proved to be too expensive.

Attempts to cut the shavings themselves likewise did not prove successful because thin shavings can be cut only with very sharp tools, and unless the tools are quite sharp the shavings begin to bend and clog the machinery. Further, cutting requires rapid and uniform feeding of the shavings which is not always possible, and even if all these difficulties have been overcome, the output even at the high speed of cutting will be quite small.

Another process which is used to a certain extent by briquetting concerns outside of Germany consists in allowing the shavings to get rusted. This makes them somewhat brittle so that they can be broken up in a rolling mill or coal crusher. Before, however, they can be sent to the briquetting presses they must be passed through a screen so as to eliminate large lumps and pieces of shavings which might injure the presses. One of the disadvantages of this process is that the metal, being partly rusted, is of lower quality.

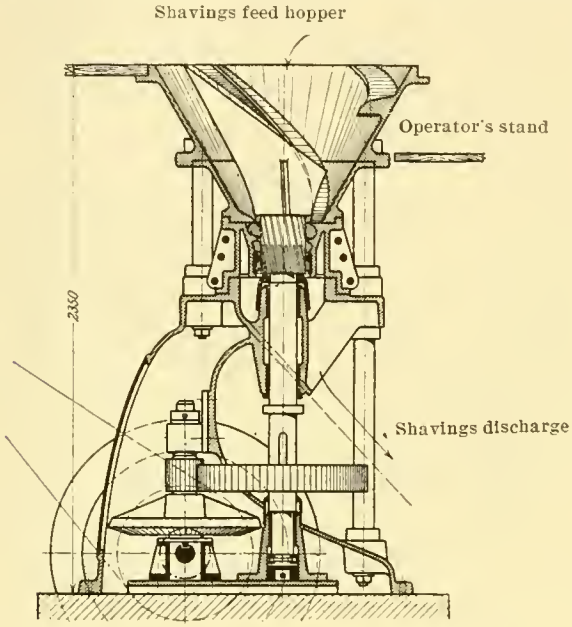
Hammer mills can be also used for this purpose but the disadvantage of such types of mills lies in the fact that the shavings are apt to roll about the rollers sometimes to such an extent that it requires a hammer and chisel to get them away.

The application of scrapers does not entirely eliminate this evil, besides it is necessary for various reasons to make one of the rolls adjustable which complicates the use of scrapers.

The locomotive factory of Henschel & Son in Kassel, Germany, has built for its own use a kind of rolling mill consisting of two geared rollers, a characteristic feature of this construction being that both rollers are of the same diameter and mesh from top outward. At the outer sides of the rollers are located sharp deflectors. One of the advantages of this construction is that it can take care of large bales of shavings because the rolling breaks up the bales. On the other hand, however, this construction did not prevent the shavings from twisting all about the rolls even though the deflector could be made very strong and could be placed quite close to the rigidly held rolls.

The Lauchhammer Company in Reise uses another process, namely, of baling the shavings which must be in this case mixed with a certain amount of thin sheet iron pieces and wire. The baling press consists in this case of a large box with four movable holes. After this box has been filled with shavings by means of a lifting magnet, the cover is mechanically forced on and then first one of the side holes and next two more touching it are gradually forced in. The press consumes about 175 h.p., 25 h.p. for forcing on the cover, 50 h.p. to move the first side hole, and 100 h.p. to force in the other two holes in contact with the first one. Six bales can be made in this way per hour. In order, however, that they should maintain their shape the bottom of the box must be covered with sheet iron or wire; then the shavings come in the middle and the top is again covered with sheet iron or wire. In machine shops this process is, therefore, not applicable since there is no sheet iron or wire waste available in the first place, and in the second place the space required and the cost of operation are prohibitive.

The locomotive factory of Henschel & Son build the shavings breaker shown in Fig. 8 A, while Fig. B shows the feeding hopper of the same machine. Tough shavings have the undesirable ability of wrapping themselves around the rolls. This property has been made use of here. The roll of peculiar shape rotates in a funnel which is provided with spirally located guides forming as they go downward, channels. Ribs on the roller gradually force the shavings into the passage where they are more and more compressed and shifted outward. By an appropriate formation of the ribs in the funnel and on the roll, the shavings are uniformly distributed through all the channels over the entire cross section of the roll. With say 30 r.p.m. of the roll with 8 ribs in the funnel and 20 on the roll itself, 4800 cuts are made per minute. To this must be added that by being compressed in the channels the shavings are broken to pieces: there is practically no actual cutting which is necessary only in the case of very tough shavings or pieces of wire and sheet metal. Because



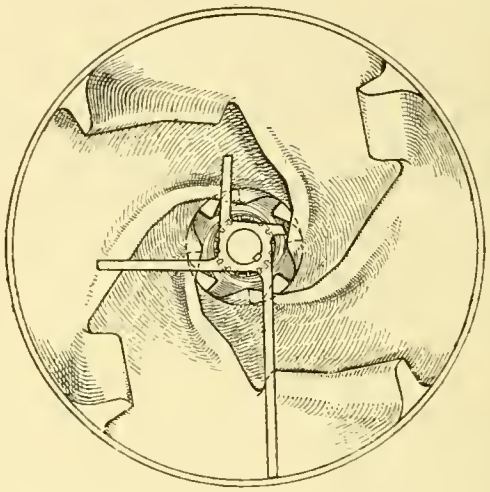


Fig. 8 Metal Shavings Crusher

of the very low velocity of the rolls which is from 20 to 25 r.p.m. and has at most a diameter of 200 mm. (say 8 in.) there are no violent blows and this reduces the work of the apparatus. The power consumption varies quite materially. It was found that the average power consumption of the larger units for an output of 2500 to 3000 kg. (5500 to 6600 lb. per hr.) was only 13 kw. The largest output obtainable from one engine was 3500 kg. (7700 lb. of manganese copper in 25 minutes) which was obtained with the engine driven by an electric motor rotated at 25 h.p. The cost of breaking up the shavings is approximately 1 mark per ton (say 24c per 2200 lb.). The main elements of this cost are power consumption and wages for bringing the material in and taking it away. The wear of the machine itself does not amount to anything for all practical purposes. (*Wirtschaftliche Behandlung der Eisen- und Metallspäne,* R. Philipp, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, no. 17, p. 962, 3 pp., 3 figs. *dp.*)

Railway Electrification and the Solution of the Smoke Problem in Chicago

The article presents an abstract of the report submitted as a result of an investigation begun four and a half years ago by the Chicago Association of Commerce.

The investigation was at first in charge of Horace E. Burt and after his death in 1913 was conducted by W. F. M. Goss as Chief Engineer of the Committee. The report is quite voluminous (1177 pages), and only the most important conclusions can be here reported.

The Chicago electrification would equal the combined electrifications of the whole world, would involve problems never heretofore met, and would be the first ever undertaken for air betterment where terminals were adequate from an operating viewpoint. At the same time the steam locomotive stands only third among smoke producing services and its elimination would reduce the gaseous pollution of the air only 5 per cent and the solid pollution less than 4 per cent, some of the other worst offenders from the point of view of smoke production being high pressure steam plants, metallurgical and other manufacturing furnaces, and domestic fires.

Smoke regulation in many places erred in confining itself to the visible aspects of smoke, whereas the really harmful factors are invisible gases and the solids of combustion, sulphurous gas and mineral dust in particular.

The researches of the Committee disclosed a significant fact by emphasizing the relatively great importance of the solid constituents of smoke. The cloud effects are of secondary importance as compared with the effects produced by the soot and dust of smoke. The problem of smoke abatement, therefore, is not entirely or largely a problem of suppressing visible smoke, but is one of suppressing the shower of soot, dust, and cinders constantly falling from a smoke polluted atmosphere. Owing to the finely divided state of the solids emitted in the smoke of steam high-pressure stationary power and heating plants, the resulting pollution may be regarded as affecting wide areas since such materials are easily carried by the wind and air currents.

No type has been found except straight electrification which could provide a substitute for steam locomotives. The power requirements of heavy traffic such as is met in and around Chicago are still beyond the gasoline driven engine. The Diesel and oil burning marine engine have the power, but neither type is self-starting, an imperative requirement for switching work. A new Diesel experimental locomotive was examined in Switzerland. Much has been hoped from it, but the inventor himself was doubtful of its success in such heavy yard switching work as would be required here. The storage battery appears to lack power, to be too expensive, and to share with electrification the disadvantage of producing power house smoke. Compressed air and hot water motors were found impractical. Their use is suggested on those sections of the Chicago track which cannot be electrified. Finally electrification itself in Chicago must depend upon the existence and operation of a steam driven electric generating station which would give off enough smoke to counterbalance at least part of the advantages gained by the electrification.

On the whole it seems to be clearly the opinion of the Committee that the results obtained would not warrant the extremely large investment (close to $275,000,000) to abate only a comparatively small part of the visible smoke of the city. It recommends, therefore, the organization of a Pure Air Commission, the business of which would be to eliminate such pollution of air by dust or smoke, not by railroads only but from all sources, including domestic fires, as can be avoided with reasonable expenditure in money and trouble. (*$600,000 Inquiry Finds Electrification Will Not Solve Chicago's Smoke Problem, Engineering Record,* vol. 72, no. 24, December 11, 1915, p. 727, 5 pp., 2 figs. *gd.*)

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Safety Devices on Blast Furnace Hoists.

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ANNUAL MEETING PAPERS

IN this issue is continued the publication of abstracts of the papers given at the 36th Annual Meeting of the Society, held in New York, December 7 to 10, 1915, including the papers of the Textile Session, the Junior Prize paper for 1915, and papers contributed by the Research Committee and the Sub-Committee on Railroads. The three Textile Session papers follow.

HEATING BY FORCED CIRCULATION OF HOT WATER IN TEXTILE MILLS

BY ALBERT GREENE DUNCAN, BOSTON, MASS.

Member of the Society

SINCE the days of the old coal stove, three methods of heating textile mills have been in use: *First,* direct circulation of live or exhaust steam at low pressure; *second,* fan or indirect hot air system, using either live or exhaust steam in heating coils arranged in a central battery to heat the air; and *third,* use of hot water through direct heating surface in the various rooms, heating the water with either live or exhaust steam in closed heaters. This paper treats of the last method, which, with the widely distributed areas encountered in large textile mills, involves forced circulation of the hot water. It describes the manner of handling the problem of properly heating the widely separated units of the textile mills[1] shown in Fig. 1.

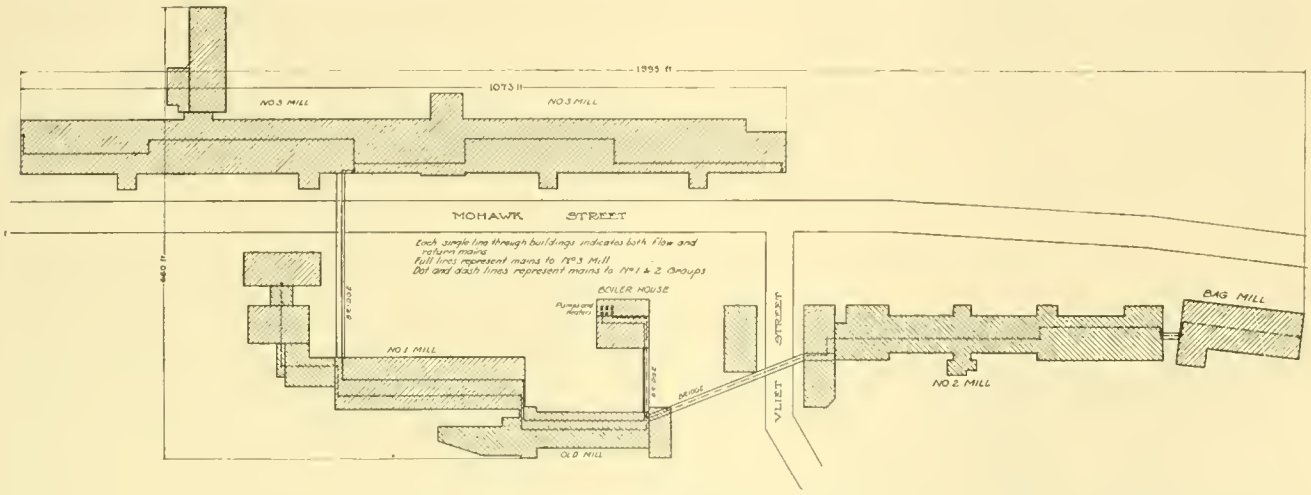

FIG. 1 PLAN OF HARMONY MILLS, COHOES, N. Y.

A system of forced circulation of hot water was decided upon for three reasons: *a* The mills are primarily driven by water power, and the auxiliary steam plant which is in daily operation to carry about 20 per cent of the mill load, reaching a maximum of 50 per cent in times of low water, is located at a central point, the distribution of power being by electricity. *b* The central plant arrangement necessitated the carrying of heat over long distances. *c* As certain of the mills were located below the level of the power plant, a gravity system of return, either of hot water or steam, was impracticable.

The mills consist of seven buildings, varying in size from 40 by 100 to 1073 by 76 ft., and an office building; they contain 825,434 sq. ft. of floor surface and have a cubic content of 10,354,000 cu. ft. They present a somewhat typical condition in cotton mills, where buildings have been built of various types over a period of many years. The mills under consideration still use a building of three stories put up in 1837, and they occupy subsequent buildings, including their largest mill, consisting of five stories with basement, built in 1876.

The heating system was divided into two sections for convenience of regulation. The general direction of the mills was north and south, and the east side of the longer mill was on the top of a bluff 80 ft. above the river and exposed to extremely high winds. The mills being located in a northern latitude, where atmospheric temperatures of 20 deg. fahr. below zero are not uncommon, the question of different exposures of various portions of the plant was a special problem. Further than this, the plant naturally divided itself by its configuration into two manufacturing groups approximately equal in area; and consideration was given to the possibility of shutting down either of these groups and running the other at full capacity.

It was early determined that the regulation of the heat in the various departments should not be left to the individual overseers, but should be placed under the charge of the engineer in the power house, long distance reading thermometers being installed so that the temperature in different portions of the plant could be read there. By this method, the two primary factors of heat control, namely, the temperature of the water and the speed of its circulation, could be accurately regulated in accordance with outside temperature.

While there was no engineering objection to solving the problem by any one of the modern systems of direct steam heating, it was felt that the ability to control the temperature of water from a range of 100 to 240 deg. fahr. gave a flexibility to the system impossible of attainment in any other way. Practically stated, a steam system will operate economically only at full load, while a forced circulation of hot water can be readily regulated to meet all manufacturing and

[1] Harmony Mills, Cohoes, N. Y.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December, 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members, 20 cents to non-members.

weather conditions, and will maintain its efficiency at any degree of temperature.

The method of determining the amount of radiating surface required in various departments for a forced circulation system of hot water does not differ materially from the well-known methods employed in determining the heating surface of the number of heat units required for any other method of heating. Well-known factors were used in the installation described, and those in Table 1 are submitted as a basis for future determinations, bearing in mind that many modifying conditions apply which must be decided for each individual case.

The difference in temperature figured in the case under consideration was 70 deg. and the heat as that required to heat

	1	2	3	4
	B.t.u. Req'd without Leakage & Wind Exposure	B.t.u. Req'd with Leakage & Wind Exposure	B.t.u. actually Provided For	Percentage Req'd on each floor to Total Req'd in Bldg.
	1,810,000	2,672,100	1,778,000	24.0
	1,003,000	1,308,900	928,700	12.5
	877,400	1,158,000	1,348,100	18.1
	877,400	1,158,000	1,151,400	15.5
	865,000	1,128,900	2,219,700	29.9
Total	5,432,800	7,425,900	7,425,900	100 Per Cent

FIG. 2 SECTION OF MILL UNIT, AND PROPORTIONING OF HEATING COILS

the mills to 70 deg. in zero weather with temperature of water 212 deg. For temperatures below zero, it was considered that the ability to heat water to 240 deg. and the heat given off by mill machinery in operation were ample margins of safety.

TABLE 1 HEAT LOSS IN B.T.U. PER HR. PER SQ. FT. OF EXPOSED OUTSIDE SURFACE OF BUILDING FOR 1 DEG. FAHR. DIFFERENCE IN TEMPERATURE BETWEEN INSIDE AND OUTSIDE AIR

Medium	Heat loss B.t.u.
8 in. solid brick wall	0.40
12 in. solid brick wall	0.31
16 in. solid brick wall	0.26
20 in. solid brick wall	0.23
24 in. solid brick wall	0.21
28 in. solid brick wall	0.19
Single window	1.00
Double window	0.50
Slate on tight wood roof	0.30
Standard mill roof 2½ in. plank T. and G.	0.18

The engineer will find plenty of opportunity for the exercise of his judgment in determining the percentage loss of heat to allow for leakage, window exposure, roof exposure, and other factors depending in each case upon the location of the individual building, and many other problems arise from the character of cotton mill operation.

In comparing the cost of a forced circulation hot water system with that of a good exhaust steam system, it may be said that with the exception of the additional cost of the pumping plant required by the former, the cost of installation of either is about the same. The cost of maintenance of the hot water system is believed to be much the lower by virtue of gradual rather than sudden changes of temperature of radiating surface and absence of water hammer.

The amount of radiation in the case at point was also calculated on the basis that the system would be adequate to heat up the mill following a shutdown of several days at zero temperature. On this account, no allowance was made for the well known fact that cotton machinery gives off a great deal of heat during operation. Consequently, the theoretical water temperature necessary to heat the mills was found to be many degrees too high during ordinary running conditions.

Fig. 2, which refers to one of the largest of the mill units, will make clear the proportioning of heating coils. The departments in this five story mill are shown in transverse section, together with the location of the heating coils on the side walls or ceilings. In this building there are about 1500 belt openings between the first and second floors.

Experience with the system later showed that more coils were placed upon the top floor and fewer upon the lower floor than were actually needed, this being due to belt openings mentioned and to the natural effect of heat leaking up through elevator shafts and other passages to the top floor of the mill, which also contained the spinning machinery, the kind of cotton machinery producing the most heat.

The heart of a forced circulation hot water system is the pumping plant. The pumping layout in these mills is shown in Fig. 3. The essentials of each unit are a closed heater, of the feedwater type, and a pump. Two pumps are used normally, one for each section of the mills. Each is connected to its own heater and is so arranged that in case of breakdown the third pump or heater shown can be used interchangeably with either of the two sections of the system. As to the type of heater, one with a short coil is preferable, to be run with the steam inside the coils surrounded by the water in the shell; this is an essential feature of the system, as the heater coil must be so proportioned as to clear itself readily of the water of condensation, which, at times of starting-up especially, is large in volume.

The heaters for this installation were of extra large capacity and adapted to use exhaust steam to heat the circulating water in any but the most extreme weather, when live steam is used. Their strength, however, was proportioned to receiving steam at full boiler pressure of 180 lb., so that in case of an accident to a valve when using live steam no danger could arise from explosion.

The three heaters were installed in connection with a boiler feedwater heater of the same size; and by a proper arrangement of valves, a greater or less amount of the exhaust steam furnished by the pumping plant and auxiliaries of the station could be used in the circulating water heaters or the feedwater heater as was required. The temperature of the circulating water could thus be maintained at any desired value.

Whether the heaters were using live or exhaust steam, the drips were collected in an open heater to which the make-up water of the boiler plant was added and thus were pumped back through the closed feedwater heater to the boilers.

In the present instance, the heating plant was installed in a station used only as an auxiliary unit, and a large amount of exhaust steam from auxiliaries was not available at all times, the main steam turbine being run condensing under high vacuum. For this reason steam driven pumps were installed, and it was found in practice that, except in extreme weather, they furnished sufficient steam to heat properly the circulating water. As the returns from the heaters were immediately delivered to the boilers, very little loss occurred in the transference of heat to the circulating water.

It can be readily seen that, in cases where a power station is used as a primary source of power, where large amounts of steam are used for service pumps or other purposes, an electrically driven or other form of power driven pump might prove most desirable. But it is the author's opinion that, unless the power plant in question operates on a twenty-four hour basis, a method of pumping by steam for a portion of each day should be installed, as it is the universal experience of textile mills that the larger proportion of the heat required during the twenty-four hour day must be supplied when the mill is not running. With the exception of a few departments, such as weaving, in any but the most extreme weather the heat engendered by the machinery is sufficient to keep the rooms at working temperature after 8 or 9 A. M.

As the system centers round the pumping plant, this was necessarily installed at an additional cost over what would be required for a system of direct steam heating, but the advantages of centralized control and steady and uniform temperatures more than offset the additional cost entailed. In the example under consideration, the pumping plant cost 29 per cent of that of the total system.

To obtain records showing the result of the system in actual service, the steam pipe supplying the turbine pumps, from which also the live steam was taken for the heaters in case of need, was furnished with a steam meter and, as a check, all other lines in the power plant leading to the main turbine, for mill uses and other purposes, were also metered. The total result was checked by a venturi meter on the feedwater side, and over a period of years the sum of these metered results checked within approximately 5 per cent, an amount which could be easily accounted for by boiler blow-offs, leakage, emptying of boilers, and other minor losses. Another meter was placed in the branch line feeding the circulating pumps alone, so that by subtracting the amount of steam required to drive the pumps, the steam going direct to the heaters could be accurately determined. A third meter in connection with the heating system was installed in the exhaust pipe as a check upon both the amount and the direction of flow of steam, as to whether or not the heaters were receiving exhaust steam from power plant auxiliaries, or whether exhause from the circulating pumps was being put into the feedwater heater supplying the boilers. Furthermore, two other flow meters measured all the water circulating through each of the two parts of the system, and these two main pipe lines were equipped with recording thermometers, giving the temperature of flow and return in each.

A summary of the records for the heating season 1914-15, is given in Table 2. The figures giving the average boiler horsepower for twenty-four hours are significant, and the author believes that no such result has ever before been accomplished in a textile mill of this size. Previous experience in other mills of about half the size of the one under consideration, heated by a combination system of direct steam and indirect hot air, gave results expressed in boiler horsepower of approximately twice the horsepower required in proportion to the size of the respective mills.

After the operation of the system had become thoroughly standardized, a marked saving in temperature of water and consequently in coal was effected. This result was accomplished after careful study of the amount of heat given off by manufacturing and machinery, attention to double windows over 80 per cent of the mill, elimination of draughts through stairways and elevator shafts, and any other conditions which prevented the system working at its best efficiency. This proves the chief claim that centralized control of heating in textile mills is the method for the most efficient results.

Fig. 4 shows a plot of the total steam consumption per day with different outside temperatures during all full working days when the system was in operation during the past 2½ years, Mondays and the days following holidays excluded. It is noted that 500 boiler h.p. is required to heat the mills in zero weather. No heat whatever is required when the outside

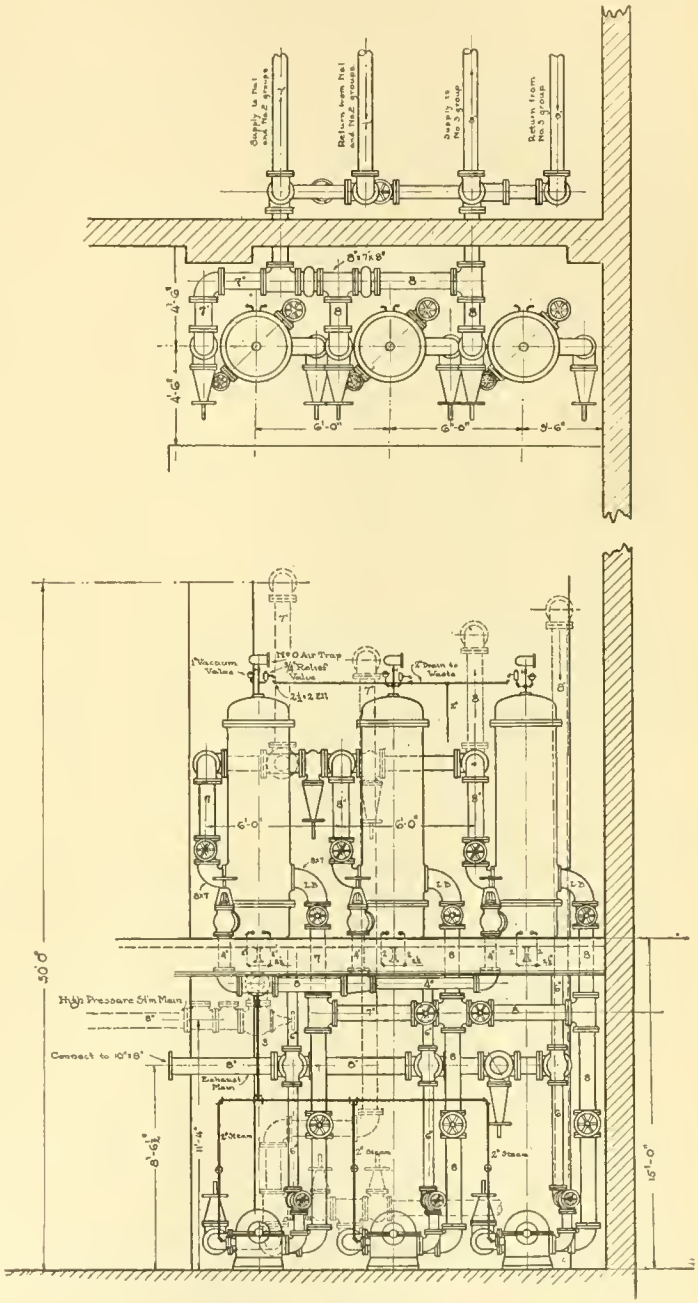

Fig. 3 Heating System Pumping Plant

temperature is above 50 to 55 deg., yet a temperature of 75 deg. is maintained throughout the mills. It must be remembered that about 7000 h.p. is used to drive the machinery; all this power is dissipated in heat from the spinning frames and other machinery, and its total heat equivalent is about 180,000,000 B.t.u. per 10-hr. day, or substantially 180,000 lb. of steam. Therefore, if this heat equivalent is added to that supplied to the heating system, we find the upper dotted

line extended to the base line would indicate no heat required with an outside temperature of 74 deg. fahr., which is substantially the average mill temperature maintained.

Fig. 5 gives a plot of heat supplied to the mills during Sundays and holidays during the past 2½ years when the system was in service. It was not the intention to maintain full working temperature of the mills when they were not running and a room temperature drop of 5 to 10 deg. usually took place, which was made up on the day following; therefore, the amount of heat on these days was less than that required to maintain a uniform temperature and that supplied on Mondays and the days following holidays was greater. An average line through the plotted points intersects the base line at an outside temperature of about 70 deg. and shows conclusively that more heat was supplied to the mills on Sundays and holidays than on full working days, even though the same temperature was not maintained.

The results from the operation of this system have demonstrated two facts: that the proper heating of textile mills is based on the one hand on a thorough understanding of the engineering problems involved, and on the other hand on a careful watching of losses of heat, which can be most readily accomplished by having the plant under centralized control.

Losses in heat arise from many causes. Our experience shows that the benefit of double windows offsets their cost many times, not only on the side of the mill exposed to prevailing winds but on all sides; in the case in question 80 per cent of the mill windows are double windows. Openings from the heated rooms to entry ways and elevator shafts are a constant cause of loss, especially at night, and during the first years of this system constant vigilance was necessary to impress upon night watchmen the importance of keeping all such openings closed. Non-enforcement of this regulation means that all the heat of the mill becomes centered in the upper story, where it is lost by the opening of windows, made necessary to keep the room at a working temperature. If study and proper regulation is made along the above indicated lines, except in extreme weather, heating can be confined in the daytime to the lower floors of the mill, to the weaving and carding departments, and to portions of the mill where very little machinery is in operation.

Certain other general subjects naturally fall within the

TABLE 2 OPERATION OF HARMONY MILLS HEATING SYSTEM 1914–1915

Week Ending	Average Outside Temperature Deg. Fahr.	Total Steam to Pumps and Heaters Thousand Lb.	Average Boiler H.p. Equivalent 24 Hr.	Total Heat in Steam Million B.t.u.	No. 1 Group of Mills					No. 3 Mill				
					Per Cent Time System in Service	Total Pumpage Million Lb. Water	Temperature Water Flow Deg. Fahr.	Temperature Drop in Deg. Fahr.	Mill Temperature Deg. Fahr.	Per Cent Time System in Service	Total Pumpage Million Lb. Water	Temperature Water Flow Deg. F.	Temperature Drop in Return Deg. F.	Mill Temperature Deg. Fahr.
Nov. 7...	49	242	43	240	27	20.2	117	7.2	73	18	15 3	108	5.8	75
14...	39	569	100	563	58	43.3	125	10.6	72	43	39.7	111	7.8	74
21...	33	961	170	952	78	63.1	136	13.1	73	71	57.1	117	8.8	73
28...	32	1,333	236	1,320	97	72.0	150	26.4	74	89	70.5	128	11.8	77
4 weeks...	38	3,105	137	3,075	65	198.6	132	....	73	55	182.6	116	....	75
Dec. 5...	41	638	113	632	76	49.4	137	23.0	74	66	43.1	110	5.3	80
12...	31	1,203	212	1,191	96	69.4	153	28.1	74	86	63 1	126	12.7	80
19...	24	1,667	294	1,650	100	70.7	173	27.8	76	95	73.9	127	15.1	77
26...	16	1,972	348	1,952	100	68.4	173	32.7	73	99	75.6	142	18.8	77
Jan. 2...	20	2,379	419	2,355	100	74 0	169	14.2	75	100	85.5	157	15.5	78
5 weeks...	28	7,859	277	7,780	94	331.9	161	....	74	89	341.2	132	....	78
Jan. 9...	27	1,623	286	1,607	88	64.8	154	11.4	75	87	69.2	143	10.7	77
16...	31	1,323	234	1,310	87	63 1	149	9.5	73	83	65.8	139	7.0	81
23...	32	1,103	194	1,094	73	51.5	153	11.2	75	67	53.1	136	6.7	78
30...	23	1,424	252	1,410	84	55.3	155	11.1	74	81	60.7	146	10.2	78
4 weeks...	28	5,473	241	5,421	83	234.7	153	....	74	80	248.8	141	....	79
Feb. 6...	20	1,876	331	1,857	87	57.3	160	11.4	76	82	60.7	152	11.3	83
13...	26	1,399	246	1,385	95	58.4	146	10.7	74	91	65.1	131	7.9	77
20...	32	1,202	212	1,190	83	47.2	148	11.2	76	74	53.3	134	10.0	82
27...	36	750	132	743	63	35.1	128	10.2	76	48	34.0	124	9.6	84
4 weeks...	29	5,227	230	5,175	81	198.0	146	....	75	74	213 1	135	....	82
Mar. 6...	25	1,529	270	1,514	92	52 9	152	13.0	75	79	63.4	133	8.4	80
13...	33	972	171	962	81	50.3	138	11.1	73	68	52.8	126	8.6	78
20...	35	1,066	188	1,055	93	57.4	147	10.4	75	64	43.1	125	9.6	80
27...	38	917	161	908	77	44.8	145	9.8	71	61	46.1	125	8.0	80
Apr. 3...	34	1,082	191	1,073	90	55.1	144	9.3	....	65	50.3	132	8.3	81
5 weeks...	35	5,566	196	5,512	87	260.5	145	....	74	67	255.7	128	....	80
Apr. 10...	48	422	74	418	41	25.1	141	9.4	....	24	17.3	121	5.6	....
17...	50	275	48	272	28	15.4	141	10.3	....	24	17.5	121	6 0	....
24...	56	95	17	94	10	6.5	122	11.0	....	5	2.7	102	8.6	....
3 weeks...	51	795	46	784	29	47.0	135	....	....	21	37.5	115	....	....
25 weeks..	35	28,025	198	27,747	73	1,270.7	145	...	74	64	1,278.9	128	....	79

limits of the above discussion. The relative merits of heating circulating water by live steam and exhaust is a matter to be decided entirely by the individual plant, as already indicated, and is based upon the conditions of the power plant operation and the available supply of exhaust steam. Where the amount of steam required for heating or other purposes is a small percentage of the amount required for power, it is not good judgment, in the author's opinion, to interfere with the highest possible efficiency of power production by the use of a small portion of the exhaust steam from the main power unit for heating purposes, and the question involved in that can usually simmer down to a matter of figures.

Offices or other rooms which require more heat or heat at different times of the day than is required in the mills and which do not share in receiving heat from manufacturing and machinery, must be separately provided for. These, however, represent usually but a small percentage of the total heat required that the general problem of mill heating is not affected by them.

In the mill in question, the office building is a detached structure, and during the first year of operation it is safe to say a large amount of heat was wasted by having this connected to the main mill system, as heat was required in offices on mild days when none should have been used in the mills. This difficulty was overcome by installing a siphon system of heating and circulating the water in this building by a special form of ejector or steam siphon which could be operated or closed off entirely independent of the mill system.

In the installation described another method of running circulation coils would have been preferable to the one used.

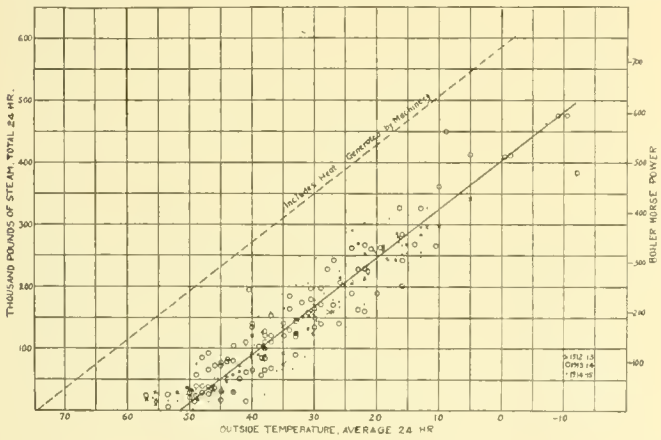

Fig. 4 Steam Consumption Per Day

The method used was the standard one, running the supply mains to the top floor of the respective mills and then, after distribution through the coils on this floor, returning the water through return drops to the return mains placed in the bottom story; in other words, the distribution was in a vertical direction. Although not affecting the efficiency of the heating system, a method of circulating the water through each floor or department by itself, leading out of and returning to vertical risers and return mains is preferred in a cotton mill using different processes on each floor, as it enables the heat to be put on and taken off of each department by the operation of the fewest possible valves.

DISCUSSION

Charles H. Bigelow said he noted that live steam was used for heating hot water part of the time, and the location of the heater required that all the condensation should be returned to the boilers through the feed pumps, which caused an extra expense, which could have been avoided if a closed heater was located in the upper part of the boiler house at a sufficient distance above the water line of the boilers, so that the condensed steam would return into the boiler by gravity, which would eliminate the expense of handling that steam, and thus make a further saving in the operation. As the upper floors of the mill would be above the location of this heater the pumps for handling the hot water could be located on the boiler room floor and would not have any extra work to do in handling the circulating hot water on account of the heater being elevated. This should be the most economical method

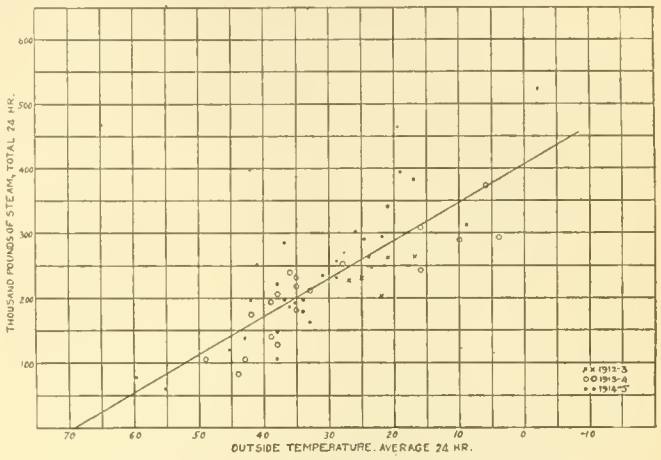

Fig. 5 Heat Supplied Sundays and Holidays

of heating the hot water as the steam would give up its latent heat of vaporization and return to the boiler without any work being done on it. In fact it would probably be more economical than trying to use exhaust steam part of the time, for as Mr. Duncan states, and as the speaker himself has noted considerable of the heating is required when no exhaust steam is available.

In a case of one large mill a hot water system was installed with the intention of heating the water by means of steam bled from a turbine. A reducing valve was also provided for use when the turbine was shut down. The condensation had to be returned to the boilers through pumps, which was a constant expense, and it worked out in practice that live steam was used a great deal more than the bled steam from the turbine, and that portion of the installation was not as economical as had been expected.

F. W. Parks said that a point the paper did not bring out was the comparison of coal cost.

There are very few industries that permit of a unit of heating cost comparison as well as does the textile industry. Mills running on the same grade of goods, and located in about the same climate, can be roughly compared in their heating costs on the basis of spindles, or looms, or production. In few other industries can such a comparison be made.

The cost of heating the mill which the paper refers to is just about half that of any other mill that he knew of, on anywhere near the same grade of goods, with the same necessary processes of manufacture. He said this statement was particularly true of the coal costs which he had of mills in New England that are doing their heating by exhaust steam or live steam, and that he based it on figures he had for Mr. Duncan's mills of the cost per spindle, the cost per square foot, the cost per cubic foot, and the cost per loom.

A. F. ERNST asked whether the heating and control of the atmosphere in the mill is automatic, or whether it is left to the operating engineer. He asked also whether there is any attempt made to control the humidity of the mill, and if so, what is the means of humidifying.

THE AUTHOR. In answer to the question whether the heaters could not be placed on top of the boilers, fed with live steam and the drips returned to the boilers by gravity, I would say that this plan was considered and in fact has been adopted by the author in a previous installation in a smaller plant. In the present case, however, it was desired to arrange the heaters so that they could be readily operated either by live or exhaust steam without the use of traps or other complicated devices.

The power plant in this mill is a steam turbine and it was considered at the outset whether exhaust steam should not be bled from the main turbine exhaust for heating. The knowledge, however, that most of the heating would be done when the turbine was not in operation, decided against this plan.

The power plant has steam driven auxiliaries and in addition to the usual boiler feed pumps and the circulating pumps for the heating system, a combination motor and steam driven unit, consisting of centrifugal injection and air pumps for the main turbine condenser. We had consequently a large and varied amount of exhaust steam from auxiliaries and never attempted to use steam from the main unit. By dividing the load of about 150 horsepower between the motor and steam turbine driving the condenser pumps, the amount of exhaust steam can be accurately limited to the amount that the feed water heaters and the heaters of the heating system can condense without excessive back pressure. We can also easily adjust the amount of steam going to the feedwater heater or the heaters of the heating system. These heaters were also placed high up in the plant and drained by gravity to an open heater to which make-up water was added and the feed pumps located lower than this open heater, took their suction from it under a head. Another reason we did not put the heater on top of the boilers and limit their use to live steam, was because we found during zero weather our water power was so irregular that calls on the steam plant were made to its full capacity; consequently, at such a time our auxiliaries are running full blast and have plenty of exhaust steam which can be utilized in the heating system and the water condensation easily pumped back to the boilers through the arrangement of an open heater as mentioned before.

In regard to the question by Mr. Ernst, the control of the heating in this mill is not automatic, but is done by the engineer in the power plant using a chart showing the temperature of water to be carried in relation to outside temperature. In times of very mild weather, additional regulation can be secured by running the circulating pumps at reduced speed. We have found this method amply able to take care of the varying requirements for heat at different times during the day in the different rooms of a textile mill without the expense and complication involved in automatic control of either water temperature or flow. The humidity control is left in the hands of the foreman of the different departments and is non-automatic.

The United States Bureau of Standards has made an investigation of the causes of failure and deterioration of fusible tin boiler plugs in service. The report of this investigation is embodied in Technologic Paper No. 53, issued by the Bureau.

RELATIVE VALUE OF PRIVATE AND PURCHASED ELECTRIC POWER FOR TEXTILE MILLS

BY F. W. REYNOLDS AND DAN ADAMS, BOSTON, MASS.

Members of the Society

THE rivalry between the isolated plant and the central station has called forth many valuable and interesting papers, usually prepared by those most vitally interested either in the isolated plant or the central station. It is perhaps safe to state that it is difficult to prove the general proposition entirely in favor of one side or the other. Each case is a problem to be decided on its own merits, and the correct solution can be assured only by a correct evaluation of all the various technical and financial factors involved.

RELATIVE COST OF PRIVATE AND PURCHASED POWER

Figs. 1 and 2 give the cost of purchased power for ordinary textile mill conditions for any load up to 2000 kw. These curves are plotted from the published schedules of public service corporations, one in New England and one in the Middle West. While rates as good as these cannot be obtained in all localities, still these are actual and representative rates. For comparison, the cost of private power has been plotted, using in each case the price of coal obtainable in the district served. The cost is for power delivered at the point of distribution at 550 volts in all cases. No provision is made for use of steam other than for power, and where such use is considerable, the relative cost of private power may be much lower than given. While the cost of purchased power given is actual, the cost of private power is theoretical, and is not intended to give more than an approximate and general comparison, but is based on known actual conditions.

In an actual private plant the power cost very often exceeds that given. The investment as stated is too low to cover any reserve or relay capacity, and therefore the reliability must be considered somewhat inferior to that of those central stations which were used for this comparison. Also, the investment will not take care of any disadvantageous conditions, such as expensive foundations or difficulty in obtaining condensing water; and no cost items are included for land or for coal in storage. All of these items are too indefinite to be included in a general cost estimate, but are always encountered to some extent. The operating costs assumed, while no better than should be obtained, are really somewhat lower than the average. Nothing has been included for supervision other than the actual power plant labor, but this supervision is usually a legitimate item of expense.

A textile mill load is properly considered somewhat more favorable than the average industrial load on account of its very steady demand for power, not only throughout the working period of each day, but also throughout the year and over a period of years. For this reason, special power rates can be obtained by textile mills in some localities, notably in the South, and to some extent in New England. Under these special rates, power usually costs about 1⅛ cents per kw-hr. for demands from 1000 to 2000 kw. and about 1 cent above 2000 kw. Such rates leave little financial inducement for the mill to build its own power plant.

It will be seen that the curves, Figs. 1 and 2, are very nearly parallel. This means that the size of the demand has little

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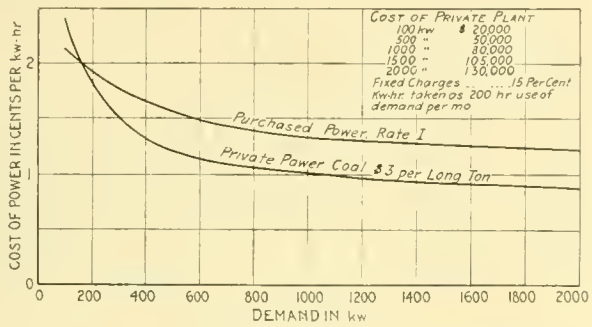
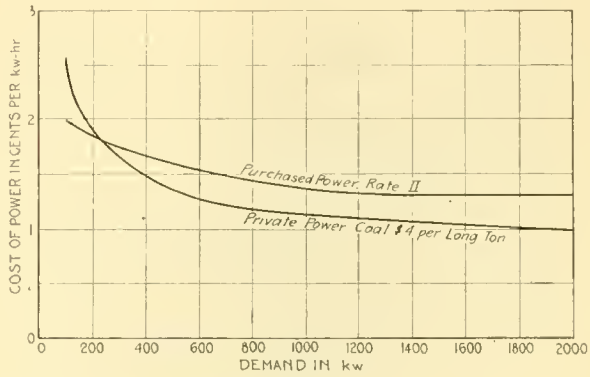
effect on the relative cost. The larger plants show a slightly larger proportional saving than the smaller ones, and the very small plants—under 200 kw.—cannot compete with the purchased power rates given.

Figs. 3 and 4 have been prepared from the same data as Figs. 1 and 2, to show the effect of load factor on the cost of power in the case of a 1000-kw. demand. It will be seen that the curves for private and purchased power costs follow the same general direction. It appears, then, that load factor also has little effect on the relative cost of power.

There is a striking similarity between the curves shown for private and purchased power, both when the variable is the size of the demand and when it is the load factor. The inference is that these power rates were devised to compete with isolated plants rather than from actual costs, or desired rates, of the central station power. This is entirely logical, being simply an application of the law of supply and demand. If it be true that the cost of central station power is determined by the cost of generating in isolated plants, then it will be unnecessary to discuss further the relative cost. It is improbable that the central station will sell cheaper than the average isolated plant cost, and if its rates are very much higher, it cannot sell much power.

The above, of course, applies only in the case of new plants, where power can be purchased without any sacrifice of existing investment, and where steam is needed only for power. Also, it must be remembered that the individual plant may depart widely from the average.





Figs. 1 and 2 Relative Cost of Power for Loads up to 2000 kw.

All that has preceded is a comparison of purchased and private power where the private plant is not yet built. But, in the case of a going plant, the purchase of power would save operating expense only, and would not wipe out fixed charges on investment already made. Fig. 5 shows the cost of private and purchased power, as in Fig. 1, but without including fixed charges. This, then, is a comparison between purchased power and a going plant under good working conditions. The difference in cost is so great that it appears improbable that central stations can cause existing plants to shut down unless in the case of important changes or additions, or the necessary renewal of considerable apparatus, or because of extremely poor operating economy.

EFFECT OF USE OF STEAM ON COST OF POWER

Every textile mill uses some steam for heating and manufacturing. This factor is of great importance, and should always be weighed accurately in considering purchased power. In general, textile mills may be divided into two classes in this respect. The first contains those mills using only a relatively small amount of steam in manufacturing, and includes most silk and knitting mills and cotton and woolen mills not engaged in scouring, bleaching or finishing. Dye houses, finishing mills, print works, and textile mills which finish their product are included in the second class, and have a large but variable demand for steam in the process.

Slashing may be taken as typical of a small demand for manufacturing steam. Very often exhaust steam is used in this process. The pressure desired varies from 5 to 12 lb., which is a suitable pressure to bleed from an engine receiver or bleeder turbine. Only in rare cases would it be economical to run non-condensing apparatus to supply slashers on account of the high back pressure required and the relatively small demand. In the case of a bleeder turbine, the saving in live steam amounts to about 30 to 40 per cent of the steam bled. This saving is reduced by additional fixed charges on extra cost of turbine and exhaust piping, for a relatively small service, and, in a large plant with a long run of pipe, may be negative. For a rough figure, applicable to average conditions, the gross saving will be about $200 per year for each 1000 lb. per hour bled, with coal at $4.00 per ton. This figures out about $0.0001 per kw-hr. in the case of a large cotton mill, or about 1/50 of 1 per cent of the cost of production.

While there is no doubt that exhaust steam can be and is successfully used in slashers and similar machines, still live steam at reduced pressure has a tendency to reduce operating difficulties and increase production. When exhaust is used, there are apt to be occasional periods when results are not satisfactory, due to a temporary drop in pressure or excessive condensation or to adverse atmospheric conditions.

As regards steam for heating, there are two factors, often ignored, which militate against the use of exhaust in textile mills, especially in cotton and woolen mills. One is the large amount of heat liberated from the machinery during working hours and the second is the diversity in time between the use of power and of steam for heating.

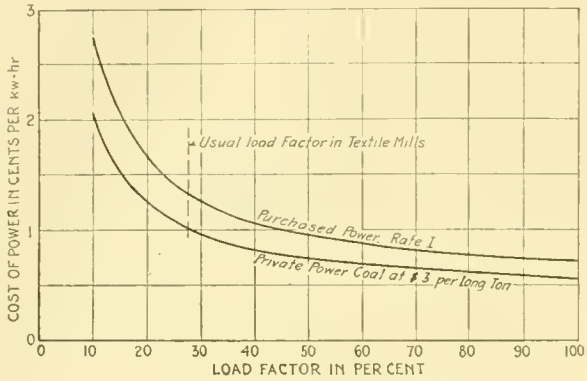
In some cases, the machinery provides more than half of all the heat required in zero weather, and for much of the heating season no extra heat whatever is needed during working hours, except in the storehouse and basements.

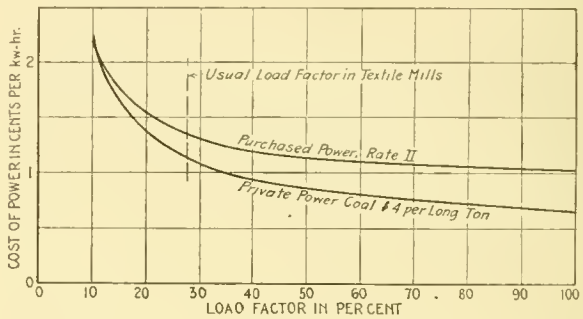
In a weaving mill in northern Massachusetts, where the power used per cubic foot of space is much less than in a balanced mill, the heating system was actually in operation only 25 hours per week average during working hours during the heating season, or about ¼ of the entire yearly operating time of the mill. Of course, all heat used outside of working hours —nights and week ends—must be live steam. If exhaust is to be used the rest of the time, as a general rule, it is proper to count on a demand only about one-half of the maximum, since the machinery provides the remainder, and this quantity

probably will not be used more than 700 hr. per year. The only way to meet a demand for exhaust of this character with economy is by bleeding from an engine or turbine. In a cotton mill cited above, bleeding steam for heating would effect a saving amounting to $0.00005 per kw-hr., a little less than in the case of slashers. In knitting and silk mills, the saving will be relatively greater, but in warmer climates much less.

It appears, then, that the coal saving effected by using exhaust steam for heating and slashing is very small—smaller, in fact, than the unavoidable errors in estimating the total cost of power. There is, however, some further saving due to economy in investment. It is apparent from the foregoing that if steam for these demands is bled, the extra boiler capacity necessary to meet them is reduced approximately one-half. Also, it is cheaper to get this extra boiler capacity as part of a larger plant built for power generation than to provide it in a separate plant by itself as would be necessary if power were purchased.

This matter was investigated in the case of a fairly large cotton mill. It was found that the complete power plant would cost $65.00 per kw., but if the cost of an independent steam plant for heating and slashing were deducted, the cost would have come out about $58 per kw., this latter being the figure used in comparison with purchased power.





FIGS. 3 AND 4 RELATIVE COST OF POWER FOR LOAD FACTORS 10 TO 100 PER CENT

While it is entirely unsafe to apply average figures to individual cases, it is desirable to form a clear conception of the relative importance of the various factors, and we may say that, in general, the entire fuel and investment saving due to the bleeding of steam for heating and slashing will range from $0.0005 to $0.0010 per kw-hr. A saving of this size cannot have a very important influence on a decision for or against purchased power. Nevertheless, the matter should always be considered.

A very different result is obtained in those mills having a large demand for steam for boiling water and drying cloth. In such cases, a large proportion of the prime mover exhaust may be utilized. In some cases, all power is produced in non-condensing apparatus, and all exhaust utilized, and manufactured power becomes then so cheap that no central station can compete. It is seldom, however, that a textile plant can utilize all of its exhaust all the time. This is because of diversity in time and amount between the use of steam and use of power. The importance of this can best be shown by citing an actual case.

Figs. 6 to 11 give curves showing the demand for steam in a worsted mill dye house for one week's operations. These curves are plotted from actual flow meter readings in exhaust main, which were taken every fifteen minutes. In this case the exhaust was provided by a non-condensing turbine. For comparison, the steam fed to the turbine was measured on one day and plotted. For the other days, the steam to turbine was averaged from the kilowatt-hour readings. The curves show how the demand for steam varies from hour to hour and day to day, and also lags behind the power load.

The demand for steam in a dye house is light early in the forenoon, but persists for two hours or more after the mill is shut down. The dye house does not run at all on Saturday mornings, which is a custom not uncommon. The result is a very large surplus of exhaust which must be wasted, and in spite of this, considerable live steam make-up is required, as shown by the curves. It is obvious that such conditions result in great inefficiency. Actually less coal would have been burned if a standard condensing turbine had been installed and live steam exclusively used in the dye house. The expected result of this installation was that power would be furnished as a by-product at a purely nominal cost. The actual result was that the power cost was considerably higher than in a plant having no use for steam in the process. This case is especially worthy of study because it is a typical balanced worsted mill of fairly large size doing its own dyeing; there were no special or unusual features involved: the installation was actually made, and the results as given were determined by careful tests.

The reasons and calculations leading to the installation of this non-condensing turbine are not known to the authors, but there is no reason to doubt that the installation promised to be very profitable. The total steam used in the dye house was considerably in excess of that to be supplied by the turbine, and it was apparently safe to assume that all exhaust would be utilized. With the turbine, there would be no trouble from oil, and the exhaust pressure was taken at 10 lb. to give good service.

The factors which made this attempt a failure were

a The diversity in time and variable demand for steam

b The deterioration of turbine which gradually increased its steam consumption

c It was found by experience that a few of the processes in which the use of exhaust steam was tried suffered either in quality or speed of production. For this reason the actual demand for exhaust probably was not as great as that estimated, although this difference was not very large.

It is evident that all of these factors may be encountered in any similar installation and must be allowed for in the estimates.

It is interesting to inquire if it would have been possible to make this installation efficient and still use exhaust steam. The demand is so variable that it is hardly probable that a non-condensing turbine could be satisfactory. It would be im-

possible to avoid surplus exhaust at times and live steam make-up at others. A bleeder turbine appears to meet the situation better, but is not without its difficulties. The required output of the turbine is about 1200 kw. The maximum amount that can be bled at that load from a 1200-kw. machine is about 12,000 lb. per hr., but the greatest demand for exhaust steam in the dye house is 50,000 lb. per hr. If the turbine has different characteristics, involving practically a 2400-kw. steam end, all the exhaust needed could be bled, but the turbine would run at half load economy. It would be better to use an intermediate size and bleed what steam is possible, supplying the dye house peaks with live steam make-up.

Table 1 gives the total steam used per week during the operating time of the mill for turbine and dye house for the operation as actually observed; as it would have been if guaranteed steam rate of turbine had been maintained; if a condensing turbine had been installed; and with a 1600-kw. bleeder turbine.

These figures show that the condensing turbine is cheaper to operate than the scheme installed, and is not much more expensive than any of the schemes. It is safe to state that the condensing turbine would have been the lowest of all in first cost and the most satisfactory from the standpoint of dye house operation.

TABLE 1 STEAM USED FOR POWER AND MANUFACTURING

	High Pressure Steam to Turbine Lb. per Wk.*	High Pressure Steam Make-up in Dye Ho. Lb. per Wk.	Total High Pressure Steam Lb. per Wk.
Present operation, 1200 kw. non-cond. turbine	3,110,000	....	3,110,000
Same with guaranteed steam rate of turbine maintained	2,466,000	47,000	2,513,000
With 1200 kw. cond. turbine	1,120,000	1,580,000	2,700,000
With 1600 kw. bleeder turbine	2,294,000	273,000	2,567,000

* Includes turbine auxiliaries. Condenser driven by motor.

In this particular case, then, a large demand for steam in the process has little influence on the relative cost of private and purchased power. If power generation in a condensing turbine with live steam used in the process is as economical as the use of exhaust steam, the comparison previously made between purchased and private power where there is no demand for steam is approximately true in this case. There would be some investment saving in providing steam capacity for manufacturing as a part of a larger plant.

It is hardly possible to give general figures of any value to show the effect of large steam demands on the cost of power. In many cases, the factor is of less importance than has commonly been supposed. Nevertheless, it seems entirely improbable that purchased power can compete successfully in very many cases of this kind. The success of the private installation, however, depends very largely on the skill and thoroughness of the preliminary study of conditions, with special attention paid to the diversity factor and to the variations in demand.

RELIABILITY, DESIRABILITY, ETC.

In textile work, the reliability of power is usually of greater importance than its cost. This is because the cost of power is a very small item in the cost of manufacturing, whereas reliability affects the earning power of the whole mill at its foundation. It is rather difficult to collect satisfying statistics on power reliability by each method of supply. One cotton mill buying power reports interruptions totaling 45 min. in five years. In this case the transmission line was less than half a mile long. Reports from several central stations give total interruptions on the individual lines ranging from 12 min. to 4 hr. per year.

A hydroelectric company in the South, which sells to many mills, reports that interruptions of service to textile mills from all causes have averaged less than 2/5 of 1 per cent for the last nine years. Such records are doubtless better than the average. A large number of managers of representative mills in the South purchasing hydroelectric power state that they consider this more reliable than private steam power.

In most cases, purchased power is transmitted electrically by pole lines. Where these lines are short, well constructed and in duplicate, the reliability is very good. On the other hand, a single line many miles in length and fed at a long distance from the consumer is subject to interruptions and regulation troubles. It is fair to state, however, that great improvements have been made in the reliability of transmission.

The reliability of generation is usually better in a large central station than in an isolated plant, and this is especially true when a number of stations are tied to the same system.

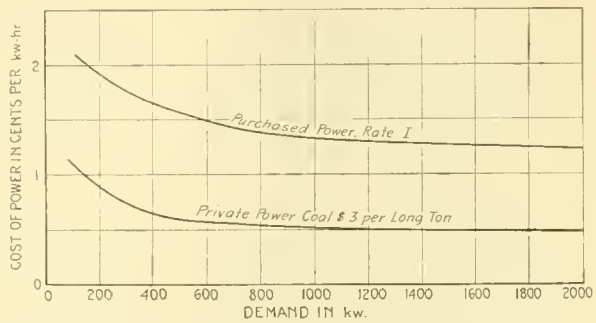


Fig. 5 Relative Cost of Power, without including Fixed Charges

In considering the purchase of power, reliability should be treated as a very important factor, and carefully investigated. If there is any serious question on this point, the private plant would be the wise decision in most cases.

Assuming that reliable power can be purchased at a cost approximating that of private power, it is not apparent that there are any attending disadvantages. There are, rather, many points in its favor. The saving of investment for a power plant often is considered important, especially when that money can be invested to better advantage in the manufacturing plant.

Specialization in manufacture of product only is worth something. A considerable part of the effort of the engineering department of a mill is devoted to keeping the power plant running efficiently. Where cost of power is only 2 or 3 per cent of the cost of manufacturing, the services of the engineering department would probably be of greater value to the mill if devoted solely to keeping the producing machines running efficiently.

In the case of a new development subject to future growth, the central station offers a perfectly flexible source of power.

When a radical change in existing conditions is introduced it is inevitable that there will be some wrong applications. Whenever the purchase of power proves undesirable, or too expensive, it is easy to give it up. The fact that so very few plants have gone back to private power after once purchasing

is pretty good evidence that purchased power really is desirable.

POWER CONTRACTS

Conditions governing the use of power in textile mills are such that power companies often offer them special rates at a flat price per horsepower-year or per kilowatt-hour, with a guaranteed minimum. Such a contract would be received more favorably by the average mill man than one based on demand and monthly use of demand with various discounts, even though the final results were identical.

TABLE 2 POWER PURCHASED FOR TEXTILE MILLS

From U. S. Census Report for 1910

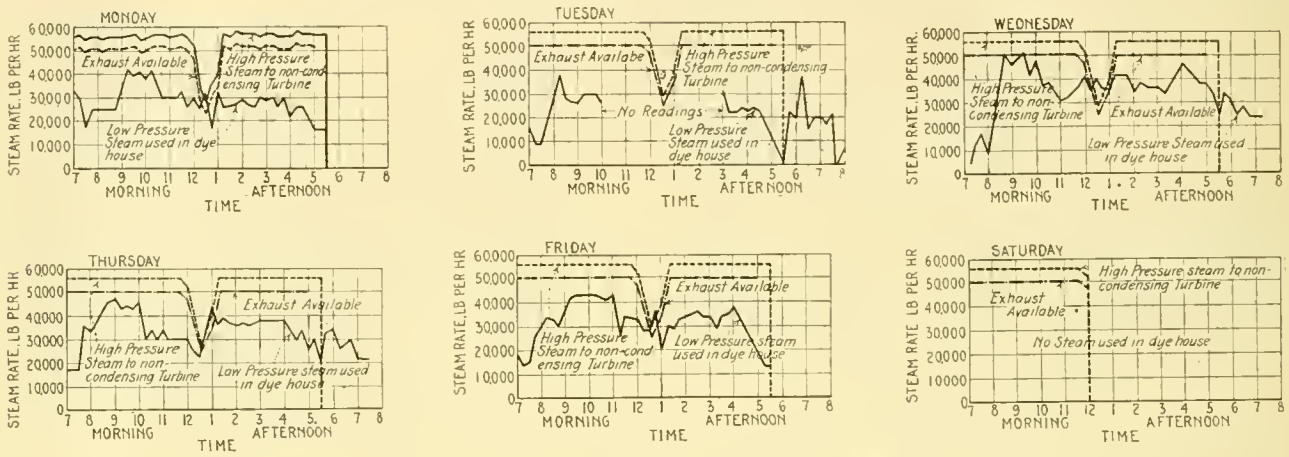
Industry	Total h.p. Used	Total h.p. Purchased	Per Cent Purchased
Cotton goods, including small cotton wares	1,296,517	108,512	8.4
Hosiery and knit goods	103,709	13,286	12.8
Silk and silk goods including throwsters	97,947	10,354	10.6
Woolen, worsted and felt goods and wool hats	362,209	13,783	3.8
Total	1,860,382	145,935	7.8 Average
All Industries	18,675,376	1,749,031	9.4

Contracts for purchased power should be carefully studied in all detail before signing, as there are many technical features which are sometimes made to react to the disadvantage of the consumer. In general, power companies show a tendency to get the consumer's point of view and to make their contracts more simple and more liberal.

PURCHASED POWER IN THE TEXTILE INDUSTRY

The figures in Table 2 from the 1910 U. S. Census show the total and relative amounts of power purchased in the various textile industries, and also the total figures for all industries, for the year 1909.

It will be seen that the hosiery and silk industries purchase relatively more power than the average textile mill, and this might be attributed to the comparatively small demand for power in these mills. The small use in woolen mills is probably due to the generally large use of steam in this industry. Since these figures were compiled, the capacity of central stations has more than doubled. It will be interesting to observe from later census reports if the use of purchased power in the textile industry has increased proportionately.



Figs. 6 to 11 One Week's Steam Demand in Worsted Mill Dye House

DISCUSSION

Fred N. Bushnell (written). One notable feature of the paper stands out prominently, and that is the absence of any attempt to show the relative value between mechanical and electrical drives, which indicates that material progress has been made in the trend of thought and state of mind with which engineers, closely in touch with textile problems, now view the application of the electric motor to this class of work.

One of the greatest difficulties encountered in any attempt to show comparative costs, and one that nearly always places purchased power at a disadvantage, is the incomplete knowledge of all the facts entering into the cost of private plant manufacture, and the necessity of assuming economies which may or may not be realized in practice.

The authors frankly point out that in an actual private plant the power cost very often exceeds that given; that the investment as stated is too low to cover any reserve or relay capacity; that the investment will not take care of any disadvantageous conditions, such as expensive foundations or difficulty in obtaining condensing water, also that no cost items are included for land or for coal in storage, all of which must be taken into consideration in studying the curves.

On the other hand a price named for purchased power is a definite, unequivocal and positively known quantity about which there is and can be no question, and this fact should also be borne in mind in any attempt at comparison.

We have now reached a period of highly developed specialized knowledge in matters immediately affecting our principal activities, and a tendency has very naturally developed to eliminate all problems of minor importance, not directly connected with our principal article of manufacture.

The shoe manufacturer is seldom a tanner of the leather or a weaver of the cloth he uses, the toolmaker does not mine or produce the steel he needs, nor the miller the wheat he grinds, and the day is approaching when the textile mill will find no more reason for manufacturing its own power than it will for the study of the intricacies and uncertainties of agriculture in order to supply its raw cotton.

The authors are to be congratulated upon the evident fairness with which they discuss the subject.

John A. Stevens (written). Although this paper purports to be an unbiased comparison of isolated and central station electric power, it conveys the impression that the latter is preferable.

As the authors state, each case is a problem to be decided on its own merits, and the correct solution can be assured only by a correct evaluation of all the various technical and financial factors involved. Each is, in other words, strictly a technical and financial problem which requires careful study indicating economies brought about by a certain investment, of which the savings affected by the increased economies represent a certain earning. Sometimes the balance is in favor of isolated power and sometimes of central station power.

A proper comparison of the two systems of power must include the following items, which are very often slighted, misrepresented or omitted: To the price of purchased power must be added the fixed costs of all transforming equipment, including housing, transformation losses and cost of attendance: and if an existing plant is superseded, its fixed charges must also be included at full value.

The cost of isolated power should include every item associated with the power plant, that is light, heat and power and all thereto connected, due reduction being made for use of steam for heating and manufacturing purposes. The fixed charges on the investment, 12 per cent of its initial value being sufficient, should include heavy foundation waterways and coal handling apparatus along with the other plant equipment.

It should be brought out here that careful design of the private industrial plant is of prime importance if central station power is to be competed with. In numerous cases of industrial plants having been pronounced failures, more attention was paid toward making the plant attractive than economical.

The question of reliability has often been brought up. A prime mover is as reliable in an isolated plant as it is in a central station, and if the isolated plant possesses more than one unit, reliability is not a factor. The prime movers in a well run plant are the most reliable parts of the plant. The weakest part of a central station system is its distribution, and from this source the prospective purchaser of power will experience the most inconvenience.

The authors' examples of power costs clearly represent special cases in which, with study from different aspects, the favor might be swung back to isolated service. In the case of the dye house, for example, numerous factors are not considered. Low pressure steam requires piping much larger than does high pressure. A combination of a condensing and exhaust steam turbine will greatly help out the diversity of steam and power demand, and at the same time eliminate some of the losses in bleeder turbines.

One of the most important features not mentioned is an absolutely controllable supply of low pressure or stage exhaust steam at some predetermined pressure. That is to say, whether or not a low pressure system can be installed in a plant depends on the amount of low pressure steam to be used, the amount of power to be used and the cost of installation of the low pressure system, including the additional rates imposed on the steam plant by the low pressure system. A suggested method of approach is a complete analysis of light, heat and power in its every minute detail, including the land occupied by the equipment as against the purchased power, where practically no space would be absorbed by an isolated plant. Further, it is to be specifically recommended that in every case power be purchased in the form of energy, that is, on the basis of kilowatt-hours used.

R. J. S. Pigott. The authors conclude that for small power plants there is very little chance for the isolated plant to make good. In the small plant, the duties for the men operating it are small and cannot occupy their whole time. A low grade man is very frequently employed, and only works part of his time in the power plant, causing the reliability to suffer.

For a fair comparison between the isolated plant and the central station another point which must be known is whether or not proper reserve is carried in the former. The authors state that in few industrial plants is a proper reserve carried, and this has been my own experience. Enough engine or turbine power is put in to run the plant when all the machines are operating, but no spare units are carried. Such a plant is not in a position to be compared fairly with purchased power, because it is not as reliable as a central power station. If the central station carries a 20 or 25 per cent reserve, the isolated plant ought to carry that much, if the reliability is to be the same.

In the cotton industry there is stated to be very little chance for the use of exhaust steam, which seems extraordinary. It is possible that the temperature demand is such that live steam direct to the machines must be used, but it would appear well for mill owners to remodel their processes so as to use low pressure steam wherever possible in place of high pressure steam.

In the works where I am now engaged, nearly half the steam put through the turbines is employed either in the processes or for heating. The power plant has a capacity of 13,000 kw. In this particular plant, low pressure steam, 15 lb. gage, drawn from bleeder turbines, is supplied. Whatever steam is not required for pressures or heating in the main plant is passed on to the condensers, with the consequent benefit of comparatively high economy on whatever steam is not used in the bleeder system. The steam consumption would be very nearly doubled if we were to use high pressure steam drawn from the boilers, and condense all the steam sent through the turbines.

We have remodelled a number of our processes in order to make use of low pressure steam; the effect upon kw-hr. cost is very pronounced, as the power from bleeder turbines is produced at 75 to 90 per cent thermal efficiency. The case is analogous to that of steam auxiliaries exhausting into a feed water heater.

From an inspection of most of the industrial plants which make use of steam in processes, it would appear that not sufficient attention is given to the ability of the bleeder turbine to furnish steam at a very low cost; and for those who are interested in the question of private or purchased power for industrial works, it would be very advisable to give serious consideration to the remodelling of their processes and heating conditons, to make as much use as possible of bleeder turbines. The growth of sales of this type of turbine in the last two or three years indicates that the advantages of low pressure steam for industrial purposes are being realized.

F. J. Bryant. This problem of exhaust steam came up when we enlarged the power plant of our cotton finishing works, where a large portion of the steam generated is used for drying. We considered the bleeder turbine very carefully and decided that it did not meet our needs.

We have at present a number of 5 to 10 h. p. "Twin-angle steam engines," which drive drying machines and serve a double purpose of speed regulator and reducing valve. The part of the machine which these engines control consists of a set of drying cylinders over which the cloth passes after it has been partly dried over steam coils. The steam in these cylinders, and the amount of steam in them, depends upon the weight of the goods which they are drying and the amount of moisture in them. As the engines discharge their exhaust into a header

which supplies the cylinders of several machines, very good economy is secured. If the pressure falls too low more is admitted by a reducing valve, and if it gets too high a safety valve lets it off. A turn of the throttle valve speeds up the work and lets more steam into the system. All drips and condensations are trapped to a hot well and then returned back to the boiler.

As we now have a surplus of low pressure steam, we are considering the substitution of an alternate current motor and variable speed transmission for one of the engines, and thus cut down the exhaust.

Arthur L. Williston. In this paper the author has assumed that there are three objections to the isolated plant: first, the lack of opportunity to use the exhaust steam; second, lack of margin in the plant; and third, lack of reliability. These are serious shortcomings for any plant to have, but I think it is important that we should not associate them with any particular type of plant. I am sure that we all know central stations that have at least one of these defects; and in some instances all three may be present. It is also true that isolated plants may be so designed and operated as to have none of them. The point that seems to me to need special emphasis is the fact that the same high quality of skill and judgment that is usually bestowed upon the design of the central station is, as a rule, equally important for the isolated plant.

For example, there is not the slightest reason why the isolated plant should not have as large a margin as is needed. It surely is not necessary to go to a central station in order to get a wide margin. It may be obtained in any plant.

Likewise, it is not necessary to go to the central station to get reliability. In the isolated plants with which I have had experience for the past twenty-three years (which happen to have been plants in educational institutions) we have had as great a degree of reliability as we could reasonably expect to have from central stations. In the last plant, since it was started five years ago, we have had practically perfect reliability. A central station does not always give an absolute 100 per cent of reliability.

During the previous discussion it has been pointed out that in an isolated plant processes may often be remodeled so as to use exhaust steam in place of high pressure steam, and that when this is done there is distinct economy in favor of the isolated plant as compared with the price of power furnished from a central station. In educational plants there is little opportunity to use steam for special processes, but they do use large quantities of exhaust steam for heating.

Our shop and laboratory buildings at Wentworth Institute contain equipment not very different from that found in a great many manufacturing plants, and are, for illustration, in almost every way quite typical of the small plants in a great many industries. It is our experience that the exhaust steam used for heating alone consumes all, or very nearly all, the exhaust of our power plant, for six months in the year. There is during the other six months a certain amount of waste, but for one-half of the year the only cost of light and power is a small depreciation charge for the engine dynamo and the renewal of the lamps. A very distinct economy will usually be found in favor of the isolated plant wherever conditions approaching these can be found.

In a great many instances wrong conclusions have, I think, been drawn when making comparisons between isolated plants and central stations because persons have relied on data drawn from improperly designed isolated plants rather than from the results that would be obtained from well-designed isolated plants with thoroughly up-to-date equipment and with all opportunities for economy taken adavntage of.

Charles H. Bigelow said that in connection with the problem of isolated plants, he had had some experience in using exhaust steam at a textile plant where there was a large demand for low pressure steam. A 500 kw. non-condensing turbine was first installed, and the exhaust steam used from that at about 8 lb. pressure. The demands for the exhaust steam were very variable, as well as the loads on the turbine; part of the time steam would be escaping through the exhaust pipe into the atmosphere, and at others the required amount would have to be made up through a reducing valve from the high pressure line.

They have since put in a 1000 kw. bleeding turbine, the load having increased, and installed a recording steam flow meter on the supply pipe to the factory. The load on the turbine was the factory load with a four or five-car traction load superimposed, the latter varying from nothing to 300 kw. almost instantaneously.

It was found from the charts that the demands for power as well as low pressure steam were very variable, but the bleeding turbine holds the pressure steady, at 10 lb., varying one pound each side of it as shown on the recording chart. The broad line is as straight as it could be drawn, showing that the regulating mechanism for holding the pressure steady in the first stage of the turbine is doing its part of the work, although it takes about two pounds variation in pressure to make it work.

Incidentally there is an indicating steam flow meter on the supply pipe to the turbine, and this swings from perhaps 15,000 to 30,000 lb. per hour, back and forth, depending on the load and the demands for steam. The bleeding turbine seems in this case to be solving the problem of supplying a variable amount of low pressure steam, without loss to the atmosphere as was formerly the case. The balance of the steam passes to the surface condenser through which the circulating water flows by gravity from a pond owned by the company and under winter conditions operates at over 29 in. vacuum. The condensate flows over a V-notch which incidentally gives a check on the two other measurements of input and the balance of output.

In regard to processes for using low pressure steam, there is a good deal of tradition in the pressure required for manufacturing processes. What is generally really required is temperature, and he wondered whether anything has ever been done to superheat low pressure steam when used in manufacturing processes.

Walter N. Polakov. In this very interesting paper, the figures and curves are based on averages of actual performance, but the question is whether what has been done in the past is necessarily giving information as to what should have been done.

It has been pointed out in the discussion that in mill plants the power plant employes are usually of not very high grade. The owners try to hire the cheapest kind of help they can get, and in my experience I have found that on an average between 30 and 40 per cent of the cost of power generation can usually be saved merely by a proper method of operation, as it is not very uncommon to see firemen in a mill wasting say 5 tons of coal a day.

Comparing cost curves of private and purchased power, and assuming that large public utility power plants are also not as efficient as they might be, the rate for purchased power

will probably be reduced in the future by 20 per cent. on the average; whereas, private power cost will also probably go down some 50 per cent. In other words, the difference between the costs of private and purchased power, as shown in Figs. 1 and 2, will be much more pronounced in the future than the authors pointed out from actual experience of the past.

Dan Adams. This paper was intended to be a discussion of the relative value of private and purchased power, as applied to the textile industry only, and the conclusions are not applicable to any other industry, such as machine shops. Mr. Pigott has shown the great savings which can be made from bleeder turbines in this latter industry, which is very different from the textile industry.

The chief difference in regard to the heating has been brought out very clearly in Mr. Duncan's paper. Simply there is no demand, or I will say only a small demand, for heating, coincident with the demand for power; and that is due to the large amount of heat liberated from textile mill machinery, which I think is peculiar to that industry.

Prof. Williston mentioned the saving by heating from exhaust in an institution, but the same thing holds true there. Of course there is a very large saving from the use of exhaust steam for heating in any plant where the demands for power or light and heating coincide, such as office buildings or educational institutions.

It was pointed out by Mr. Bryant and Mr. Bigelow that there are difficulties in controlling the use of exhaust steam in a textile plant, in order to obtain economical results. Usually these problems can be solved, and it is a fact that most textile mills of this character use exhaust steam very generally. It was not intended in this paper to discount the savings which can be made from using exhaust steam when conditions are suitable, but it was intended to point out some of the difficulties; and we feel that some expensive mistakes have been made when it has been attempted to apply exhaust steam to these processes, without an absolutely clear and detailed analysis of all the conditions.

Mr. Bigelow also cites the case of the bleeder turbine, which is running very successfully, and there are many such cases. The bleeding of steam through a turbine is undoubtedly very economical when conditions are suitable.

In the case cited in the paper we could not seem to produce very economical results by using a bleeder turbine, and this was owing to the relation between the demand for exhaust steam and the demand for power. It was found that at times the demand for exhaust steam was more than could be bled from a standard bleeder turbine of the right capacity. For instance, the power output was 1200 kw. and the total demand for steam at times reached 50,000 lb. per hour. All that can be bled from a 1200 kw. turbine is about 12,000 lb. per hour, which was inadequate.

Now, if you use a large bleeder turbine for the sake of being able to supply exhaust steam, you will necessarily reduce the economy of the turbine, when it is not bleeding, because you are then running it at part load economy.

In this particular case, there was no use for exhaust steam whatever for something over 10 per cent of the time. The dye house was shut down on Saturday morning, which is quite common in worsted mill dye houses. The combination of all these factors resulted in a very small saving in this case, but it does not necessarily follow that it would be so in all cases.

Mr. Williston mentioned the fact that isolated plants can produce power as reliably as central stations, and this point was also brought out in the paper, that isolated power is absolutely reliable if the isolated plant has sufficient relay capacity. It should be remembered, however, that if small plants are provided with relay capacity, the investment charges run up very fast and the cost of power then approximates or exceeds the cost of purchased power.

Mr. Polakov brings out the point that the private power cost given in the paper is subject to material reductions. While it is true, as he states, that industrial power plants can on the average be improved very materially, this is less true of the textile industry than of most industries. In other words, I believe that the textile mills have devoted more attention to the economical generation of power, and this is perhaps due to the fact that they are very large consumers of power.

THE ENGINEER AND THE BUSINESS OF FIRE INSURANCE

BY JOSEPH P. GRAY,[1] BOSTON, MASS.

Non-Member

THE large Factory Mutual Companies are today, almost without exception, managed by engineers who were educated and trained in their professions. The engineer's connection with the fire insurance business was first brought about by changing conditions in the manufacturing field, which demonstrated the need of more scientific methods for the prevention of loss by fire. Previous to 1880 or 1885, the fire insurance business had been carried on wholly, even by the management of the Factory Mutual Companies, in an empirical manner. The management of the Stock Insurance Companies devoted little or no attention to questions relating to construction and protection of property. Their efforts were devoted entirely to trying to estimate or guess what was the hazard connected with a particular piece of property and to obtain from the owners a sufficient amount of premium not only to cover the hazard, but also to protect the company against losses incurred on other property where their guess had not been correct.

The management of the Factory Mutual Companies was of a somewhat broader character. Their efforts had been devoted largely to advising their members how to care for their property and to giving them what advice they could on how to protect themselves against the fire hazard. At that time, the fire hazard connected with manufacturing was much less than at present, due to slower running machinery, less haste for product, and lack of volatile oils. The fire protection at the mills was of a rather primitive character, consisting of a few standpipes, to which hose was attached, and to which were connected force pumps of limited capacity, usually located inside the mill. In some cases perforated pipe sprinklers had been provided over the more hazardous portions of the property.

I must make one exception to my statement that, previous to 1880, the fire insurance business had been carried on wholly in an empirical manner. That exception was in Lowell, and an engineer, James B. Francis, the father of hydraulic engineering in this country, was responsible for it. In 1850, the ten corporations located in that city formed a mutual agreement for the payment of all losses incurred by fire. This mutual agreement, which was really an insurance company in itself, was in effect for thirty-seven years. Mr. Francis, who

[1] Pres. Boston Manufacturers Mutual Fire Insurance Co.

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at that time was engineer and agent of the power company in Lowell, which in turn was owned by the ten corporations in question, was given full power to lay out what protection, in his opinion, the mills needed, and to adjust all losses which occurred. He made a scientific study, the first of its kind, of the question of fire prevention in mills. Under his direction, a large reservoir was constructed on Belvidere Heights and was connected by 12-in. pipes with the hydrant and standpipe systems in all the mill yards. He also had a series of tests made of the flow of water in small pipes and through small orifices. From the results obtained, a scientific system of perforated pipe sprinklers was devised, and the mills were equipped with it. Mr. Francis' efforts were to such good effect that the average yearly fire loss during the period of thirty-seven years that the mutual agreement was in effect was only five cents on each one hundred dollars of capital stock of the corporations covered by the agreement. As the property value was largely in excess of the capital stock, the actual loss per hundred dollars of value was even less than five cents. I think it can be truly stated that Mr. Francis, in addition to being the father of hydraulic engineering in this country, was also the father of fire prevention.

In 1878, Edward Atkinson assumed the presidency of the Boston Manufacturers Mutual Fire Insurance Co. He very soon realized that the changing conditions in manufacturing required a more scientific study of the fire hazards connected with it than had been given in the past. He also realized that better means must be provided for the extinguishment of fires, which, due to manufacturing operations, were constantly occurring in our manufacturing plants.

Fires had been very disastrous in woolen and paper mill plants, resulting frequently in the complete destruction of the plants. Many insurance companies were reluctant, and some refused to grant any insurance on these two classes of property. The investigations which Mr. Atkinson instituted resulted in determining that the cause of the trouble in woolen mills was largely, if not wholly, due to the character of the oil used in oiling the stock, and in the paper mills was due largely to fires which originated from hot bearings located in dark and badly constructed basements. He then employed Professor Ordway, of the Massachusetts Institute of Technology, and one of the leading chemical engineers of the country, to make a thorough investigation of wool and lubricating oils. Professor Ordway's investigation was a most complete one and resulted in new types and mixtures of oils for use in oiling wool stock. Safer types of lubricating oils, also better methods of using them, were devised by Professor Ordway. His report was submitted to the manufacturers of oils, with the request that they carry out the suggestions contained therein. Further, it was printed and distributed to the members of the Mutual Companies with the request that they buy only such oils as it advocated, and that they send samples of such oils to the insurance company for test. The final result of Professor Ordway's work and the putting of his recommendations into effect by Mr. Atkinson was the bringing of the woolen mill into the class of preferred risks and reducing largely the hazard of fire due to friction of machinery in paper mills, metal works, and other places where heavy losses had occurred from hot bearings.

At about the time that Mr. Atkinson assumed the executive management of the Factory Mutual Companies, electric lighting was invented and arc lights had been installed in some of the mills, the current being conveyed to the lights over bare copper wires. Realizing the hazard connected with this method of lighting, Mr. Atkinson employed the best electrical talent available to make a study of the problem. The result was the first set of rules for electric wiring ever devised.

The automatic sprinkler had been invented just previous to Mr. Atkinson's entering the field of fire insurance. Investigations instituted by Mr. Atkinson clearly demonstrated the value of that piece of apparatus for extinguishing fires. At the time there was only one sprinkler construction company, and the pipe sizes adopted by that company were much too small and wholly inadequate. Many of the mills were equipped with a type of fire pump which was constantly failing. Fire hose was also proving defective.

The Inspection Department connected with the Factory Mutual Companies at this time was made up of men who, while they had an excellent knowledge of manufacturing operations, had but little or no experience along engineering or scientific lines. It was evident to Mr. Atkinson that the department should be reorganized along engineering lines. One of the first men brought in by Mr. Atkinson, and one to whom the success of the department's reorganization was largely due, was John R. Freeman.

Scientific investigations were made of all kinds of apparatus. Specifications for the Underwriter fire pump were devised and put into effect to such an extent that to-day that pump is the standard fire pump the world over. Rules and requirements for installation of automatic sprinkler apparatus were also laid down. A laboratory was organized for the testing of all kinds of apparatus, this laboratory being the first of its kind in the world. Mr. Atkinson lived long enough to see this inspection department become the largest and most successful one in the world, and he is largely, if not wholly, responsible for bringing the engineer into the insurance field.

The great success attending the work of the engineers in the Inspection Department resulted, as changes were made in the management of the companies themselves, in the transfer of a number of these engineers to executive positions, until to-day the executive management of nearly all of these companies is in the hands of engineers.

The fire insurance business of the country is today in a much safer condition than it ever had been in the past. It will, I think, be acknowledged that this condition has been brought about by the work of the engineer, and his influence upon the insurance business of the country is greater to-day than ever.

In the manufacture of brass and brass products, the weight of the finished product leaving the plant is much less than the total weight of copper and zinc entering. A small part of this discrepancy is due to the unavoidable oxidation of the metals in melting, but by far the largest part of the loss is in the form of metallic particles of copper, zinc and brass. These losses occur principally at three points in the process: (a) in the casting-shop ashes; (b) in the slags from furnaces melting scrap brass; (c) in material spilled on the floor throughout the manufacturing process. The amount of these products in some plants is nearly 100 tons per 24 hours.

In general the problem of reclaiming this metal has been to free the metal from adhering slag and separate it from the associated slag, coal and cinders. On its face, this problem appears simple. That it is not simple, however, is attested by the concentrations of fine metallic particles in the sewers and stream beds of the New England brass manufacturing districts.

In the February *A. I. M. E. Bulletin* are described tests carried out on a Hardinge conical ball mill for grinding the slag while allowing the brass to be separated by screening.

MISCELLANEOUS PAPERS

FOUR-WHEEL TRUCKS FOR PASSENGER CARS

BY ROY V. WRIGHT, NEW YORK

Member of the Society

THE Pennsylvania Railroad uses four-wheel trucks under all of its passenger coaches, although the P 70 class, 70 ft. in length and having a seating capacity of 88, weigh light from 118,000 to 122,000 lb.; loaded with passengers they weigh about 135,000 lb., and never more than 140,000 lb. It is the standard practice on that system to use such trucks under all passenger equipment cars weighing less than 120,000 to 125,000 lb., except for so-called load carrying cars, including baggage-express, mail, baggage-mail, etc., which are designed to weigh over 140,000 lb. when loaded. The light weight of the bodies of the Pennsylvania P 70 coaches—and these are now standard on that system—varies from 93,000 to 96,000 lb. It is assumed that these cars regularly carry as much weight in passengers and hand baggage as coaches on other roads, inasmuch as they seat 88 persons, or several more than the maximum provided for in the standard coaches of most roads. It is the practice on the great majority of railroads to use six-wheel trucks under coach bodies weighing much less than this, comparatively few roads using four-wheel trucks under bodies weighing more than 85,000 lb. and many of them using six-wheel trucks under bodies weighing even less than this.

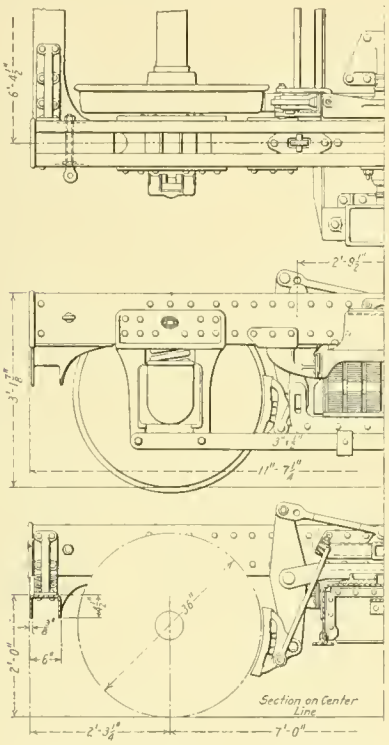

FIG. 1 ORIGINAL FOUR-WHEEL STEEL PASSENGER CAR TRUCK BEFORE APPLICATION OF CLASP BRAKES

In designing the trucks for a passenger coach four features must be kept in mind, and generally in the following order as to importance, although there may be some question as to the relative value of the last two.

a They must be designed for safety.

b They must ride smoothly, for travelers are particular as to this in these days and will desert a road with rough riding cars if a competitor furnishes better service. With heavy steel cars operated in long trains at high speed and with the locomotives taxed to the limit of their capacity, it is difficult to operate and brake the trains without occasional roughness and jolts, and a factor such as truck design cannot be allowed to contribute further to the rough riding.

c The weight of the truck must be kept to a minimum if for no other reason than the effect on the cost of conducting transportation.

d The truck should be designed with a view to keeping the cost of maintenance as low as possible. Here, as in the

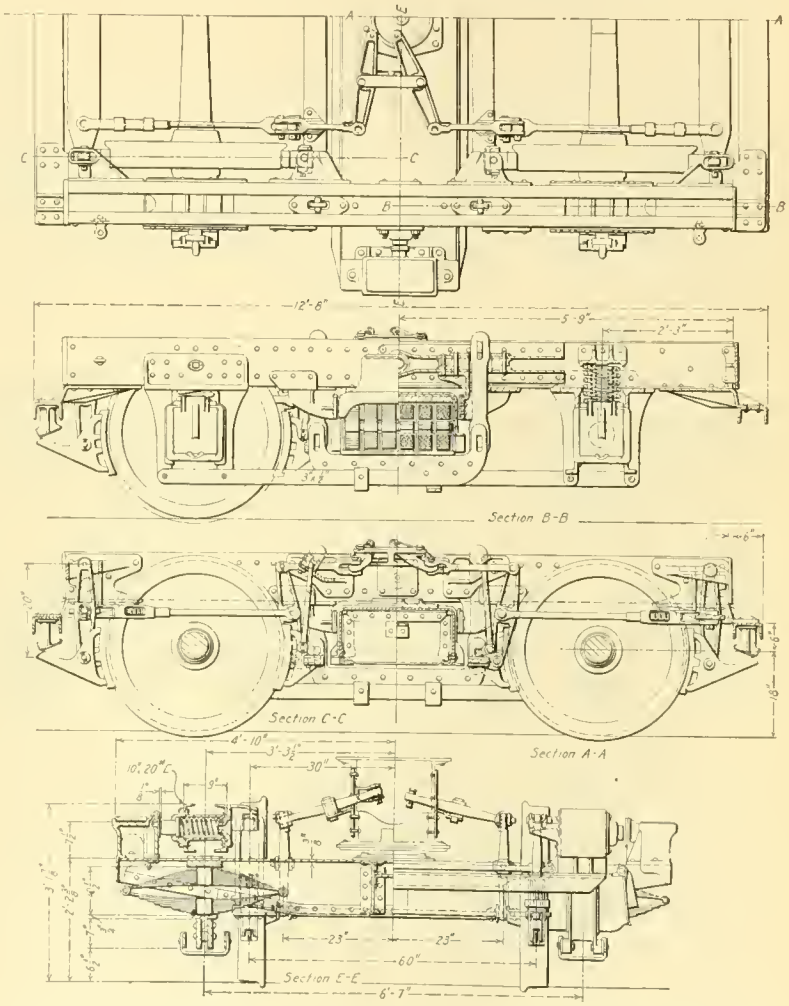

FIG. 2 ORIGINAL FOUR-WHEEL STEEL PASSENGER CAR TRUCK WITH CLASP BRAKES APPLIED; PENNSYLVANIA RAILROAD

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies without discussion may be obtained; price 5 cents to members, 10 cents to non-members.

requirement for safety, it is desirable to have as few parts as possible and of simple construction.

How does the four-wheel truck meet these requirements under the heavy passenger equipment on the Pennsylvania Railroad?

a The four-wheel truck of modern steel construction which has been in use on that system for a number of years has given splendid satisfaction so far as safety is concerned. As on other roads, some trouble has been experienced with hot boxes and it was at first thought that the journal bearing area was too small. The use of large bearing areas does not seem to have materially improved conditions and it is now believed that the difficulty is entirely due to dirt or gritty matter entering the journal boxes. The problem then becomes one of improving the journal box lid and dust guard to prevent this, rather than to increase the diameter or length of the journals.

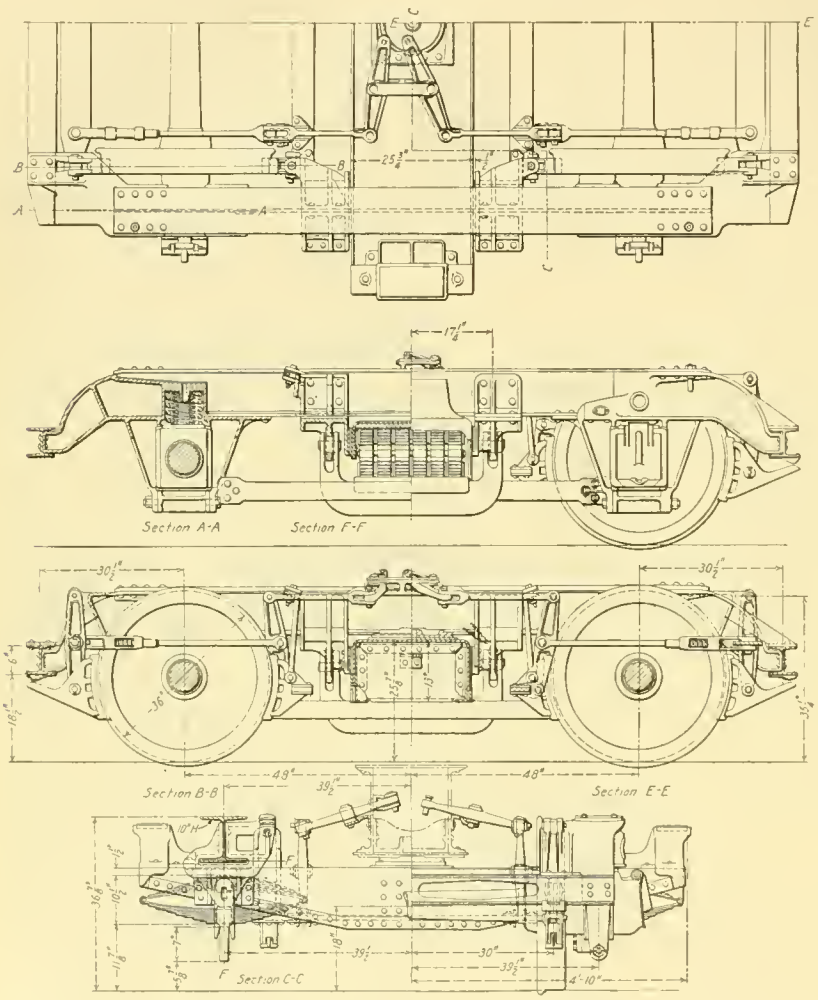

Fig. 3 Present Standard Four-Wheel Steel Passenger Car Truck; Pennsylvania Railroad

There has been no breakage of axles, except for three cases due to defective material when the first steel trucks were introduced many years ago. No physical weakness has developed in any of the parts in the ten years the trucks have been in service, so that as far as safety is concerned there can be no question. The possibility of accident would seem to be less with the four-wheel truck because of the smaller number of parts required.

b There seems to be a feeling on the part of some mechanical engineers that the four-wheel truck, with its shorter wheel base (7 or 8 ft. as compared with 10 to 11 ft. for the six-wheel truck) will ride less easily than the six-wheel truck. With coil springs over the journals, elliptical springs under the bolster, and provision for lateral motion of the bolster, it would seem that there ought not be much difference in this respect.

Experiments show that much of the rough riding or jolting on passenger coaches has been due to the method of anchoring the top of the dead lever to the truck frame. The unbalanced forces in the truck when the brakes are applied tend to tilt the truck frame out of horizontal alignment, thus causing a "jerky" action. By anchoring the dead lever to the body underframe this is eliminated. This development is comparatively recent and affects the six-wheel as well as the four-wheel truck. The effect of anchoring the dead lever to the truck frame has possibly been more noticeable on the four-wheel truck, because 1— to —1 dead levers are used, resulting in a greater pull on the frame than in the case of the six-wheel truck; then, too, the resisting moment is less because of the shorter wheel base of the four-wheel truck. This improvement has been patented.

c There is a wide variation in the weights of different types of steel passenger car trucks, but it is probably fair to state that a pair of four-wheel trucks will weigh from 10,000 to 15,000 lb., or more, less than a pair of six-wheel trucks having the same carrying capacity. In other words, for the same total weight of car the one with four-wheel trucks will carry 10,000 to 15,000 lb. more lading or body weight, or with the same weight of body the total weight of the car with four-wheel trucks will be from 10,000 to 15,000 lb. less than the one with six-wheel trucks. For a car weighing 120,000 lb. and equipped with four-wheel trucks this means a saving of from 8 to 11 per cent in total weight as compared with what it would be if six-wheel trucks were used. On most roads it is the practice to carry car bodies weighing more than 85,000 lb. on six-wheel trucks, which weigh fully 15,000 lb. per car more than four-wheel trucks. A locomotive that can haul eight cars equipped with such six-wheel trucks over a given division will haul nine cars of the same seating capacity having four-wheel trucks—a saving much to be desired.

d Roughly speaking, the cost of maintenance of a steel passenger car truck may be said to be very nearly in proportion to the number of its wheels and axles, those with the brake shoes being the parts subjected to the greatest wear and requiring frequent repairs and renewals. While no exhaustive data are available as to the comparative cost of repairs and maintenance of six-wheel and four-wheel trucks of the same carrying capacity, they are said by those who have checked these costs to be at least 50 per cent greater for the six-wheel truck.

As a partial check on these conclusions, it is proposed to review briefly the development of the four-wheel steel truck for passenger cars on the Pennsylvania Railroad. From the outset and throughout this development the aim has been to reduce the number of parts to a minimum and make the construction as simple as possible.

In designing the first four-wheel steel trucks in the early

part of 1905, it was aimed to use them under the largest coach possible and keep within the M.C.B. load limits for 5-in. by 9-in. axles. Shortly after the trucks had been placed in service, three of the axles broke in the wheel seat where the stress is least. Investigation finally showed that the breakage was due to defects in manufacturing caused by a faulty furnace which had been discarded shortly after these axles were made. In the meantime, however, as a measure of absolute safety, it was decided to increase the axles on existing cars ½ in. in diameter and on new cars to go to the next larger size standard M.C.B. axle, the 5½-in. by 10-in. Because of hot box troubles the length of journal was afterward increased to 11 in., although experience has since indicated, as previously noted, that the trouble was probably due more to dirt getting into the journal box than the lack of journal bearing area. The 5½-in. by 11-in. journal is now standard for all four-wheel and six-wheel trucks.

In going from the wood to the steel construction spring planks, axle guards and brake beams were done away with, the brake levers being attached directly to the brake heads. Each side frame was formed of two 10-in. 20-lb. channels, with the flanges turned inward and forming a box girder construction. The channels were spaced so as to measure 9 in. overall. This was done to provide sufficient strength for resisting the lateral stresses, a requirement which has been overlooked in some designs. To check or limit the lateral motion or swaying of the bolster a spring arrangement was used, as shown in the drawing (Fig. 2).

The subsequent use of clasp brakes made it necessary to modify this design somewhat. Fig. 2 shows the details of this modified design, which in general is practically the same as the original design, other than the braking arrangement, except for changes in the end construction of the frame to provide for the outside brakes. The detail of the original end construction is shown in Fig. 1. The end rail in the original design, which was formed of a ⅜-in. plate pressed in the form of an inverted U, 6 in. in width, was changed to make room for the brake levers. The outside brakeheads in the case of the clasp brakes are attached to the lower ends of the brake levers, which are anchored at the top to castings riveted to the ends of the side frames. A 6-in. channel with flanges turned downward connects these castings and forms the end rail. It was also necessary to add brakehead tie bars because of the impossibility of connecting the tension rods for the outer brakeheads direct to the brake lever. It should be noted, however, that this brakehead tie bar is a simple rectangular bar and that the brake tension rod connects to it as close to the brakehead as possible. Obviously the weight and the cost of maintenance of this tie bar is much less than for a brakebeam where the force is applied at the middle. All of the brake levers, including the dead and live levers, are of the same size and interchangeable except for drilling.

The peculiar form of the outer brakehead is noticeable. In the first application of the clasp brakes the ordinary type of brakehead was used with springs to hold it balanced when hanging loose. These springs were difficult to maintain and were done away with by redesigning the brakehead and adding the tail piece. When the brakehead hangs loose this tail piece rests against a casting which is riveted to the underside of the end rail. When the brake is applied there is a clearance of ½ in. between the brakehead tail piece and the rest. This device has given most satisfactory results.

The next development was a modification of this design to provide for the application of a motor for use under motor cars on electrified divisions. To do this it was found necessary to increase the wheel base from 7 ft. to 8 ft. 6 in. Transoms were also added to support the lip of the motor and the bolster design was modified slightly; otherwise the same parts were used as in the original design.

The next development was a radical one, the box girder side-frame being replaced by a Bethlehem 10-in. 54-lb. H-beam, thus simplifying the design as to construction by reducing the number of parts and still providing sufficient moment to resist the side stresses. As shown in Fig. 3, the journal box pedestal casting has a projection to which the top of the lever for the outside brake is anchored and which also supports the end rail, a 6-in. H-beam. The H-beam which forms the side frame has its lower flange and web cut away over part of the journal box pedestal casting and is strongly riveted to it through both the upper and lower flanges. The casting which was formerly used on the end rail to balance the brakehead was replaced by a steel clip which is sprung over and welded to the lower flanges of the end rail.

Another noticeable change was the shortening of the bolster hangers, thus limiting the amount of side swing and making it possible to do away with the complicated spring mechanism which was formerly used to check and limit the lateral motion of the bolster with the longer hangers. Before making this change, the springs were gradually blocked and finally wedged solid on a number of the cars. As this had no noticeable effect on the smooth riding, it was decided to discard the springs entirely.

The more important of these changes, that is, the side frame construction and the change in the hanging of the bolster, were first made on four-wheel trucks for suburban cars, several hundred of which were built. These trucks, however, were of lighter construction than those used under the standard coaches and are not considered in this discussion. The details of this improved truck as designed for use under standard coaches are shown in Fig. 3.

The paper concludes with a description of a modification of this standard truck made necessary by the Philadelphia-Paoli electrification of the main line of the Pennsylvania Railroad.

DISCUSSION

Geo. R. Henderson (written). In reading Mr. Wright's very interesting paper, the writer's thoughts followed the abandonment of the equalizers which for so many years were considered necessary for easy riding, especially on rough track. It is well known that the Pennsylvania track is nearly perfect and it is a question whether these trucks and loads would be satisfactory on average track. This accounts for a considerable saving in weight, as the equalizer and spring seats were quite massive for heavy cars.

It is still the practice of many roads to use equalizers under tenders of passenger locomotives and also under high speed electric cars, and it is an interesting question as to just how far we can go in this respect and still not interfere with the comfort of the passengers. The condition of the track is a very important part of the problem in the writer's estimation and should not be overlooked when considering this question.

S. G. Thomson said that the clasp brake as used on the Philadelphia and Reading Railway, to-day, was giving most excellent satisfaction, and has done so ever since it was developed. One hundred and fifty or more cars have been in service for a number of years, and little or no difficulty has been experienced. The brake is highly efficient and the stops seem to be very much easier and shorter than with the single shoe and higher brake-shoe pressure.

In regard to the question of journal lubrication, he had found that at 80 or 90 miles per hour, some trouble was experienced from hot boxes. Careful readings of journal box temperatures seemed to indicate that the temperatures build up during closely consecutive runs, the wheels and journals not having had time to cool down before the return trips. During the rush season it was often necessary to schedule certain cars for six trips per day, equal to 300 miles or more. The cars were all-steel, weighing about 118,000 lb., which seem to be, in his judgment, about the limiting weight for four-wheel trucks at these high speeds, particularly where they are closely consecutive.

He thought, therefore, that the factor of speed seems to have a fundamental bearing on the question of the use of the four or six-wheel trucks on modern passenger equipment, and that the four-wheel truck should prove entirely satisfactory for anything less than the weights or high speeds on consecutive trips as has just been mentioned.

L. R. Pomeroy said it was astonishing how much money railroads spend to get another car on a train, to be hauled with the same engine, where the cost is more than it would be to run cars with logical trucks. He thought it was quite true that six-wheel trucks have been developed more generally in the West, and it is only in recent years that they have become general on ordinary passenger coaches.

In the West some of the reasons why the six-wheel truck was adopted on cars which would now be considered light were the very light gravel ballast, light rails (from 60 to 70 lb.), and cast iron wheels.

He presented the following figures of weights of four and six-wheel steel trucks under steel cars:

Four-wheel trucks on the Harriman Lines, 5 x 9 journals; weight 26,500 lb. complete. Western Pacific, 5½ x 10 journals; 31,120 lb. complete. Barney & Smith special built-up truck, similar to the Atlantic Coast Line, 5 x 9 journals; 27,600 lb. complete. N. Y., N. H. & H. R. R. standard trucks, 31,400 lb. complete.

Six-wheel steel trucks on the Harriman Lines, 5 x 9 journals; 42,000 lb. complete. Rock Island, 5 x 9 journals; 41,220 lb. complete. Commonwealth, 5 x 9 journals; 40,900 lb. complete. Pullman standard truck, 5 x 9 journals; 43,720 lb. complete. New York Central latest form of steel truck, 45,000 lb. complete. The latter weighs considerably more than the average of the others, and is partly accounted for by being equipped with clasp brakes. Barney & Smith built-up truck, 5 x 9 journals; 42,000 lb. complete. Canadian Pacific trucks under 70-ft. diners, 41,200 lb. complete. Canadian Pacific under sleepers 72 ft. 8 in. long, 40,900 lb. complete; under sleepers 70 ft. 3 in. long, 41,800 lb. complete; under sleepers 74 ft. long, 41,800 lb. complete.

He did not think that even under ordinary conditions of service, there is any justification whatever for a six-wheel truck under a suburban car, and yet a great number are running on these trucks. He said he had never yet come across a 70-ft. car of the ordinary passenger coach type where the six-wheel truck was justified with the track in use to-day.

The Wabash has a 60-ft. all-steel mail car, 5 x 9 journals, six-wheel trucks, total weight 124,000 lb. The trucks weigh 42,000 lb. With four-wheel trucks, 27,000 lb., the total weight would be 109,000 lb. We have a great many cars that weigh as much as 124,000 lb. running successfully with four-wheel trucks.

There are two classes of six-wheel steel passenger cars on the New York Central, the earlier form with equalizers, in connection with Commonwealth frames, and the latter with half elliptic springs over boxes and short equalizers between the springs. The total weight of the car is 142,000 lb. and that of the six-wheel trucks 42,000 lb. With four-wheel trucks the total weight would be 127,000 lb. There are a number of cars of no greater weight running to-day on four-wheel trucks.

On the 63-ft. 78-passenger cars of the Central Railroad of New Jersey, Commonwealth trucks, with 5½ x 10 journals, are used. The total weight is 115,800 lb. With six-wheel trucks the total weight would be 131,800 lb.

The body of the N. Y., N. H. & H. R. R. 1914-schedule 70-ft. 88-passenger car weighs 89,000 lb. Add the weight of a six-wheel truck, 42,000 lb., and the total weight would be 131,000 lb. In later cars the four-wheel standard type truck was substituted. The heavy four-wheel truck weighs 31,400 lb. and has a 5½ x 10 journal, and it brings the total weight of the car to 121,400 lb. on four-wheel trucks. These cars are giving excellent satisfaction in respect to freedom from hot boxes, and comfortable riding.

The Grand Trunk composite steel frame wood finish car, 74 ft. long, seating 97 passengers, weighs 137,000 lb. Deducting the weight of the six-wheel truck, 40,000 lb., leaves 97,000 lb. Adding the weight of the four-wheel truck, 27,000 lb., makes 124,000 lb. Those figures are well within the capacity of the four-wheel truck.

The total weight of the Union Pacific 69-ft. steel truck baggage car is 106,000 lb. With six-wheel truck it would weigh 122,000 lb.

The Postal 60-ft. four-wheel truck car has a total weight of 111,600 lb., which would be increased to 127,600 with the six-wheel truck.

The Lehigh Valley has a steel well flat car, with a capacity of 220,000 lb. The light weight is 91,900 lb., making the total loaded weight 311,900 lb. The car has a six-wheel truck, with 6 x 11 journals, and yet the ratio of total weight of the car against the projected area of the journal is only 475.

The Santa Fé has a 70-ft. 83-passenger all-steel car which weighs 134,000 lb. and has six-wheel trucks; with four-wheel trucks it would weigh 118,000 lb. The 70-ft. 76-passenger chair car on the same road weighs 136,000 lb. and has six-wheel trucks; with four-wheel trucks it would weigh 120,000 lb. It will be seen, also, that these cars could be properly put on four-wheel trucks.

Geo. W. Rink. I would ask Mr. Thomson whether the type of truck which gave trouble with hot journals was that with the coil spring over the journal box. We had this type of truck[1] in service on twenty-eight 63-ft. passenger cars weighing 101,400 lb. The trucks had 5½ by 10-in. journals and clasp brakes and weighed 14,500 lb. each.

The wheel beam is made up of an eye beam and two channels and the transoms of cast steel riveted to the wheel beam. The elliptic springs are carried in a cradle suspended by U-shaped spring hangers. Pedestals are of cast steel, riveted to wheel beams, and are provided with spring pocket. On trucks of this type it is very essential that holes be reamed and the rivets fill the holes, otherwise there will be trouble in maintenance.

We had a number of cases of hot journals on these trucks when first placed in service. There is a tendency in this construction to so distribute the pressure on top of box as to cause an excess pressure per square inch on the journal bearing. We also found a strong tendency for the journal boxes to bind in such a manner that they were thrown in or out, due to

[1] Railway Age Gazette, August 16, 1912, p. 279.

the action of the coiled spring over the box, resulting in excessive wear of box flange and pedestals. This truck also gave trouble from loose rivets.

We are now using on our 63-ft. steel coaches and combination cars, weighing 116,000 lb. and seating 78 and 51 passengers respectively, a cast steel truck[2] with 5½ by 10-in. axle, and with wheel beams, transoms and end sills cast in one piece. The truck weighs 16,100 lb., and with generator and truck suspension 17,600 lb. These trucks have cast iron pedestals of heavy pattern bolted to the wheel beams, and have the long equalizer with coil spring adjacent to the journal boxes and the same type of clasp brake as used on the built-up truck. We do not use the same type of clasp brake as used by the Pennsylvania Railroad, but use standard brake beams.

These trucks ride very smoothly and seldom have heated bearings. We now have 126 steel coaches in service with this truck giving excellent results, fully complying with the four important features as mentioned by the author—safety, smooth riding, minimum weight, and low cost of maintenance.

Alphonse A. Adler asked whether, in car truck journals, the resistance of friction is dependent on the load, or whether it is possible to so adjust the load that there is perfect film lubrication and the resistance is only proportional to the size of the journal.

E. B. Katte said that while they have made several attempts to design a six-wheel motor car truck, they have not arrived at a design which is satisfactory from either a mechanical or an electrical standpoint, and he did not know of any six-wheel motor car trucks in high speed service.

C. D. Young. Railroads have been too prone in recent years to use six-wheel trucks, based upon their experience with four and six-wheel trucks in the days before the advent of the steel truck. Due to the flexure in the wooden trucks it was necessary to go to the six-wheel truck. As far as the probable cost and maintenance are concerned, due to the fewer parts, the four-wheel truck is preferable to the six-wheel truck, provided it gives satisfactory service.

With the use of the steel truck the total weight which will be satisfactorily carried on the four-wheel truck car can be materially increased. Ninety-eight per cent of the railroads in this country use four-wheel trucks under heavy passenger locomotive tenders, with axle loads as high as 45,000 lb., yet when a passenger car is designed there is hesitancy about putting 31,000 lb. on the same axle.

To ascertain what effect on the train resistance the two extra axles of the six-wheel truck car would have, we took the same car bodies in a train of 10 cars and compared the resistance of the train when carried on four-wheel trucks, similar to that illustrated in the paper, with that when these cars were carried on the six-wheel standard trucks of the Pennsylvania Railroad. The trains were run at 35, 50 and 65 miles per hour. Three round trips were made and the resistance of the cars was obtained. It was found that 13 six-wheel truck cars offered the same resistance as 14 four-wheel truck cars; in other words, if on a train of 13 cars the equipment is changed from six-wheel trucks to four-wheel trucks, one more four-wheel truck car can be hauled without increasing the resistance over that of the 13 six-wheel truck cars.

The author shows the development of the clasp brake for the four-wheel truck cars, which came about as a result of clasp brakes used on the Philadelphia & Reading Railway. In this connection, two or three points which were brought out in a series of tests made by the Pennsylvania Railroad of clasp and single shoe brakes, are of interest.

The single shoe brake has a total weight of 3682 lb. per car and the movable parts weigh 3084 lb. The clasp brake has a total weight of 4433 lb. per car, the movable parts weighing 3152 lb., showing an increase in total weight of the clasp brakes of 24 per cent. It was developed in our tests that it was desirable to have as low weight in the moving parts of the brake rigging as possible to overcome the effect of inertia on the first application of the brakes, for obviously the heavier the moving parts the more inertia and the longer it takes to get full braking pressure at the wheel with a given pressure in the brake cylinder. With equal weights of movable parts, it would be expected that full braking power would be developed as quickly with the clasp brake as with the single shoe brake, but for a given braking power a higher coefficient of brake shoe friction is obtained with the clasp brake car and, therefore, the stops are shorter than with the single shoe brake car.

To illustrate this, at 60 miles an hour with 125 per cent nominal braking power the clasp brake car made a stop in 808 ft., probably the shortest stop ever made on a passenger car under that braking power. The corresponding stopping distance for a single shoe is about 1250 ft., so that with 24 per cent increase in weight of brake rigging there is, with the clasp brake car, a much larger per cent decrease in the stopping distance.

Another point which cannot be ignored is that the use of the clasp brake is economical in brake shoe material. A series of road tests of brake shoes shows a saving in brake shoe material of about 30 per cent with clasp brakes over single shoe brakes.

In reply to Mr. Adler, the friction of the journals of a car running at 50 miles an hour offers such a small resistance compared with the resistance due to wind, flange, oscillation and other causes, that it has a small value in any empirical formula used to determine total resistance.

The Author. Six-wheel trucks are used extensively and there must be good reasons for this. These reasons have not, however, been brought out in the discussion. It is a severe indictment of the mechanical departments of our railroads if the use of six-wheel trucks under modern railway equipment has simply come about because in the days gone by, when wooden trucks were in use, it was found desirable to use six-wheel trucks under much of the equipment.

Mr. Henderson's discussion brings up a point which might account for the use of the six-wheel truck in the Far West, and that is that where road conditions are poor, there is a possibility that the six-wheel truck may ride more easily. On most of the sections of the roads in the East which still have poor roadbeds, old light wooden cars with four-wheel trucks are used. There is, however, a grade of track between the magnificent roadbed, which we have on the high traffic eastern lines, and the very poor condition; and, generally speaking, on that kind of track the four-wheel trucks ride just as easily as do the six-wheel trucks.

The latest type of standard four-wheel passenger car truck, modified for use under motor cars on the electrified district of the Pennsylvania Railroad at Philadelphia, is illustrated in the paper, and it is interesting to note how skillfully the designers have taken advantage of the standard design and modified it only slightly to allow for the motors, which are the largest thus far used under motor cars.

[2] Railway Age Gazette, Mechanical Edition, December, 1914, p. 627.

THE FLOW OF AIR THROUGH THIN PLATE ORIFICES

BY ERNEST O. HICKSTEIN, STAPLETON, N. Y.

Junior Member of the Society

THIS paper reports an interesting and instructive investigation made by a Junior Member. It bears the distinction of being the Junior Prize paper for 1915, and is the first paper to receive a prize from the Society, the fund from which it was awarded having been established in 1914.

This paper describes in some detail the methods used by a large pipe-line company in the Mid-Continental field in the calibrating of its orifice meter discs.

An orifice meter consists of a calibrated disc in a pipe-line, with pressure line connections running to two indicating or recording gages; one gage is for measuring the static pressure

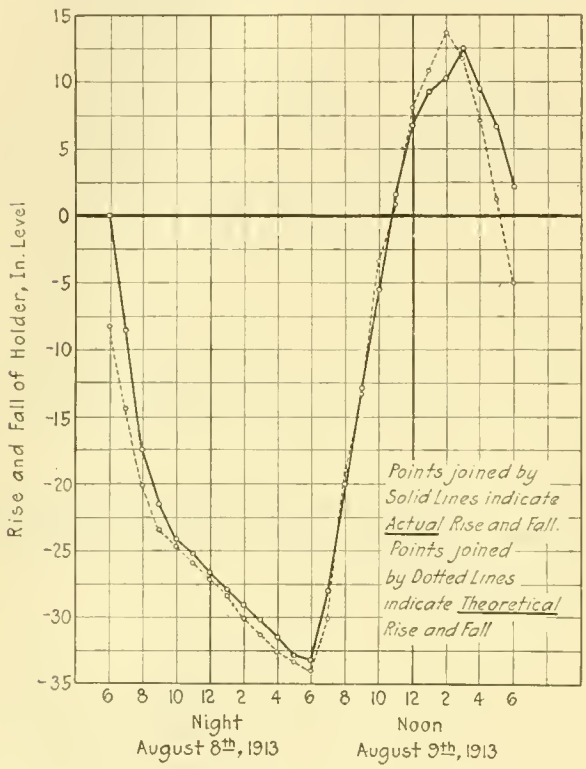

Fig. 1 Actual and Theoretical Rise and Fall of Holder, under Temperature Changes. First 24-hr. Test

of the flowing gas and the second the differential drop of pressure across the orifice disc.

The discs tested are machined out of quarter-inch boiler plate. The edge of the orifice is flat for $\frac{1}{32}$ in. and bevelled at 45 deg. for the remainder of the thickness. The disc is inserted in the flange union with the bevel facing the outlet side.

The ordinary practice in orifice meter installations is to have the gage line connections right at the flange, that is, the inlet and the outlet pressures are taken within an inch or two of the orifice disc. In this particular, the meters of the type tested show a departure from common practice. The high pressure connection was 2½ times the diameter of the pipe line ahead of the disc, and the low pressure connection was 8 times the diameter of the pipe line behind the disc. This means that in an orifice meter installation on a 10-in. line, for example, the high pressure connection is 25 in. in front of the disc, and the low pressure connection 80 in. behind it, regardless of the size of the orifice in the line.

The paper deduces the following general formula for the flow of air through an orifice disc:

$$Q_o = C_a\sqrt{hP_1}$$

where

Q_o = volume at standard temperature and pressure
C_a = so-called "air constant," found experimentally
h = differential in in. of water
P_1 = pressure at inlet of orifice

The tests were carried out at Joplin, Mo. The discs were calibrated against the displacement of air from an old artificial gas holder at that place. The holder was a two-lift holder, water sealed and of 250,000 cu. ft. nominal capacity. Roughly speaking, its dimensions were 90 ft. in diameter by 40 ft. total height. The lower lift only was used in the tests; this lift has a capacity of 110,000 cu. ft.

Of the several original outlets from the holder, all but one were securely blanked. The remaining 12-in. outlet was led into a long building, and connected to a straight run of some 40 ft. of pipe, near the center of which was the orifice flange. The air passing out of the holder went through the orifice disc, and discharged into the atmosphere perhaps 20 ft. beyond. A motor driven blower was used to fill the holder with air previous to each test.

Leakage Tests on Holder. The first tests made were to determine the rate of leakage from the holder. In order to obtain a fair average, a number of such tests were run at the start, with the holder at varying heights. Leakage tests were also run at intervals throughout the whole work, to make sure that the leakage figure first obtained had not materially changed.

The first leakage tests were unsatisfactory on account of the large difference between temperature conditions at the start and finish of test. To avoid this difficulty, tests of 24 hours duration, starting at about midnight, were made, and better results obtained. The average of three long leakage tests showed 103 cu. ft. leakage per hr. The correction used in all the Joplin tests was taken as 100 cu. ft. per hr. The result of later leakage tests showed practically the same leakage as the above average, the highest value in any 24-hr. test being 115 cu. ft. per hr.

Changes of Volume in Holder with Temperature Variation. During the leakage tests, it was noticed that the rise and fall of the holder with temperature changes was a greater factor than had been anticipated. A 4-ft. rise from midnight to noon was not uncommon during the hot weather. It was necessary, therefore, to ascertain very accurately the proper correction to apply for temperature changes taking place during a test.

It was found that the changes in volume as observed were always greater than a calculation based on the ratio of absolute temperatures alone would give. After some little study and debating, it was decided that this was due to the presence of aqueous vapor in the holder.

In studying the correction to be applied for varying temperatures, taking account of the effect of the vapor tension, it was found in the study of the volume variation with temperature that the observed rise and fall of the holder during the test corresponded with a temperature change equal to the sum of two-thirds the atmospheric temperature, plus one-third the "top" temperature, the "top" temperature being the reading found by lowering a thermometer 2 ft. or so into the holder through a bolt hole in top. This simply means, of

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course, that the average temperature of the holder air is that combination of the two observed temperatures.

Fig. 1 shows a test of the correctness of this average temperature of the holder air. The dotted curve shows the computed theoretical rise and fall of the holder, using the temperature correction just described, and based on the so-called "combined" temperature. The heavy curve shows the actual rise and fall observed. These two curves follow each other fairly well, except for a lag during the middle of the day. They bear the closest relation during the period between 9 P.M. and 6 A.M., when the effect of the sun shining down on the black holder top is not present. During the afternoon it is evident that the "top" temperature has a greater proportionate effect on the average temperature of the air in the holder than the "combined" temperature allows.

PROCEDURE DURING TESTS

Table 1 shows a sample page of the observations and calculated results of one orifice test. These tests were made with a flying start, that is, the air was started discharging through the meter orifice several minutes before the first tank level reading was taken. The final tank level reading was taken under similar conditions. Half-hourly readings of atmospheric temperature, "top" temperature, tank level, water level in seal, differential drop in inches of water across orifice disc, and the temperature of the discharged air were taken. To facilitate calculation, the tank level reading was taken by a gage stick, marked off in cubic feet displacement. The exact diameter of the lower lift was found, and from this it was computed that a displacement of 100 cu. ft. corresponded with a holder drop of 0.1835 in. This 100-ft. graduation was the smallest on the gage stick. The space could readily be divided visually into quarters, so the content of the holder at any moment could be read to the nearest 25 cu. ft. Differences between two consecutive half-hourly tank level readings would therefore give the uncorrected (or apparent) quantity of air passing out in that period. Preliminary corrections have to be applied to this value as follows: (1) holder leakage, at the rate of 100 cu. ft. per hr., (2) variation of the water level in seal, due to leakage out, evaporation, or pumping in of fresh water, (3) temperature change during test. With these corrections applied, the correct quantity of air passing through the orifice is obtained. This quantity, however, is expressed at holder pressure, and at some definite temperature, varying from day to day, i.e., the "combined" temperature. A reduction is necessary in order that the quantity of air passing through the orifice may be expressed in cubic feet at standard conditions of pressure and temperature, (29.4 in. of mercury or 14.41 lb. per sq. in., and 60 deg. fahr.).

TABLE 1 READINGS AND CALCULATED RESULTS OF A SAMPLE HOLDER TEST ON ORIFICE METER DISC

Time	Temperatures: Atmos.	Temperatures: "Top"	Temperatures: Orifice	Gage Stick Reading	U-Tube In. Water	Calculated (Apparent) Displacement in ½ hr.	"Combined" Temp.	Correction for Temp. Changes	Calculations	
8.15	66	66	66	252,675	4.39	.....	66	.....		
8.45	67½	....	65	244,050	4.39	8,625	66	0		
9.15	67	66	65	236,350	4.38	7,700	66⅔	330	Apparent total....	108,975
									Seal water correction.....	—140
9.45	66	....	64½	228,125	4.37	8,225	66	—320		
10.15	66	64½	64	219,725	4.36	8,400	65½	—230	Leakage corr.....	—650
10.45	66	.....	64	210,950	4.36	8,775	65½	0	Temperature corr..	—960
11.15	65½	63½	63½	202,325	4.35	8,625	65	—210		———
11.45	65½	....	63½	193,700	4.35	8,625	65	0	Net total.....	107,225
12.15	65½	63	63½	185,625	4.34	8,075	64½	—200	Average flow.....	8,248
12.45	65	....	63½	177,175	4.32	8,450	64½	0	Calculated C_A....	.520
1.15	65	63	63½	168,850	4.30	8,325	64½	0	Calculated C_V....	67.3
1.45	64½	....	63	160,425	4.28	8,425	64	—170	(see footnote)	
2.15	64	62½	63	152,070	4.26	8,350	63½	—160		
2.45	64	....	63	143,700	4.24	8,375	63½	0		
			64		4.34	108,975	65	—960		

Test No 227, Nov. 12, 1913. Orifice Disc No. 8301. Barometer 29.35 in.
C_V = so-called "velocity coefficient" depending on size and shape of disc. $C_V = 11.55\ C_A \div D^2$

SUMMARY OF RESULTS

About one hundred and sixty tests on 8 and 10-in. orifice meter discs were run at Joplin during 1913-1914. A summary of some of the results of these tests is included in Tables 2 and 3. A note on the system used in numbering the discs will make the summary self-explanatory. The first one or two digits indicate the size of the pipe line in which the disc

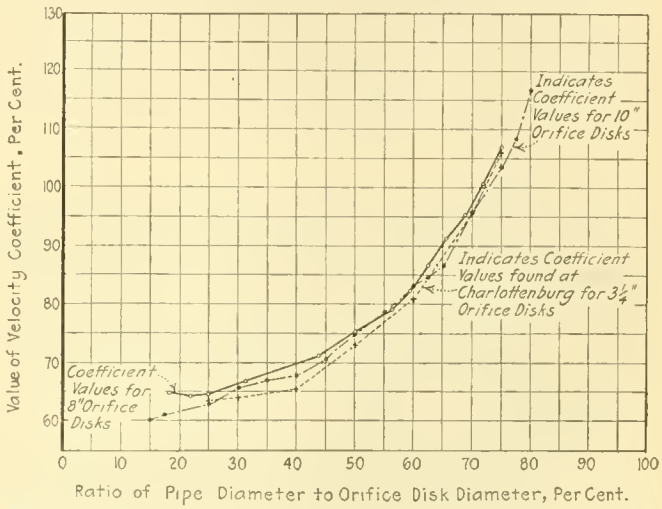

Fig. 2 Comparison of Velocity Coefficients of Orifice Meter Discs, as Found in Joplin Tests for 8-in. and 10-in Pipe Lines, with Values found at Charlottenburg

TABLE 2 SUMMARY OF SOME HOLDER TESTS ON 8-IN. ORIFICE METERS

Test No.	No. of Meter Disc	Date of Test and Duration in Hr.	Avg. Corr. Rate. Cu. ft. /30m.	U-Tube Reading, In. Water	Barometer,	Observed Temp. Flow	Observed Temp. "Combined"	Calc. C_A
201	8401	Sept. 25 1½	15,503	4.07	29.3	58	52	1.035
202	8501	26 2	25,361	3.31	29.3	62	56	1.868
203	8301	26 3	8,178	4.415	29.3	58	54	0.522
204	8351	27 3	11,671	4.26	29.3	62	60	0.752
205	8451	27 3	20,223	3.82	29.3	62	60	1.375
206	8451	28 2	20,589	3.79	29.2	64	61	1.409
207	8351	28 3	11,668	4.33	29.2	61½	60	0.747
208	8401	28 2½	15,796	4.11	29.2	61	58	1.041
209	8351	30 2½	11,850	4.31	29.3	66	62	0.759
210	8451	30 2	20,421	3.83	29.3	64	59	1.394
211	8501	Oct. 2 1½	26,647	3.36	29.3	70	67	1.914
212	8501	2 1½	26,187	3.40	29.3	67½	63	1.883
213	8401	2 2½	15,839	4.14	29.3	65	60½	1.038
214	8301	3 2½	6,124	2.355	29.3	70	69	0.527
215	8301	4 5½	8,496	4.41	29.2	70	70½	0.532

TABLE 3 SUMMARY OF SOME HOLDER TESTS ON 10-IN. ORIFICE METERS

Test No.	No. of Meter Disc	Date of Test and Duration in Hr.	Avg. Corr. Rate. Cu. ft. /30m.	U-Tube Reading, In. Water	Barometer, In. Hg.	Observed Temp.		Calc. C_A
						Flow	"Combined"	
401	10401	Dec 20 3	13,978	4.345	29.4	48	32	0.9286
402	10501	20 2	23,156	3.94	29.5	47	32½	1.611
403	10501	20 2	23,138	3.94	29.4	48½	31	1.620
404	10801	26 1	53,855	1.38	29.4	45	29½	6.384
405	10751	21 1	49,513	1.89	29.5	48	33½	4.983
406	10801	21 1	53,975	1.38	29.3	50	35	6.370
407	10801	22 ½	55,595	1.43	29.2	48	36	6.429
408	10751	22 1	50,575	1.95	29.2	49	35	5.025
409	10501	23 2	23,209	3.95	29.2	49	32½	1.626
410	10401	23 3½	14,189	4.38	29.2	48	33	0.9406
411	10551	22 1½	29,042	3.89	29.2	48	35½	2.035
412	10551	26 1½	28,225	3.68	29.4	45	26½	2.055
413	10751	27 1	48,850	1.90	29.4	48	36½	4.976
414	10801	27 ¾	55,220	1.39	29.4	49	37	6.450
415	10501	27 2	21,080	3.28	29.4	49	35½	1.605

is inserted; the next two digits, the size of the orifice; the remaining digits, the serial number of the disc. For example, 8473 would represent an 8-in. meter disc, 4¾-in. orifice; 104211 is a 10-in. disc, 4¼-in. orifice, etc. It was found necessary to discard perhaps half a dozen tests, on account of their disagreeing widely from the averages of the remainder. In two or three of these discarded tests, a shower or a fall of snow during the test furnishes a possible explanation; in other tests, no explanation was found.

It is worthy of special note that in these tests the standard used is an actual measurable volume, and not a standardized pitot tube or other indirect method of measurement. The advantage of being able to calibrate directly against displacement is a most important feature of these holder tests. A second feature of the tests is the ability to automatically secure a practically constant flow, without regulation of any kind.

Another point deserving mention is the fact that duplicate discs of sizes already tested at Joplin require no calibration of any kind. It is merely necessary to micrometer the orifice and to correct mathematically for any small deviation from the nominal diameter. For example, if a new 8-in. by 4-in. orifice disc micrometers 4.004 in. in diameter, and the result of the Joplin tests on the master 8-in. by 4-in. orifice be 1.034, the value of C_a for the slightly oversized disc would be $1.034\ (4.004 \div 4.000)^2$ or 1.036.

TABLE 4 SUMMARY OF VALUES PLOTTED

Joplin 8-in.		Joplin 10-in.		Charlottenburg 3¼ in.	
d/D	C_v	d/D	C_v	d/D	C_v
0.1875	64.9	0.15	60.1	0.25	63.5
0.219	64.2	0.175	61.1	0.30	64.0
0.25	64.7	0.25	62.8	0.40	65.5
0.3125	66.9	0.30	65.6	0.50	73.0
0.375	67.9	0.35	66.9	0.60	81.0
0.4375	71.1	0.40	67.9	0.70	96.0
0.50	75.3	0.45	70.4	0.75	106.0
0.5625	79.0	0.50	74.9		
0.594	82.2	0.55	78.7		
0.625	86.6	0.60	83.2		
0.655	91.3	0.625	84.6		
0.6875	95.3	0.65	86.6		
0.7187	100.7	0.70	95.9		
0.75	107.0	0.75	103.5		
		0.80	116.6		

The only published report[1] of tests made on orifice discs similar to those tested at Joplin gives the values of the velocity coefficient, C_v, for 3¼-in. pipe found in tests made at Charlottenburg, Germany. Fig. 2 shows graphically the values found at Charlottenburg compared with the Joplin results for 8 and 10-in. pipe. The Joplin curves agree fairly well with the Charlottenburg values, especially if the difference in the pipe sizes is taken into account.

CONCLUSION

Nearly fifty orifice meters have been installed and are now in operation, their deliveries of high pressure gas being calculated from the air constants found in the Joplin tests. Experiments which are now in the course of completion, show conclusively that these constants (with the proper correction applied for the gravity of the gas being measured) are accurate to a very satisfactory commercial degree, and it is confidently expected that with some little further study and experimenting, particularly along the lines of the mechanical details, the orifice meter will take its place among the most reliable of the various methods of measuring natural gas in large quantities.

[1] Zeit. des Ver. d. Ing., Feb. 23, 1908.

DISCUSSION

P. F. WALKER (written). The experiments made at Joplin go far in establishing the use of the orifice meter as a reliable instrument, at least when employed with conditions essentially similar to those which obtained at that time.

It is well known that for a gas flowing through orifices and nozzles the conditions of flow may be treated by two distinct methods: *first,* considering the relationships existing during the expansion which takes place with the drop in pressure, and *second,* disregarding expansion and treating the gas as a non-expansive fluid. The second method, adopted in the tests described, depends for its absolute accuracy upon the amount of expansion or drop in pressure in proportion to the static pressure in the line on the up-stream side of the orifice. The application of constants derived under one set of conditions must, therefore, be considered with care when conditions are different in marked degree. Because of these facts the corroborative tests referred to in the last paragraph of the paper were undertaken, and the writer has been associated in the work of analyzing the data from these tests.

The question which every engineer will ask, probably, is with reference to this matter of application of factors derived at substantially atmospheric pressure with a drop in pressure of but 3 to 5 in. of water in the orifice, to pipe line conditions where pressures may run close to 300 lb. and the rates of flow may vary through very wide limits, and so cause the differential pressure drop to vary correspondingly.

In the experiments referred to in the last paragraph, a short section (one mile or more) of unused pipe line was cut out and used as a reservoir. From this the natural gas was allowed to flow through orifices arranged much as in the tests with air, the only real difference being that the amount of gas flowing had to be calculated from observations on the drop in pressure in the reservoir. Observations could be, and were, made for a complete range of static pressures up to the values existing in the pipe lines at the time. A corresponding variation in the rates of flow extended the investigation over the

desired range of values of the differential pressure across the orifices.

As first calculated, and this is as far as the work has progressed up to date, it was assumed that Boyle's and Gay Lussac's laws for perfect gases held for the gas in use. This affects three elements, as follows:

a the ratio P_1T_0/P_0T_1 which is introduced to convert the measured volume at the measured pressure P_1 to an equivalent volume at the standard pressure and temperature. Since the temperatures varied so slightly in this work, as is also true for regular operating conditions, no sensible error results from considering only the possible variation of volume ratio from the inverse pressure ratio at a constant temperature.

b the pressure which occurs in the denominator of the radical expression, in conjunction with 14.7 in the numerator, to express the change in density of the gas from standard to existing pressure.

c the volume flowing, Q_0, which is determined by the use of the pressure ratio, as in the first item.

The sum total of these elements is that the left hand side of the equation of flow is affected by the pressure ratio in the unit power and the right hand side is affected in the one-half power.

Dealing with all values as for perfect gases, the value of the coefficient designated in the paper as the "air-coefficient" was calculated for each observation, the value for air being found by reducing backwards by means of the density ratio in order to compare results secured with gas of different densities. In analyzing this mass of data, three main variables had to be considered: static pressure, differential drop in pressure or the dependent quantity hP_1 under the radical, and the ratio of orifice diameter to pipe line diameter. By reducing all to equivalent values of the coefficient for one standard area of orifice, the element of variable size of orifice was eliminated. A total of 1244 values was divided into 12 groups as follows:

Those for pressures over 100 lb., with $(hP_1)^{\frac{1}{2}}$ over 40
Those for pressures over 100 lb., with $(hP_1)^{\frac{1}{2}}$ from 21 to 40
Those for pressures over 100 lb., with $(hP_1)^{\frac{1}{2}}$ from 11 to 21
Those for pressures over 100 lb., with $(hP_1)^{\frac{1}{2}}$ below 11
A similar set of four for pressures from 50 to 100 lb.
A similar set of four for pressures below 50 lb.

For each of the twelve groups, values of the "air-coefficient" were plotted against ratio of diameters of orifice and pipe, and an averaging curve drawn. From these average curves values of the coefficient were then taken and plotted against values of $(hP_1)^{\frac{1}{2}}$ for each standard orifice, each orifice thus represented fixing a characteristic curve for its particular ratio of diameter to diameter of pipe.

These final curves establish certain laws, or tendencies. For orifices less than 40 per cent of pipe diameter the coefficient is essentially constant. For larger orifices there is a tendency toward lower values for the greater rates of flow or larger values of $(hP_1)^{\frac{1}{2}}$. In general the values tend to become less for the lower static pressures, this tendency being more marked with the orifices which are large in proportion to the pipe. In general, too, the coefficients have values slightly below the corresponding value determined for air in the Joplin tests which form the basis of the paper.

The work is not yet finished, but laboratory experiments are under way to determine the actual *pressure-volume* relationship, or the variations from Boyle's Law, for the natural gas of the Mid-Continental field. When these are completed the results will be re-calculated. In a surprising degree, considering the many variables between quantities and relationships for air near atmospheric pressure and a gas far from the ideal gas on which the laws are based and handled at wide variations in pressure and rate of flow, the values of the coefficients as found in the tests with the gas agree with the values found for air. The variations discovered involve so small a percentage of error, and are themselves subject to correction in such degree, that the air coefficients determined by the author remain standard for their purpose to date.

E. D. Leland[1] (written) The author has presented a valuable record of results obtained by a reliable method of calibrating orifice discs in connection with the flow of air at low pressures, and the painstaking work tends to increase our confidence in the accuracy of this form of gas measuring device.

It would be an interesting check upon these results and afford valuable additional information, if a series of tests were made in which the flow of gas was reversed, using the same discs and the same holder, but a range of pressures materially higher, of course, making suitable provision for restoring the loss of heat due to expansion. Higher pressures are mentioned because accurate measurement of the flow of gas at comparatively high pressures is an important matter with large gas companies and has been receiving their careful attention.

TABLE 5 COMPARISON OF ACCURACY OF METERS

Cu. Ft. by Venturi	Cu. Ft. by Orifice	Cu. Ft. by Pitot	Cu. Ft. by Proportional Meter
Six-hour Test of Natural Gas at Average Pressure of 130 Lb.			
3,885,000	3,908,000	3,846,000	3,958,000
Eight-hour Test of Natural Gas at Average Pressure of 124 Lb.			
5,448,000	5,416,000	5,351,000	5,393,000
Volumes given are at 10 oz. and 62 deg. fahr.			

The author's conclusion that the orifice meter will take its place among the most reliable of the various methods of measuring natural gas in large quantities is in harmony with results obtained by F. W. Schell[2] from recent tests near Blacksville, W. Va. In August, 1915, Mr. Schell conducted a long series of tests with special reference to the accuracy of the venturi meter, but including various other measuring devices, and the results which are given in Table 5, include the performance of the orifice meter at a pressure of about 130 lb.

In these tests a 12 in. x 6 in. orifice meter, a 12 in. Wylie proportional meter, and 5 in. and 3 in. calibrated pitot tubes were connected in series with the 12 in. x 6 in. standard venturi meter in use at that point. Before using, the proportional meter was tested by means of a standard test flowmeter and found to be accurate and in good condition.

The close agreement of these various devices was very satisfactory and indicated that the gas was being measured with a degree of accuracy well within the requirements of the Pennsylvania State Public Utilities Commission.

[1] Supt. Compressing Stations, Philadelphia Co., Pittsburgh, Pa.
[2] Mechanical Engineer, Philadelphia Co.

H. B. BERNARD (written). I wish to ask the author whether he has any trouble due to erosion of the orifice on account of the small edge employed. The more common form of orifice is of ⅛ in. stock, with a flat edge for the entire thickness of the plate. Some of this type have been in use since 1911, and to date have shown no appreciable increase in diameter.

No mention is made in the paper of what size holes are used in making connections. T. R. Weymouth, Mem.Am.Soc. M.E., has found, by numerous investigations that a saddle used over a ⅛-in. drilled hole gives the best results.

I cannot agree with the author if he believes the distant connections more efficient than the flange connections. With the latter the coefficient of flow—ratio of diameters curve—is much flatter and minimizes an error in not having the exact internal diameter of the pipe. Undoubtedly eddying occurs at the orifice, but I know of no installations, not made near a compressor, where the accuracy of measurement is impaired.

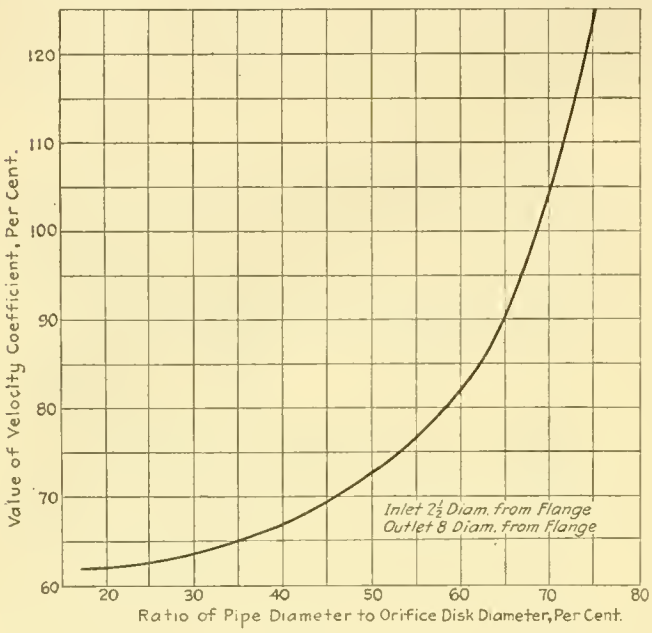

FIG. 3 VELOCITY COEFFICIENTS OF ORIFICE METER DISCS FROM TESTS BY W. T. YOUNG

Of course, any meter will invariably read high, if installed on the suction or discharge line close to the compressor, even though deadeners be used in the gage line. I doubt if the connections employed by Mr. Hickstein would eliminate this.

In a test by W. T. Young, at the Buffalo Test Station in June, 1914, an effort was made to determine the recovery of differential in an orifice meter. A Foxboro type flat edge orifice was used. Flange connections and connections as described by the author, giving a maximum differential and a minimum differential respectively, were compared. The results showed a recovery close to 17 per cent for 1.2 in. differential at the flange, under 36.72 lb. per sq. in. absolute pressure on the low side, and increasing at the rate of 0.4 per cent per 10 in. increase in differential under constant pressure. It was also shown that there was a slight drop between the inlet points, the percentage decreasing as the differential increased.

I have some data from tests performed by Mr. Young at the Buffalo Test Station in June, 1914, on Mr. Hickstein's plates, in which distant connections were used, and the results vary considerably from those obtained by the author. The tests were conducted at practically constant pressure, ranging from 30 lb. gage on some plates to 50 lb. on others, with increasing differential from zero to 17 in. of water as maximum on the largest plate, and from zero to 27 in. on the smallest plate. The efficiency curve, Fig. 3, had a value of 0.62 at 0.20 ratio of diameters; the curve crossed the author's curve at 0.63 ratio of diameters, and at 0.75 ratio it had a value of 1.234. The gas was measured by pitot tubes and flange connection orifices, which had been calibrated previously against gas holders by natural gas.

In the comparison of the author's with the Charlottenburg tests, I cannot understand why the difference in pipe sizes should be taken into account, inasmuch as the Charlottenburg curve falls outside the author's curve for the 10-in. line for the greater portion of its distance.

Considerable work on the subject of flow measurement by the orifice method has been done by T. R. Weymouth and by the Foxboro Company, and it seems that in no great length of time the orifice meter will be adopted by artificial gas companies as station meters.

G. T. VOORHEES said that some years ago he had occasion to make a number of observations on the flow of gases and liquids through very tiny orifices and at very high pressure. As he remembered, the orifices were made in a ⅛ inch plate and some of them were drilled as small as 1/100 of an inch. The pipe used was about a ⅜ inch pipe, so that the relation of the orifice to the pipe was large. He found that the coefficient of this discharge was between 60 and 80 per cent.

He asked whether the coefficient of discharge should decrease with the size of the orifice.

J. T. WILKIN said that in the manufacture of rotary blowers and gas exhausters there comes up quite often the question of efficiency tests necessitating the accurate measurement of the air and gases. The paper shows that this measurement is a very delicate thing to make correctly owing to temperatures, water vapors and other conditions.

He recited an instance in which results of tests on a large gas holder had been influenced very much by the sun shining on the holder.

He hoped there would be developed some standardized method of making tests on the efficiency of machines that would be acceptable. He thought the paper was of interest in the development of such a method.

CARL C. THOMAS said that the difficulty of making accurate holder tests is very great. When the gas comes up through the water and is collected in a large vessel the changes in volume due to humidity, and the changes in humidity resulting from changes of temperature, necessitate very considerable corrections. He had had quite a good deal to do with holder tests and he believed that the only accurate way to conduct these tests was to wait until the gas inside the holder had attained as nearly as possible a constant temperature. This conditon does not occur in the day time except on some very cloudy days, and then the results are not so good as at night. The best results he had seen were obtained between 11 p. m. and 4 a. m. He would have some doubt about computing the contents of the holder by using some function of the temperature at the top of the holder and that at the bottom.

With regard to the change of coefficients with different sized orifices, that depends upon the amount of gas or the velocity of gas passing through. It is fairly well established that the coefficient does change as some function of the velocity of the gas flowing through the orifice, but accurate experimental data are not yet available showing over what range orifice measurements are reliable. The condition of the orifice has a great deal to do with the matter. He has been interested in results

obtained on natural gas lines connected with the City of Los Angeles, where questions had arisen which were evidently dependent upon the maintenance of orifices in good condition. The velocity flow is very high,—sand is carried along with gas, —and other influences, such as corrosion, deposit, etc., affect the readings.

The bevel of the orifice has a very distinct effect upon the quantity of gas which will flow through it, so that some standard has to be arrived at and maintained in order to insure continuous reliability.

S. A. Reeve said that he had made considerable use of a holder for commercial tests of gas flow and had found that entirely satisfactory conditions could be obtained by using a covered holder, and by keeping a constant flow of water circulating over the bell of the holder from the tank. The air was not pumped in through the water but through a dry pipe so that the humidity did not vary considerably, and the temperature in the building, through the action of the water circulation, seemed to have been kept constant. The holder was about 30,000 cu. ft. capacity.

Prof. A. M. Greene, Jr., asked whether with a small differential change in pressure it is not necessary to consider the pressure on both sides of the orifice or some function of that pressure.

The Author. As Mr. Bernard states, one type of meter disc is made of 1/8 in. stock, with a flat edge for the entire thickness of the plate. Another type, on the other hand, is about 1½ in. thick, with a flat-edge orifice. What is probably the oldest type in use in the natural gas industry is about 5/8 in. thick, with the orifice edge similar to those tested by the author, i.e., flat for a very short distance, and then beveled. These last-mentioned discs are case-hardened before being put in line. As was brought out in the discussion, the fact is unfortunate that no one type of orifice has been standardized.

Mr. Bernard questions if the size of the orifice increases after disc is put in line. Several months ago, this question was well answered by a micrometer measurement of the diameter of an 8-in. x 5-in. disc through which possibly fifteen billion cubic feet (twenty million a day for about twenty months) of natural gas at between 250 and 400 lb. line pressure had been passed. No appreciable increase in diameter was found, and the author feels that there is little ground for the apparently common misapprehension that the orifice diameter increases when a disc is put in use. One disc has come to the author's attention, with a part of the edge (possibly one quarter the size of a finger nail) chipped out. This was a case-hardened disc; and the presumption is that the damage was caused by a rock traveling with the gas at high velocity. It is important, however, to examine the disc at a meter station occasionally, as the effective area of the orifice may be altered by some object lodging in front of it.

The connections used were ordinary 1/4-in. nipples screwed into the pipe, care being taken that the nipple did not extend further than the inside of the pipe. This method of connecting is very simple, and proved as satisfactory as more complicated methods. A possible explanation of Mr. Bernard's criticism of the fact that the Charlottenburg curve falls outside (below) the 10-in. Joplin curve may be found in the error he mentions involved in not using the exact size of pipe when d/D was calculated.

A long discussion of the distant connections versus flange connections question is hardly in place here. The advantage of having a flat curve "to minimize an error in not having the exact internal diameter of the pipe" does not enter, unless coefficients found for one size of pipe-line are arbitrarily used on some other size of line.

As Professor Walker mentioned, corroborative tests were made before the Joplin constants, found for air at atmospheric pressure and with low differentials, were used for high pressure gas at varying differentials. Very probably more will be said about these tests in a paper to be presented by F. P. Fisher at the coming New Orleans meeting of the Society. The results of Professor Walker's study of these tests are most interesting. His handling of the large number of variables that entered into the tests was a revelation to the engineers associated with him in the work.

Mr. Schell's success, as reported by Mr. Leland, in getting four types of meters to run so closely together, is unusual. It is an indication of the improved methods and ideals now coming in vogue in gas measurement. The statement that it is impossible to get two gas meters in series to read alike is still frequently heard, but there are some engineers nowadays who know better.

The author was interested in Professor Thomas' comment on his experiences with holder tests. In the Joplin tests, it is worthy of note here, the air did not pass through the water, either in entering or in leaving the holder, as several of the contributors to the discussion appear to have in mind. The fact that Professor Thomas also found it advisable to conduct the tests at night is significant. The author, when he described his method of arriving at an approximate temperature of the air inside the holder, did not mean to establish a hard and fast rule that this temperature for *any* holder could be found as a function of two thermometer readings. All he wanted to show was that for the particular holder in question, and especially during the hours at which tests were made, such a function of two other temperatures would give the value required.

The question of the variation of a disc's coefficient with varying pressures and differentials is mentioned by Professor Thomas. Professor Walker's contribution mentions some tests made to study these changes. Apparently, for constant pressure, a variation of the differential between commercial limits (say 5 to 100 in. of water) has no appreciable effect. The effect of varying the pressure between the limits found in pipe-lines has a slight effect (not more than one per cent, between 0 and 250 lb.). Sometimes this is taken care of by the use of a "sliding" coefficient for the orifice disc.

Professor Greene asks if it is not necessary to consider the pressure on both sides of the orifice, or some function of that pressure. This question is often asked by engineers who expect to see, as a factor in the equation, a square root of the difference of two squares of pressures. However, for all purposes, where the differential reading is not greatly in excess of the values found in practice, the $\sqrt{hP_1}$ is practically equal to Constant times $\sqrt{P_1^2 - P_2^2}$, where h = differential drop in pressure, P_1 = inlet pressure (absolute) and P_2 = outlet pressure (absolute), and the equation involving the factor, $\sqrt{hP_1}$, is in a more convenient form.

In some orifice meter installations, the "static" pressure reading is taken on the outlet side of the meter. This seems more or less a matter of preference, with the restriction, of course, that the same method of connecting must be used as when the disc was originally calibrated.

Mr. Voorhees' inquiry is as to whether the coefficient of discharge should decrease with the diameter of orifice. Such is the case, not only with the discs of the type tested at Joplin,

but with orifice meter discs of every type with which the author is familiar. This is not true, however, of an orifice at the end of a pipe-line, or inserted at the end of a drum, and discharging into the atmosphere. With this type of orifice, an increase of the orifice diameter causes a decrease in the coefficient.

The discussion clearly indicates the increased interest in the subject of gas measurement by orifices. That the number of commercial orifice meter installations now in use for measuring natural gas is far in excess of one thousand is believed to be a conservative estimate. Since the paper was written just about a year ago, at least one additional type of orifice meter has been placed on the market, and there is good reason to expect that several more are to follow.

Probably the most important mechanical development of the past year has been the perfecting of a recording gage especially suited to orifice meter use. This is a compound pressure and differential-pressure gage, i.e., two records are made on the same chart by two pens using different colored inks, and marking over the same scale. This means that just half as many charts have to be handled each day, and also makes possible simplified pipe connections. A "safety" or blow-over device as an integral part of the gage—one that really prevents damage to the gage on excessive differential readings—is a most welcome innovation. This gage is of the mercury float type—the principle towards which the author has always been partial. Altogether, the installation of some sixty or seventy of these gages has gone a long way towards solving his gage troubles of the last three years.

A paper by F. G. Keyes in the Journal of the A. S. R. E., January, 1916, gives equations for ammonia based on new experimental material. The constants of the equation of state were determined from data in the region of high temperatures, and then by means of the equation, comparisons were made by calculating the volumes of the measured pressures and temperatures for the data at large concentrations.

There is some discrepancy between various published coefficients for orifices. Probably the sharpness of the edge has considerable influence. Since, apart from this, the coefficient for an orifice varies with the pressure, the best plan for the measurement of air-flow by means of this type is evidently to employ a short convergent nozzle with a rounded entrance, and to adopt a coefficient of 0.98. Capt. T. B. Morley, *Proc. Inst. Mech. E.* (meeting, January 21, 1916.)

"Ignition by compression," so generally and superficially accepted as the fundamental principle underlying Dr. Diesel's invention, was, as a matter of fact, merely a natural corollary, and was not even claimed by him as his original conception, although typical of the engines that bear his name and successfully employed in them alone. Dr. Diesel's great aim was a closer realization of the theoretical efficiency of the Carnot cycle than attainable by steam engines or internal combustion engines of the ordinary types. And although his aspirations were crowned with only partial success, it is scarcely to be doubted that they created a heat engine that has the highest efficiency that will ever be attained with fuel. Max Rotter, Mem. Am. Soc. M. E., *International Engineering Congress, 1915.*

ELASTICITY AND STRENGTH OF STONEWARE AND PORCELAIN

BY JAMES E. BOYD, COLUMBUS, O.

Member of the Society

THIS investigation was undertaken at the suggestion of Ralph D. Mershon,[1] Mem.Am.Soc.M.E., who expressed the belief that exact knowledge of the form of the stress-strain diagrams of clay products in tension and compression would make possible the design of insulators of greater mechanical strength and more definite factor of safety.

TEST PIECES

The test pieces were obtained from the General Electric Co. and the Keasbey Stoneware Works. Pieces used in some of the later tests were made at the Ohio State University.

Fig. 1 shows the shape and size of the test pieces furnished by the General Electric Co. and the Keasbey Stoneware Works. The porcelain pieces from the former were all of one composition, while the stoneware pieces from the latter were of five

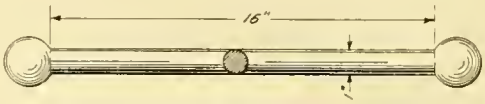

Fig. 1 Round Test Piece

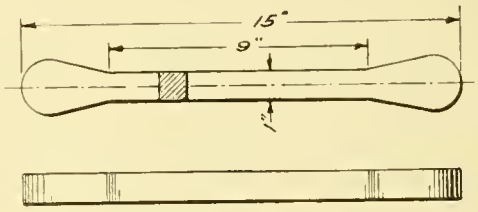

Fig. 2 Rectangular Test Piece

different types, designated by the manufacturer as W. M., 132, 2x4, 53, and 3 respectively.

Fig. 2 shows the form of the pieces made at the University by forcing the clay through a rectangular die, and then carefully cutting to the desired form in the hope of eliminating internal stresses.

All measurements of deformation were made by means of a lever extensometer, with arms approximately 0.25 in. and 12.5 in. in length respectively. Each instrument is calibrated by using it to measure the pitch of a micrometer screw, and the longer arm is adjusted to make the magnification 50.

The micrometers are supported by a pair of wooden bars clamped to the test piece about 2 in. above the clamp supporting the levers.

To avoid error when the load is eccentric, care was taken to have the two levers at equal distances from the test piece, and also to have the knife edges and the axis of the test piece in the same vertical plane.

Contact between clamps supporting extensometer levers and test pieces was made through soft solder.

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[1] Member of Research Committee and Chairman of Sub-Committee on Materials of Electrical Engineering.

Presented at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 1915. Pamphlet copies without discussion may be obtained; price 10 cents to members; 20 cents to non-members.

GRIPS FOR TENSION TESTS

The first grip tried consisted of a 2-in. pipe coupling with a reducer bushing at the end. The bushing was cut in halves so that it could be fitted around the test piece below the head and then screwed into place. One of these grips is shown in Fig. 5 at the lower end of the vertical rod at the left. Soft material, usually leather, was placed between the bushing and the head of the test piece. A rod with a spherical head was passed through a second bushing (not shown) at the other end of the coupling, giving the effect of a ball and socket joint.

Upon using this grip in tension tests, the extensometer readings revealed considerable eccentricity of loading due to lack of perfect symmetry in the heads of the test pieces and want of uniformity in the soft material against which the heads pressed. This eccentricity might have been eliminated by supporting each grip on pairs of adjustable knife edges at right angles, but on account of the inconvenience and expense this arrangement was not adopted.

Fig. 3 shows another form of grip used for most of the tension tests of the cylindrical pieces. This consists of two steel plates held together by three bolts. A conical depression in each plate holds some soft material—lead, leather, or rubber—which, in turn, grips the head of the test piece. The upper bolt passes through the pulling rod *B*, forming a hinge connection. The rod *B* may be moved along the bolt to adjust slightly and a further adjustment may be made by loosening

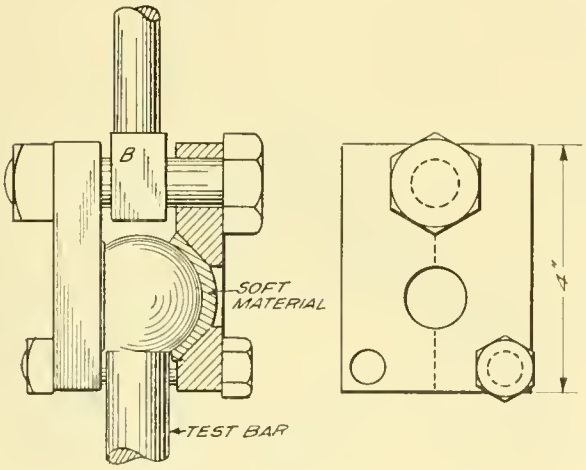

Fig. 3 Grip Used in Tension Tests of Round Rods

the bolts and changing the alignment of the test piece and grip. With this arrangement it is practicable to so reduce the eccentricity that the elongations as shown by the two micrometers become nearly equal. There still remains, of course, the possibility of eccentricity at right angles to the plane of the instruments, which may only be determined by means of a third lever.

With this grip it was found that practically all the pieces still broke at the head. (Four of these shown in Fig. 5 illustrate the characteristic failure.) As it was thought that this failure might be caused by too abrupt change of section, the form of test piece shown in Fig. 2 was developed. The clamp for this piece is shown in Figs. 4 and 5. Sheet lead was first tried as the soft material to distribute the stress. With a bearing area of about 4 sq. in. the lead failed, principally by shear, when the pull was 2900 lb. Leather failed at 2400 lb. It is evident that the slope of the head of this form of test piece is too small for these materials, unless the ratio of the bearing area to the cross section of the stem is considerably increased. Copper and aluminum were found too hard, causing the porcelain to chip locally.

These test pieces all failed at the head, but at some distance above the stem. Fig. 5 shows the head and part of the stem of one piece with a characteristic failure. Sometimes the fracture was a little below the lower edge of the bearing area, sometimes a little above.

Two explanations are suggested for this method of failure. One is that the stress is concentrated in the outer fibers of the head and is really of greater intensity here than in the smaller section of the stem, where it has become uniformly distributed. As stress is transmitted from the outer fibers inward in the form of shear, the shearing strength and modulus become factors. The other explanation is that the tensile stress developed as a result of the transverse compressive stress makes the total

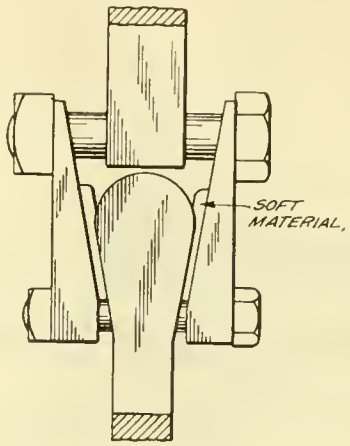

Fig. 4 Grip Used in Tension Tests of Rectangular Rods

stress at the section of failure much greater than at the stem. Assuming that the unit compressive stress is 10,000 lb. per sq. in. and that Poisson's ratio is ¼, the compression alone develops a tensile stress of 2500 lb. When this is added to a direct tensile stress of perhaps 2000 lb. per sq. in., we get a stress in the head of 4500 lb. per sq. in., which easily accounts for the failure. It is probable that both of the above factors are present and that, combined with more or less eccentricity of loading, they each contribute to the failure.

TABLE 1 TENSION TEST OF STONEWARE 53 I

Area, 0.77 sq. in. Feb. 7, 1913.
Gaged length, 12.57 io.

Load, in Lb.		Micrometer Reading			Elongation in 0.00001 In.		
Total	Per Sq. In.	Left	Right	Sum	From 10 lb.	From No Load	Unit
8	10	503	384	887	0	2	....
154	200	526	404	930	43	45	3.57
308	400	558	415	973	86	88	7.00
462	600	567	448	1015	128	130	10.34
616	800	588	467	1055	168	170	13.52
770	1000	609	489	1098	211	213	16.96
924	1200	635	501	1136	249	251	19.97
1001	1300	648	509	1157	270	272	21.64
1078	1400	665	521	1186	299	301	23.95
1155*	1500	...	...	...	...	...	....

* Broke before reading could be taken.

RESULTS OF TENSION TESTS

Table 1 gives the results of one tension test. In this test several sets of readings were made with loads up to 800 lb. per sq. in., in order to adjust the grips to reduce eccentricity. In these preliminary runs several readings were taken at each load. As these showed little variation, a single reading only was taken at each load for the last set which is given in the table.

The third column of micrometer readings is the sum of the readings of the two instruments. The micrometers read in 0.001 in., and the lever magnification is 50, so that differences

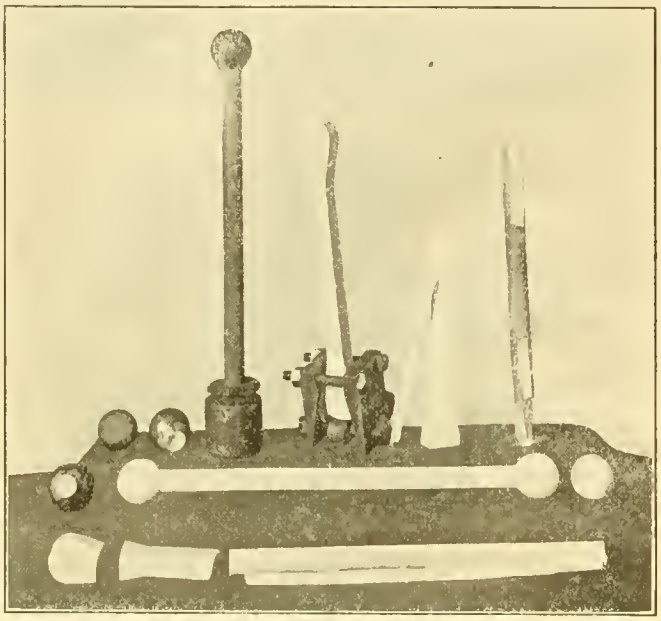

FIG. 5 TEST PIECES, SHOWING GRIPS AND TYPICAL FRACTURES

between successive readings of either micrometer represent 0.00002 in., and differences between figures in the column of sums are in 0.00001 in.

The results of this test are shown graphically by the lower curve of Fig. 6. The diagram is practically straight up to 1300 lb. per sq. in. The broken line from 1400 to 1500 lb. per sq. in. is intended to show that it carried the load represented by the ordinate but that no deformation reading was secured above 1400 lb. per sq. in. The modulus of elasticity, calculated from the single reading at 1000 lb. per sq. in., is

$$E = \frac{1000}{0.000170} = 5{,}900{,}000$$

Besides stoneware 53 I, Fig. 6 represents three other tension tests, porcelain I, stoneware 132 III and stoneware 2x4 I. In each case the particular tension test represented is the one showing the highest ultimate strength, as may be seen from Table 2.

It will be noticed that each of these diagrams, except stoneware 53 I, is practically a straight line giving no definite indication of a true elastic limit. The double curve in the porcelain diagram is probably due to temperature changes, as there was considerable draft on the apparatus at times during this run.

TABLE 2 TENSION TESTS OF PORCELAIN

Lb. per Sq. In.	Unit Elongation In 0.00001 In.					Modulus of Elasticity
	I	II	III	IV	Average	
200	2.06	1.83	1.90	1.96	1.94	10,310,000
400	3.96	3.74	3.96	4.16	3.95	10,130,000
600	6.10	5.48	5.86	6 19	5.91	10,150,000
800	8.24	7.24	7.69	8.47	7.91	10,110,000
1000	9.90	9.07	9.91	10.35	9.81	10,190,000
1200	11.97	10.75	11.81	12.23	11.69	10,260,000
1400	14.34	12.89	13.79	14.43	13.86	10,100,000
1600	15.93	14.57	16.24	16.39	15.78	10,140,000
1800	18.07	16.72	17.75	18.74	17.82	10,100,000
2000	19.97	18.39	19.89	20.71	19.74	10,130,000
2100	20.76	Broke	.....	.....		
2200	21.39		21.31	Broke		
2300	22.58		.....	*		
2400	23.53		23.30			
2500	24.64		24.72			
2600	26.16		25.44			
2700	27.10		26.70			
2800	27.97		27 89			
2900	28.76		28.68			
2950	Broke		.....			
3000			Broke			

* Broke at extensometer clamp at point where solder was crushed so that brass was in contact with porcelain.

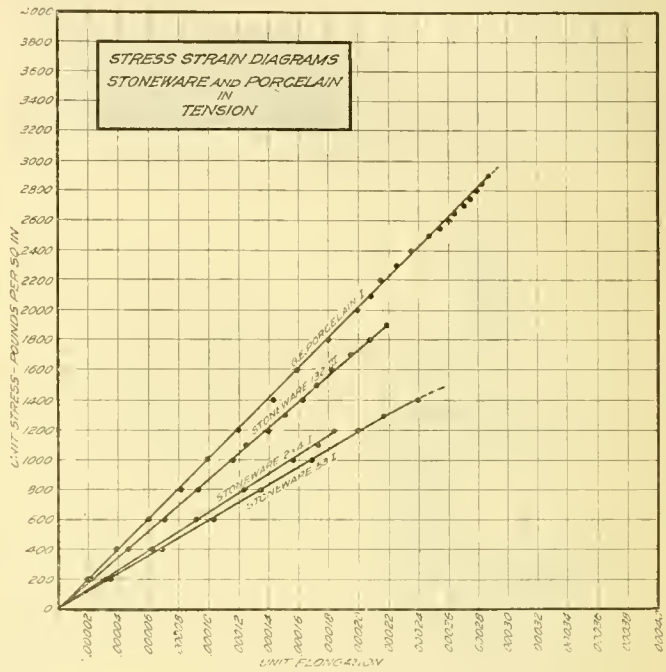

FIG. 6 STRESS-STRAIN DIAGRAMS, PORCELAIN AND STONEWARE

TABLE 3 COMPRESSION TESTS OF PORCELAIN I AND STONEWARE W.M.II

Lb. per Sq. In.	Unit Compression In 0.00001 In.		Modulus of Elasticity	
	Porcelain	Stoneware	Porcelain	Stoneware
1000	9.4	11.2	10,640,000	8,930,000
11000	104.8	129.8	10,500,000	8,470,000
12000	116.0	144 7	10,340,000	8,220,000
13000	125.7	158.2	10,340,000	8,220,000
14000	135.3	174.0	10,350,000	8,050,000
15000	145.6	189.1	10,300,000	7,930,000
15500	.....	196.5		
16000	155.4	Levers removed		
17000	166.4			
18000	177.3	Failed at 21500 lb. per sq. in.		
19000	Failed			

Table 2 gives the results of tension tests of four rods of General Electric porcelain.

COMPRESSION TESTS

For compression tests rods were cut off to a length of 16 in., and 12 in. was used as the gage length. Sheet lead was placed between the ends of the test piece and the plates of the testing machine. A preliminary test was made on a rod of stoneware 3. This rod, 8 in. in length, failed suddenly with a sharp noise under a load of 15,000 lb. per sq. in. It flew into many small fragments with the principal planes of fracture parallel to its length.

Measurement of elongation was made on two pieces, both of which failed by splitting lengthwise. Both rods are shown in Fig. 5. The porcelain rod, in a horizontal position in the front of the picture, has a single piece split off for almost its entire length. The split-off piece extends from the top of the rod to the position of the lower extensometer clamp. The other rod of stoneware W.M. shown standing at the right of Fig. 5 failed at the ends. Table 3

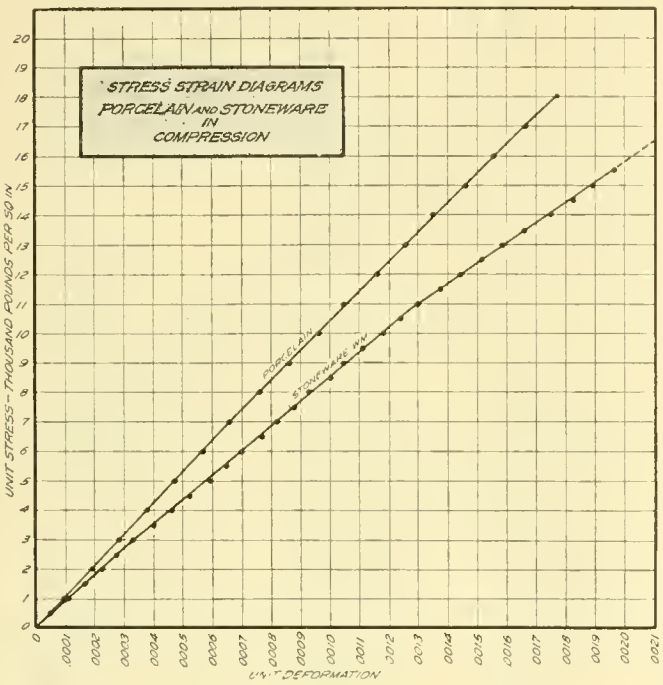

Fig. 7 Stress-Strain Diagrams, Porcelain and Stoneware

gives part of the results of the compression tests of these two pieces. Fig. 7 gives the diagram for Table 3. The porcelain curve varies little from a straight line; there is a slight change of slope at 7000 lb. per sq. in. which may indicate a true elastic limit. The stoneware curve bends slightly at 3000 lb. and shows considerable change of slope at 11,000 lb. per sq. in.

BENDING TESTS

Fig. 8 shows the arrangement of the apparatus for bending tests. The test bar is supported at two points B and B' and loaded equally at two symmetrical points A and A'. The extensometer lever is carried on a wooden beam, so mounted that it practically connects two points on the neutral surface of the test bar at equal distances c outside the load points A and A'. The connection between test bar and beam is made through two steel stirrups, of which the right one, D, is rigidly fastened to the beam and the left one, E, is joined through a pair of cone pivots. Brass clamps gripping the test bar are connected to the stirrups through cone pivots. This arrangement keeps the wooden beam parallel to the line joining the upper pivots and at a constant distance therefrom. At a point midway between the supports a third clamp is attached to the test bar and connected to the extensometer lever by a short steel rod. As the middle of the test bar rises when the load is applied, the test may be carried to failure of the piece without danger to the apparatus. The movement of the longer

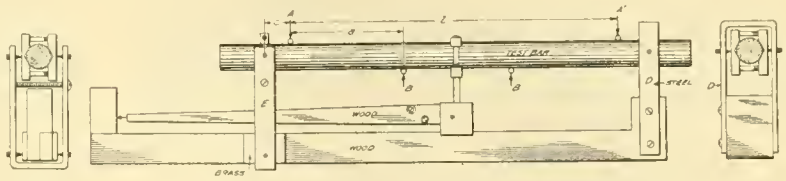

Fig. 8 Apparatus Arranged for Bending Tests

arm of the lever is measured by a micrometer attached to the wooden beam.

With this apparatus, the error due to temperature change is very small, and the curves obtained are more satisfactory than those of the tension tests.

In most of the tests the distance l between the loads was 12.6 in., and the distance a from A to B and from A' to B' was 4.2 in., so that the deflection of the middle of the bar above the line joining A and A' is the same as that of a beam supported at the ends and loaded at the third points. This deflection is

$$\frac{23\,P\,l^3}{1296\,E\,I}$$

where P is the total load, and I the moment of inertia of the cross-section. The additional deflection at a distance c from A is the product of the length c multiplied by the slope of the tangent to the bar at A.

Table 4 gives the results of one test of a stonewood rod. The stress in the outer fibers has been calculated in the usual way. In order to draw curves which may be compared with the tension and compression diagrams, the unit deformation in the outer fibers for that portion of the bar between the supports is given in the fourth column.

Fig. 9 gives the diagram for Table 4, together with those of two other kinds of stoneware and one of porcelain—the same materials which are shown in tension in Fig. 6. It will be noted that the diagram of porcelain is straight while those of stoneware 132 and 53 bend a little. The diagram of stoneware 2x4 seems to be straight when drawn to this scale, but

TABLE 4 BENDING TEST OF STONEWARE 2x4 I

Diameter, 0.945 in. to 0.955 in. Dec. 5, 1913.
Average diameter, 0.949 in.
$l = 12.6$ in.; $a = 4.2$ in.; $c = 1.2$ in.

Load in Lb., P	Deflection in In., η	Unit Stress in Outer Fibers	Unit Deformation in Outer Fibers 0.00001 In.	Modulus of Elasticity
12	0.00208	300	4.5	6,670,000
22	0.00382	551	8.3	6,660,000
32	0.00558	801	12.1	6,650,000
42	0.00728	1051	15.7	6,680,000
52	0.00904	1302	19.5	6,660,000
62	0.01080	1552	23.4	6,640,000
72	0.01256	1802	27.2	6,630,000
82	0.01442	2052	31.2	6,580,000
92	0.01618	2303	35.0	6,580,000
102	0.01806	2553	39.0	6,540,000

the figures of Table 4 show that there is a slight curvature. Since only the outer fibers in the middle third of the test bar reach the calculated stress, it is evident that the diagram from the bending test should be nearer a straight line than the corresponding tension curve.

COMPARISON OF TESTS

Fig. 10 gives compression, bending, and tension diagrams for G. E. porcelain. It will be seen that the compression curve for porcelain I has the same slope as the bending curve of porcelain II, while the tension curve for II has a little higher and the tension curve for I a little lower slope. Considering the variation in the tension tests as shown by Table 2, together with the fact that the curve for bending depends upon tension and compression jointly, it is probable that the modulus of elasticity in tension differs little, if any, from the modulus in compression.

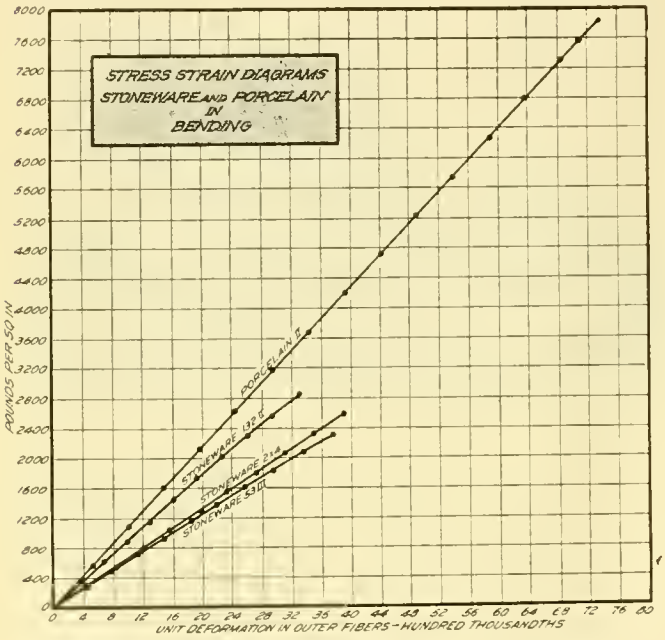

Fig. 9 Stress-Strain Diagrams, Bending Tests

If the bending curve for this porcelain be, as it seems, a straight line with the same slope as the compression curve, it follows that the ultimate tensile stress is the same as the modulus of rupture, or 7800 lb. per sq. in. If the bending curve deviates a little from a straight line, but not enough to show without greater refinement of measurement, there may be considerable deviation in the upper portion of the tension curve so that the real stress at rupture may be somewhat below 7800 lb. per sq. in. In any case, it is evident that the tension tests did not develop the full tensile strength.

Table 5 gives a summary of all the tests in which a complete series of readings were taken. The third column of this table gives the unit deformation at the unit stress of 1000 lb. per sq. in. Where no reading was taken at this load, the deformation has been computed by interpolation from the two nearest readings. The fourth column gives the modulus of elasticity calculated from the stress of 1000 lb. and the deformation of the third column. The fifth and sixth columns give the last unit deformation read and the corresponding unit stress. The modulus of elasticity calculated from these figures, or from the difference between them and the corresponding deformation and stresses at 1000 lb., will show whether the curve of the material deviates from a straight line.

CONCLUSIONS

From the results of these tests, the following conclusions may be drawn:

a The modulus of elasticity of stoneware and porcelain is practically the same in tension and compression. Its value may be obtained conveniently by a bending test.

b The modulus of elasticity of porcelain is about 10,000,000. The modulus of stoneware ranges from 6,000,000 to 9,000,000, depending on the material.

TABLE 5 SUMMARY OF TESTS OF STONEWARE AND PORCELAIN

Test Bar		Kind of Load	Unit Deformation at 1000 Lb. per Sq. In.	Modulus of Elasticity	Last Unit Deformation Read	Unit Stress	
						At Last Reading	At Failure
Porcelain							
G. E.	I	tens.	0.000099	10,100,000	0.000288	2900	2950
G. E.	II	tens.	91	11,000,000	184	2000	2100
G. E.	III	tens.	99	10,100,000	287	2900	3000
G. E.	IV	tens.	103	9,700,000	207	2000	2200
G. E.	I	comp.	0.000094	10,600,000	0.001773	18000	19000
G. E.	II	bend.	92	10,800,000	736	7822	7822
G. E.	III	bend.	97	10,300,000	646	6448	6448
Ohio S. U	III	tens.	0.000116	8,600,000	0.000330	2600	2700
Ohio S. U.	IV	tens.	121	8,300,000	271	2200	2400
Ohio S. U.	IX	tens.	108	9,200,000	329	2800	2900
Stoneware							
53	I	tens.	0.000170	5,900,000	0.000240	1400	1500
53	II	tens.	166	6,000,000	231	1400	1500
53	I	bend.	160	6,250,000	441	2666	2666
53	II	bend.	158	6,300,000	376	2291	2291+
2x4	I	tens.	0.000157	6,400,000	0.000184	1200	1200+
2x4	II	tens.	158	6,300,000	178	1100	1200
2x4	III	tens.	155	6,450,000	155	1000	1100
2x4	I	bend.	150	6,700,000	390	2553	2553
W. M.	I	tens.	0.000118	8,500,000	0.000269	2150	2200
W. M.	II	tens.	105	9,500,000	201	1800	1900
W. M.	III	tens.	109	9,200,000	191	1800	1900
W. M.	I	bend.	112	8,900,000	395	3444	3444
W. M.	II	comp.	112	8,900,000	1965	15500	21500
3	I	tens.	0.000173	5,800,000	0.000244	1400	1400+
3	II	tens.	177	5,650,000	177	1000	1100
3	III	tens.	161	6,200,000	250	1500	1600
3	II	bend.	169	5,900,000	384	2231	2231
132	I	tens.	0.000113	8,900,000	0.000181	1600	1650
132	II	tens.	127	7,900,000	152	1200	1250
132	III	tens.	116	8,600,000	219	1900	1900
132	II	bend.	112	8,900,000	328	2848	2848

c The compressive strength of porcelain and high grade stoneware in a column 16 in. long and 1 in. in diameter is about 20,000 lb. per sq. in. The stress-strain diagram is practically straight up to 7000 lb. per sq. in.

d The tensile strength of porcelain is above 3000 lb. per sq. in. The diagram is a straight line up to this stress. The tensile strength of stoneware ranges from above 1100 to above 2200 lb. per sq. in. The stoneware of the greater modulus has the greater strength.

These tests failed to develop the full tensile strength of the material. Judging from the bending tests and the form of the diagrams, it is probable that the real tensile strength is about twice as great as the figures here given.

DISCUSSION

Ralph D. Mershon (written). In suggesting to Professor Boyd the investigation he has so excellently carried out on the mechanical properties of ceramic materials, I had in mind more than the bearing of the subject upon the matter of insulation. For a long time it has seemed to me there were uses for ceramic materials where they are not now used, presumably because of the lack of information relative to their mechanical properties. One important possibility is that of the employment of clay pipes in many places where iron or steel ones are now used, especially underground. Of course such pipes are regularly used for sewers and drains, and I believe that to some small extent they have been employed for low pressure gas mains. But their use seems to have been confined to cases where the internal pressure was little or nothing. It would seem that their durability might be availed of in uses involving considerable internal pressures, if more were known of the characteristics and the possible uniformity of the material composing them.

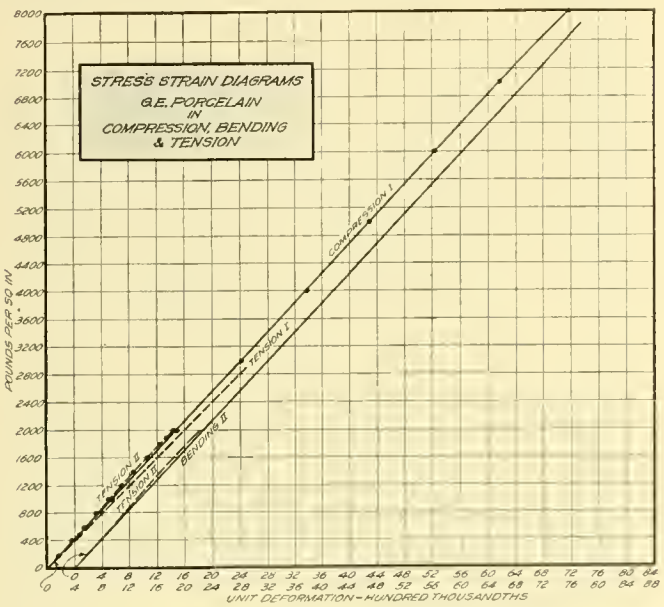

Fig. 10 Stress-Strain Diagrams for Porcelain

So far as I know, this work of the author is the first systematic investigation ever made of the mechanical properties of ceramic materials. It is to be hoped that it is a forerunner of further work along this line, both by Professor Boyd and others, and that we may have, before long, the results of investigations as to the influence of various mixtures, methods of working, and degrees of firing, upon the mechanical properties of ceramic materials, and upon the uniformity with which products composed of such materials can be produced.

R. C. Carpenter (written). The investigation described by Professor Boyd is the first that I have been able to learn about which gives information of the strength of stoneware and porcelain under conditions of use. The information given by the paper is of great value in all the arts where porcelain is employed either as a structural member or for the purpose of acting as an insulator under conditions where it must sustain a considerable load.

Porcelain is a difficult material to test in the ordinary standard testing machine because of its brittleness, so that the methods described in the paper will be found useful for all future tests of this material made in any laboratory.

The Society is to be congratulated for the success of this investigation, which is one of the results of the activity of its Research Committee. The field covered by the investigation gives information of the strength when subjected to tension, bending or compression strain, and for that reason is complete to a remarkable degree, especially when the difficulties which had to be overcome in making the tests are considered.

L. E. Barringer[1] (written). The mechanical strength of porcelain is satisfactory in some respects and decidedly unsatisfactory in others. The most consistent property is the resistance to crushing and the most erratic and unsatisfactory is the toughness, or resistance to the sudden shock of impact or vibration.

A few years ago I stated that in our experience with vitrified porcelain used for electrical insulation we had found an average compressive strength of 20,000 lb. per sq. in., and a tensile strength of from 900 to 1800 lb. per sq. in. The tension tests were made upon briquettes of the standard shape used in cement testing, with the use of special clips and cushioning materials, and the compression tests on 2-in. cubes. Professor Boyd's paper indicates a compressive strength for porcelain of the same value; I think 20,000 lb. per sq. in. is a safe basis for the calculations of designing engineers.

The comparatively high and uniform compressive strength for porcelain, as compared to its other mechanical strengths, has led engineers to take advantage of this property as much as possible, and certain types of line insulators are designed to bring the strains upon the porcelain as nearly to compressive as possible.

In several instances porcelain, because of its high insulating value and weather resistance, has been found quite the best material for insulation in electric railway equipment. In this particular field, however, porcelain can only safely be used in compression, and would meet with early failure if subjected to tensile, transverse, or impact strains.

In the matter of determining tensile strength the conditions are more complex than in developing compressive strength. The author shows it is quite necessary to devise special clips and cushioning materials to develop the true tensile strength, and in his tabulation of conclusions states that even his very carefully conducted tests failed to develop the real tensile strength of either porcelain or stoneware.

Inasmuch as the paper states only 3000 lb. per sq. in. could be developed, and this with the use of special clips, cushioning material and manipulating, although the true strength was probably 7000 lb. per sq. in., it is suggested that a working figure of 1500 lb. per sq. in. be taken for tensile strength.

One point in connection with the mechanical strength of porcelain is the effect of temperature changes. In the kilns a marked difference of strength will be found, depending upon the rate of cooling. In the finished product temperature changes even within the range of 20 to 90 deg. cent. have an influence upon the mechanical strength. In general, sudden temperature fluctuations cause lowering of mechanical strength; and temperature changes in the finished porcelain, even though brought about at a comparatively slow rate, will have a harmful effect within certain ranges. Porcelain baked at 90 deg. cent. exhibited a decided weakness upon cooling.

The effect of temperature changes is more pronounced as the rate of fluctuation increases, and has the greatest effect

[1] Engr. of Insulations, Gen. Elec. Co., Schenectady, N. Y.

upon the toughness. The tensile and transverse strengths are next most seriously affected, and the compressive strength least of all.

F. M. Farmer presented a written discussion. He stated that this constructive paper represents a considerable amount of very careful and obviously reliable work which will be particularly appreciated by all electrical engineers who have had to do with porcelain insulators. There is a remarkable dearth of reliable information of this character on porcelain.

The paper is, however, of interest for another reason, namely, it emphasizes the small amount of research work which is being done on standard engineering materials. The importance of this general class of research work is frequently overlooked. The ultimate commercial engineering value of such data is often, and perhaps usually, much greater than that obtained from researches which have terminated in more startling results. Many of our common engineering materials are constantly changing, due to improvements in the methods of manufacture, different methods of treatment, etc., and consequently their properties should be redetermined occasionally.

Porcelain, for example, has been improved very greatly in the last fifteen years and yet, despite the enormous increase in its use for purposes where knowledge of the physical properties is important, no reliable data are available on such an

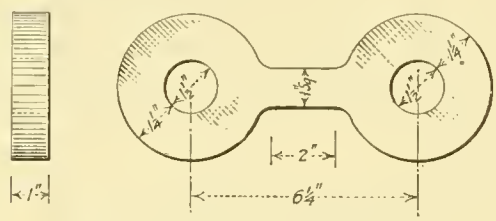

Fig. 1 Porcelain Test Piece

important property as tensile strength. In this paper it is concluded that the tensile strength of porcelain is above 3000 lb. per sq. in., whereas the usual sources of information give the value as 650 to 2200 lb. per sq. in. These latter figures were undoubtedly obtained many years ago and do not apply to the modern porcelain.

It will be conceded that no general conclusions as to the strength of porcelain can be drawn from the small number of tests described. While four or five specimens of a given sample of porcelain may be sufficient, it is necessary to test not only samples of as many different makes as possible, but samples of different thickness, and samples which have been subjected to various temperatures and periods in firing, etc.

Nothing is stated as to the kind of porcelain tested. Presumably it is what is known as electrical porcelain, but further information would have been desirable, such as the kind of clays used, methods of firing, temperature of the furnace and time of firing.

A form of grip and of test specimen which would develop the maximum strength of the porcelain would be desirable. While the conclusions in regard to the tensile strength drawn from the bending and compression tests are probably correct, data obtained by direct tests are more convincing. It would seem off-hand that the rectangular test piece with longer bearing surfaces at the ends would have developed the maximum strength of the porcelain.

T. D. Lynch[1] (written). We have done most of our testing of porcelain in the final piece as made for service. The sections of such pieces are more or less irregular and for that reason difficult to reduce to a square inch section. We have made a few tests, however, on samples of porcelain with holes in either end for the purpose of attaching clevises, as shown in Fig. 1. Such samples showed approximately 1500 lb. per sq. in. tensile strength, and about 15,000 lb. per sq. in. compressive strength, or ten times the tensile value. These tests are not at all conclusive. Our full-size tests on the finished piece indicate that the strength of porcelain is probably very much influenced by internal stresses, and it would be interesting to know of any study made by the author along this line.

An investigation of the internal stresses in brasses and bronzes was conducted by P. D. Merica and R. W. Woodward and reported before the American Institute of Metals in 1915. Perhaps some similar test could be made on porcelain to determine if possible a heat treatment that will eliminate internal stresses or at least reduce them to a minimum.

John F. Ancona thought there was a possibility that the peculiar failure of the pieces in the tensile tests might be attributed to some condition of internal stress.

Elliott H. Whitlock said that in connection with the effect of temperature of cooling on the homogeneity of the sample he had found that with a certain material the temperature rise curve of the firing had a great deal to do with the final strength. If the temperature rose to a certain point and was then allowed to drop and then again brought up to a higher point, the material was very much weaker than if the same temperature had been reached by a continuous rise. He thought that possibly the rate of firing might have as much to do with the tensile strength of porcelain as the rate of cooling.

Percy H. Thomas (written). The author found that fair and reliable results were difficult on account of the great tendency in the test machine for the stress to be applied unevenly to the porcelain section, and also on account of the extreme local stresses at the point of application. While great care was taken in this work to eliminate such effects, other forms of specimens and other methods of holding the test pieces might be much better.

Porcelain is used in practical service in certain cases in such a way as to be called upon to support very material stresses, and does so very reliably. But in practice the shape of the porcelain pieces and the method of support are such as to avoid the difficulties found in the tests described. For example, the high tension suspension type porcelain insulator serves to give mechanical support to a line conductor, at the same time insulating it. The porcelain part, as far as we are here concerned, is a cup in which an iron pin is fastened by filling the cup with Portland cement. The cup is held on the outside by a metal cap into which it enters and to which it also is secured by Portland cement. When the inner pin is pulled out in the testing machine, the metal cap being made fast to the resisting jaw of the machine, the porcelain cup is pulled apart, leaving its bottom portion in the cap, and the rim following the pin. The characteristic fracture is that of tension stress. A porcelain cup 1 in. internal diameter and with a wall ¾ in. thick may resist a stress as high as 13,000 lb. in some instances, which is equivalent to 2500 to 3000 lb. per sq. in., assuming an even distribution. But as this stress must be greater near the surface of the wall than on the interior, the true unit stress must be much higher. This corresponds fairly well with the test values of the paper.

[1] Research Engr., West. Elec. & Mfg. Co., E. Pittsburgh, Pa.

Furthermore, in spite of the very serious stresses to which these insulators are subjected, there are no signs of brittleness or unreliability in service on this account.

The conclusion would be that, when properly used, porcelain is a very strong and reliable material, and by no means deserves the reputation it has been given by its behavior in tests of porcelain rods and narrow tubes.

John A. Brashear. For nearly twenty-five years I have thought of using or attempting to use a porcelain disc of a special design instead of glass for a reflecting telescope. Silvered glass mirrors were introduced some forty years ago; that is, silvered on the front instead of the back surface, and I have thought in the case of large glasses, the disc could be made of porcelain, which could be given an approximate curvature before the enamel was deposited upon it, and if this enamel could be put on thick enough, then ground, fined and polished, and then the surface silvered, it would make a very excellent substitute for the glass mirror. I do not know whether any studies of the coefficient of the expansion and contraction of porcelain have been made, but in the glass disc it is an important factor, so that in the case of large telescopes it gives very great trouble. In the case of the 72-in. reflector which we are now making for the Canadian Government, the disc alone, which is 12 in. thick, weighs two and one quarter tons; and the 100-in. which is being made for the Mt. Wilson Observatory, weighs in the neighborhood of four tons. If this weight could be reduced in the porcelain disc, and the material be made homogeneous, with a coefficient less than glass, it would be a great advantage to the instrument itself.

The Author. In regard to internal stresses, mentioned by Mr. Lynch, it was first thought that the failure of the round rods at the head was due to this cause. Accordingly the rectangular pieces were made with a gentle change of slope, and considerable care was used to so handle the clay as to leave all parts of the piece in the same condition. The nature of the failure of these pieces seemed to indicate, not internal stress, but the combination of the direct tension with the tension resulting from the transverse compression of the grips. As suggested by Mr. Farmer, a grip with larger bearing surface should make it possible to develop the full tensile strength. The head of the test piece should enlarge somewhat more rapidly than shown in Fig. 2.

Transverse compression not only weakens a rod subjected to longitudinal tension but also strengthens it for longitudinal compression. Bands around porcelain rods near the ends seem to have the same effect as in hooped concrete columns.

Internal stress is probably an important factor in insulators where there are rather abrupt changes of section. In metals the amount of internal stress may be determined by measuring the dimensions of a small portion, then cutting it free from the rest of the body and measuring again. The difficulty of cutting makes this impracticable with porcelain. A form of test bar with an enlargement or contraction near the middle will enable one to separate the effects of compression of the grips from those of internal stress and unequal distribution of stress. To differentiate completely between these last two factors may not be possible, but series of tests varying one at a time the two elements of heat treatment and form of piece should give valuable results. Whatever internal stress is found may be due either to the heat treatment or the mechanical treatment of the wet clay, and another set of experiments will be necessary to settle all these questions. For testing these pieces, bending tests with a constant moment for a considerable length will be found easier to apply than direct tension tests.

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

In its report to the Council, published in The Journal for December 1915, the Publication Committee presented a carefully thought-out plan for the publications of the Society, certain features of which it has already been possible to carry out. Several letters commenting on this plan have been received, which are published herewith. The recommendations of this Committee are also reprinted in this connection for convenient reference.

TRANSACTIONS

1. That the publication of the annual volume of Transactions be continued.
2. That it be published in the same size and binding as heretofore.
3. That it shall contain, subject to the approval of the Publication Committee, all of the papers and discussions presented at meetings of the Society (not including section meetings), and technical reports of Committees; and shall contain a syllabus of each paper, summarizing the essential facts and conclusions.
4. That it shall contain all the papers and discussions presented at section meetings which in the opinion of the Publication Committee are of sufficient merit.

REVISES

That additional revised copies of the papers and discussion be printed and bound in pamphlet form at the earliest practicable date. A charge will be made for such pamphlets.

ADVANCE PAPERS

That papers for the meetings of the Society be printed in pamphlet form in advance, as heretofore, and be sent to members gratis upon request, a notice of these papers with syllabi, being printed in The Journal one month before meetings.

THE JOURNAL

1. That The Journal be published monthly as heretofore, but with the view to making it a semi-monthly or a weekly as soon as the amount of matter to be handled requires it and funds for that purpose are available.
2. That the size of The Journal shall for the present remain as it now is.
3. That The Journal shall contain:
   - *a* All of the papers and discussion presented at regular meetings of the Society, preferably in substantially complete form, or adequately abstracted, according to the character of the paper, as soon after the meetings as possible.
   - *b* Papers, or abstracts, with discussion, presented at meetings of Local Sections.
   - *c* Announcements and reports upon Society affairs and incidents, employment bulletin, library notes, personal notes, etc.
   - *d* Department for contributed discussions on papers previously published, or new matter.
   - *e* Members correspondence department, including suggestions on Society affairs.
   - *f* Review of World's Technical Press.
   - *g* Review of technical books, by experts selected by the Committee.

PUBLICATIONS OF THE SOCIETY

To the Editor:

I think Professor Christie's letter expresses exactly my opinion and judgment of the publication matter. While the out of town members constitute the majority of the Society's total enrollment, this does not fully state the fact, because a very small percentage of the local members attend meetings, so that but a small fraction of the total out of town membership is present whenever papers are presented.

Furthermore, the discussion from such sources naturally tends to be verbal rather than written, and expresses less mature thought, or at least not so careful presentation.

In my own case, I never have sent for advance copies of papers, and probably never, or at least very rarely, will, because I am, like a good many others, extremely busy. I cannot tell from the summary of a paper whether it is really worth while or not, but I can tell very quickly by sketching over it, as I always do with the Proceedings of the American Society of Civil Engineers. Of two papers of the same title, and having approximately the same summary, one might, in my opinion, be extremely valuable and merit extended and careful discussion on my part, and another composed to such an extent of generalities and mere presentation as not to be worth my careful reading.

It is my experience that, speaking by and large, probably the most suggestive portions of papers presented to the American Society of Civil Engineers have been found by me in discussions, or at least brought out by such discussions. Consequently, I feel very strongly that no trouble or expense should be spared to increase even by a small percentage the number and quality of discussions of papers. My own personal judgment, therefore, is that positively the best expenditure which the Society could make would be to return to the earlier plan of publishing all papers in The Journal before meetings, just as is done by the Civil Engineers and the Electrical Engineers.

H. T. Cory.

San Francisco, Cal.

To the Editor:

Referring to the report of the Publication Committee, I do not hold my opinions of much value, but am giving you them for such appraisal as you may make of them.

TRANSACTIONS

1. I should not like to see the annual volume discontinued; it is of much value to me.
2. If published in the same same size and binding as before it will suit me better than if changed. I have all of the previous volumes, and I consider them as large as one cares to handle or provide cases for.
3. I think it should contain all approved papers and discussions.
4. There might be some meritorious papers at section meetings that should be included. There is so much rehashing of matter, and publication of stuff that is only filling, that a careful pruning by the Editors is advisable.

JOURNAL

1. Yes.
2. Satisfactory to me.
3. (a) Yes, if not involving too much expense.
   (b) Such as are considered of sufficient value to warrant their publication in the transactions.
   (c) Yes.
   (d) Yes.
   (e) Yes.
   (f) Doubtful value to me. These would perhaps involve more expense than the work would be worth, and in some cases work to the disadvantage of the Society.
   (g) No.

REVISES

This should be left to the Publication Committee who could respond to such demands as were made.

ADVANCE PAPERS

Not necessary if item (a) under Journal is complied with. Otherwise, yes.

Jno. C. White.

Madison, Wis.

To the Editor:

I am much pleased to learn that the publication of the Transactions is to be continued in volumes corresponding to those which we already have, and that they will contain as heretofore all the technical material of value resulting from the meetings of the Society. Those who have been connected with the Society for a number of years set great store by the Transactions in their complete form and wish to keep the form and style intact.

The publication of advance papers will also aid in bringing out discussion both oral and written and will thus add to the value of the meetings. These advance copies are also convenient for filing under subjects in the libraries of the members. It is sometimes desirable to file a paper on some particular phase of engineering together with publications of similar import for convenience of reference. The Journal itself would be more usable and more in accordance with the general scheme if it were printed in the usual 6 x 9 size. The publication of papers in The Journal could be largely dispensed with as unnecessary and the text confined largely to matters of general interest, such as reports of meetings, announcements of meetings, reviews of publications and periodicals and other miscellaneous material which would not appear in the Transactions. Matter which would naturally appear in the ordinary technical journals of the country is out of place in The Journal of the Society. Nothing should be published in The Journal at additional expense which can just as well be read elsewhere; in other words, The Journal should be what the name implies, a monthly record of Society matters which do not appear elsewhere. The small size is much more convenient for library purposes as it conforms to the ordinary pamphlet filing cases.

C. H. Benjamin.

Lafayette, Ill.

To the Editor:

The writer has the following comments to make on the plan for publications of the Society.

Under Transactions and Revises the writer agrees entirely with the outline as published.

Under The Journal the writer would raise objection to the present size of The Journal. It is large and unwieldy and not convenient for ordinary perusal. It is believed that the former size of The Journal, or the size used by fiction periodicals, would be very much preferable. This statement is made after several years experience with both sizes, and the regular receipt of publications of other societies not printed on the large page now used by The Journal.

Under paragraph 3 the writer would suggest that in The Journal all discussion be omitted. By doing this, the original papers could be printed in fairly complete form in The Journal as far in advance as possible, and in our opinion would be ample record for the members until such time as the

Transactions were published. This would also do away with the publication of advance papers except in cases where publication in The Journal would not be possible previous to the presentation of papers.

W. B. Sanford.

New York, N. Y.

FAHRENHEIT SCALE

To the Editor:

As you probably know, a paper is being circulated for expression of opinion relative to the discontinuance of the Fahrenheit thermometer scale. This paper is being sent out by a member of Congress, Representative Johnson of Washington.

I wish to know what attitude is being taken by the Engineering Societies regarding this matter. There has been quite a determined stand taken against the forcible adoption of the metric system, but I am not sure whether this extends to the use of the Fahrenheit scale. The change would cause considerable commotion in our definition of heat units.

P. F. Walker.

Lawrence, Kansas.

[Comments from the membership on the question raised by Prof. Walker will be appreciated by the Secretary.—Editor.]

DEVICE FOR RECORDING DATA IN A BOILER PLANT

To the Editor:

The instrument illustrated herewith has been designed in an endeavor to produce a device that will assist the responsible head of a boiler plant to a knowledge of the performance of his boilers, hour by hour, without the necessity of analyzing in detail the figures of the daily coal and water logs. The boiler room superintendent usually knows pretty closely how many pounds of steam ought to be evaporated per pound of coal burned, and he is principally interested in learning, with the least amount of work, whether his assumed standard of economy is being consistently maintained.

The instrument, which for lack of a better name has been styled the *Econograph,* is conveniently located in the manager's office. It produces a daily chart that shows by separate lines, but simultaneously, the water rate, the coal rate and whether the ratio of water to coal has fallen below the assumed standard. The chart not only shows whether the desired degree of economy has been maintained, but also, in the event of the economy falling below the desired standard, the chart shows the time of day when the drop occurred, and for what length of time the boilers were run at a degree of economy lower than the assumed standard. The diagram also assists, by mere inspection, in locating the cause of falling off, that is, it indicates whether the poor economy was brought about by decrease in evaporation, or by unusual increase in fuel.

The daily chart consists of four lines or curves, coincident as to time, but independently recorded on the chart as follows:

1. A line showing the amount of water fed to the boilers;
2. A line showing the fuel fired;
3. A line showing the time at which unevaporated water was withdrawn from the boiler, through the blow-off or otherwise.
4. A line showing the time at which the economy of steam production fell below the assumed standard of performance which was expected to be maintained, and the time when the desired standard was regained.

The water line on the chart gives, to scale, the total water fed to the boilers at any given hour, in thousands of pounds. The inclination of this line from the horizontal shows approximately the rate at which water was being supplied at any given time, and shows fluctuations in rate of water supply. The fuel line shows the total fuel fired at any given time and the rate of firing. Thus, the slope of the water and fuel lines indicates at a glance the probable cause of any change in economy.

The hour at which an apparent change occurs is automatically shown so that the time of commencement and the end of a period of inefficient operation on the day-shift, night-shift, or at any time, is recorded beyond dispute. If standard economy, or better is being maintained, the chart shows it, indicating that there is no necessity for analysis of the water and coal logs; but if economy drops, the time at which the drop occurs, is definitely fixed and an analysis of the coal and water

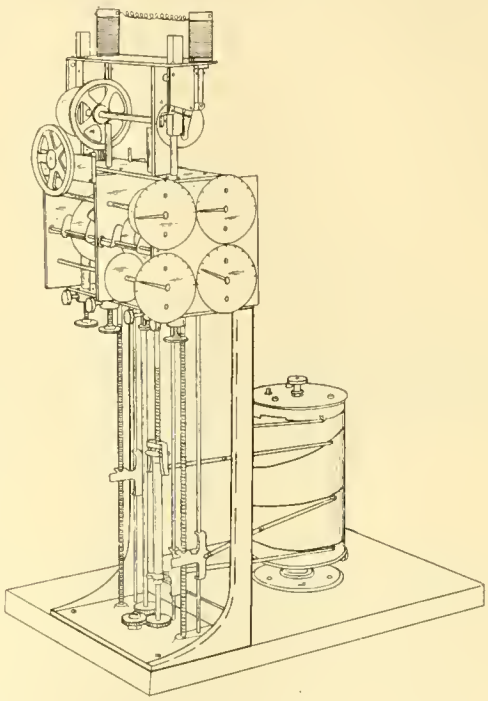

Fig. 1 Detail View of the Econograph Instrument

logs for that period of time should be made to locate the fault.

The instrument comprises a clockwork drum carrying a sheet of paper on which four pointers draw independently the lines above referred to. One of the pointers is connected through a train of gears and an electrically operated tripping mechanism with a contact switch connected to a water weigher, or to the recording device of a flow meter that measures the amount of water fed to the boilers, or it may be connected with the recorder of a steam-flow meter. The second pointer is connected through a similar set of gears and an electric tripping device with a moving part of the stoker, or with an automatic coal scale, or with a contact device actuated by wheel-barrows or carts delivering coal to the boilers, as the case may be, or if gas or oil is used for fuel, the pointer is actuated by contacts on the indicator of the fuel meter.

The third pointer draws a straight horizontal line so long as the ratio between water and fuel is equal to or greater than the standard which it is desired to maintain, but when the ratio of water to coal drops below the standard, this pointer makes a break in the diagram at the hour when the drop occurred, and the line remains broken until such time as effi-

ciency again reaches standard. This broken line gives unmistakable notice to the plant manager, who can refer to the water and fuel lines directly above to ascertain the probable cause, and he can then make the usual analysis of his boiler room water log and coal log covering the time in question and can institute proper inquiries in the fire room.

The third pointer does not draw attention to economy that is better than standard, because it has been found impractical in practice to attempt to record diagrammatically minute fluctuations in the ratio of coal and water, and it is sufficient for practical purposes to indicate sharply, as by the broken line, only those times when performance falls below standard.

The fourth pointer is connected by an independent circuit to the blow-off valve of the boiler, and shows by a break or jog in its line, the hour at which the blow-off valve is opened, and the length of time it remains open, to direct attention on the diagram to the time at which unevaporated water was removed from the boilers, in order that it may not be inadvertently figured as having been evaporated.

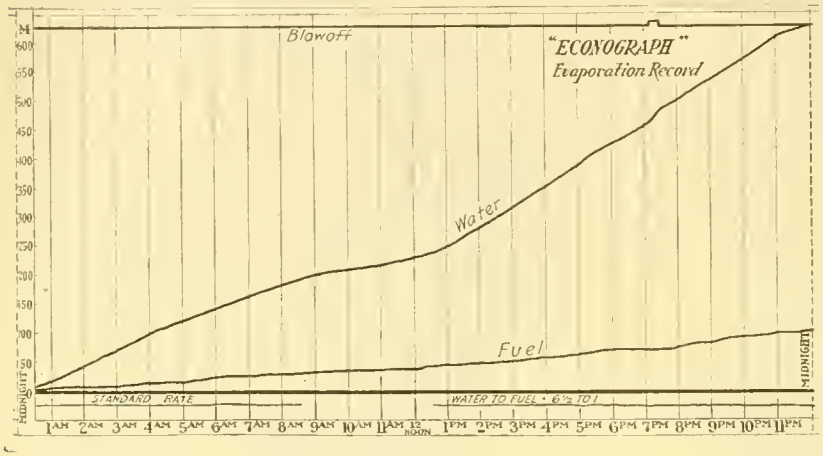

Fig. 2 A 24-Hour Record of Boiler Operation made by the Econograph

The diagram may be of either twelve or twenty-four hours' duration, and is usually made on transparent paper, so that the chart of one day's run can be compared with that of another day by laying one chart on top of the other. In reading a finished chart, it is seen at first glance whether the standard performance has been maintained, the hour at which economy fell below standard, and at what time it was regained.

Directly above is the coal line which extends upward from left to right across the sheet and its inclination shows at a glance whether there has been any sudden increase or decrease in the coal rate. The water line is directly above the coal line, and its inclination shows any apparent variation in rate of water supply.

Thus, the bottom line, which is called for convenience the *efficiency* line, draws immediate attention to poor economy, while the coal line and the water line show at a glance whether the drop in efficiency is probably due to change in rate of coal or water supply. If the blow-off valve has been opened and water has been withdrawn from the boiler without being evaporated, the top line of the diagram shows at what time it occurred.

The total coal and total water at any hour can be measured approximately on the diagram, and by laying a ruler along the slope of the water line or the coal line, the operator can estimate the coal or water in pounds per hour at that time. A little practice enables one to easily estimate these quantities very closely.

The primary object of the device is to record on paper and to draw attention to those times at which poor economy obtains, and to indicate to the engineer (by the independent water and coal lines) where the trouble is likely to be found. An analysis of the boiler-room logs of coal and water for the period of poor economy will reveal the cause in the usual way.

The instrument is not intended to take the place of the technical knowledge requisite to maintain high boiler economy, but it does away with some of the tedious work of analyzing boiler data, and calls attention to those times of poor economy which it is profitable for the engineer in charge to study, referring back to his log data.

To adapt the device to conditions at different plants, it is provided with adjustments, such as dials that indicate periodically the times at which charges of coal and water are supplied. Another pair of dials shows the ratio at which the machine is set; thus, if it is desired to maintain a standard evaporation of, say, 7 lb. of water per pound of coal, the latter dials will show a ratio of seven to one. This ratio can be set within reasonable limits to any desired standard. The adjustment is made by turning the vertical thumb-screws shown below the dials.

No two plants deliver coal and water in exactly the same size charges, that is, one boiler may be fed by a coal weigh-scale which delivers 300 lb., and another boiler will be fed by a scale that delivers 500 lb., and similarly with the water supply. The device is, therefore, provided with adjusting screws by which the units of coal and water are converted to equivalent scales on the chart, so that the water line and the coal line of the diagram can be measured to the same scale.

The instrument records with accuracy the correctness of the recorded results depending upon the accuracy with which the units of fuel and water are measured before being supplied to the boilers. Details of the mechanism would be of little interest in this description, although they are simple in construction. It is here desired to merely describe the results attained by the device as a means for assisting the power plant manager to arrive at a quicker and easier analysis of his boiler performance.

George B. Willcox.

Saginaw, Mich.

Society Affairs

Engineering Survey

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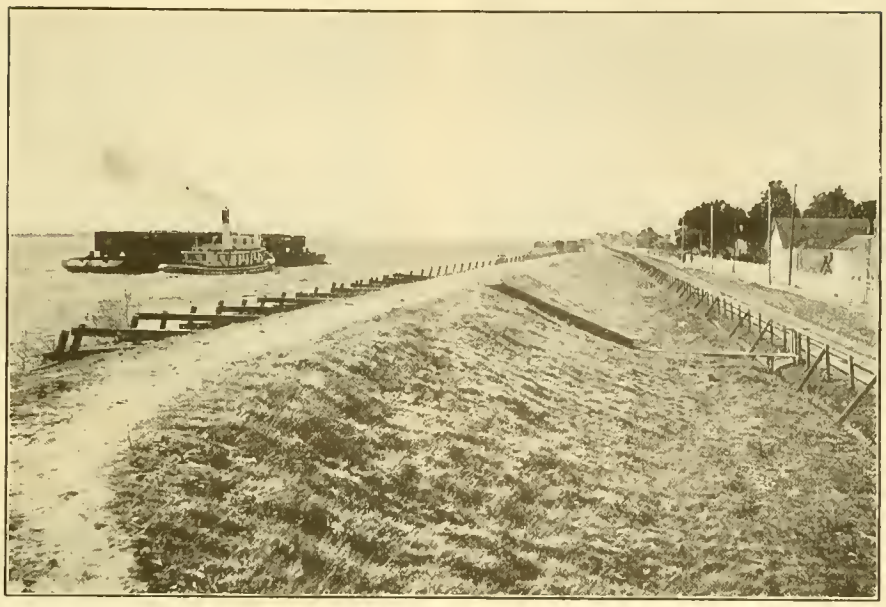
SOCIETY AFFAIRS

THE SPRING MEETING AT NEW ORLEANS

THE Committee on Meetings and the New Orleans Committee of Arrangements have practically completed their plans for the Spring Meeting to be held at New Orleans, April 11 to 14. Information regarding the program, hotels, transportation and features of interest to be inspected at New Orleans is published herewith, and will be followed in a few days by a circular to the membership giving further and later details.



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MISSISSIPPI RIVER AND LEVEE NEAR NEW ORLEANS

Everything points to a meeting which to most of those who attend will prove unique. The problems of the engineer in the South are peculiarly his own and not only will certain of these problems be considered during the professional sessions, but every facility will be afforded to visit industrial plants and to witness engineering construction work which are typical of the industries and undertakings of that part of the country.

Headquarters will be at the Hotel Grunewald and the meeting will open as usual on Tuesday afternoon of the week of the convention and close on Friday, but it is hoped that many will remain over during the day Saturday for the purpose of making inspection trips in the vicinity.

There are several plants near New Orleans which are peculiar to the locality, but due to infrequent train service, or other reasons, it requires about a day to visit them. For this reason, the Committee decided not to plan definitely for excursions to these plants during the time of the meetings, but have arranged instead for inspection parties on Saturday for the benefit of such members as may stay over another day. The plants which the Committee have particularly in mind are the salt mines at Weeks Island and Avery Island; the sulphur mines at Sulphur, La.; the oil refineries near New Orleans or at Baton Rouge; the sawmill of the Great Southern Lumber Company at Bogalusa and wood distillation plant at Slidell, La.; rice irrigation pumping plants in Western Louisiana and the oil fields of Western Louisiana and oil and gas fields of Northern Louisiana.

The tentative program is published on the next page. Attention is called in particular to the opening session on Wednesday morning, when there will be a discussion upon Industrial Preparedness: What it Means and How it Can be Accomplished.

Following this session the visiting members will be in the hands of their New Orleans friends until Friday morning of the convention, when the last professional session will take place. The New Orleans Committee have in preparation one session for their part of the program which will include papers upon the evolution of low-lift pumping plants in the Gulf Coast country; tests upon the capacity and economy of multiple evaporators; and the mechanical equipment used at the docks in the Port of New Orleans.

Papers to come up for discussion at the session on Friday

Copyright, H. J. Harvey, New Orleans.

ONE OF THE EXCURSIONS DURING THE SPRING MEETING WILL BE TO THE RECLAIMED LAND NEAR NEW ORLEANS

morning will treat of miscellaneous subjects, notably the measurement of the flow of fluids and related topics; the dynamic balancing of rotating bodies, the measurement of viscosity and the flow of heat.

TENTATIVE PROGRAM

Tuesday, April 11

Afternoon....Registration.
Evening.....Informal Reception.

Wednesday, April 12

Morning.....Business Meeting, followed by Professional Session on "Industrial Preparedness."
Afternoon....Trip on the river which will give an opportunity to view the harbor as a whole and inspect the new cotton warehouse and other features of interest.
Evening.....Address for the general public, by Mr. W. B. Thompson, Commissioner of Public Utilities of the City of New Orleans.

Thursday, April 13

Morning.....Professional Sessions at which papers will be given on engineering subjects of local interest.
Afternoon....Entertainment at Country Club, or some other excursion.
Evening.....Reception and dance.

Friday, April 14

Morning.....Professional Sessions.
Afternoon....Excursion to reclaimed land near New Orleans.

TRANSPORTATION NOTICE

The Committee on Meetings has been pleased to accept the invitation of the Section of the Society at Birmingham, Ala., to make a stop in that city on the trip to New Orleans. A train schedule as given below has been designated by the Committee for those going from the vicinity of New York, which allows a stop of 24 hours in Birmingham. The route is through Washington and Chattanooga via the Short Line (comprising the Pennsylvania, Southern, Norfolk and Western, and Queen and Crescent Lines). The Pullman cars of the train will be parked at Birmingham so that members may conveniently spend the entire day, Monday, in accepting the hospitality of the Birmingham Section.

While it is expected that a number will prefer to go to New Orleans by boat rather than by train, and that, on the other hand, some, unable to take the time for the stop at Birmingham, will leave a day later than the schedule indicates, it is hoped that as many as possible will take the official train in order to add to the sociability of the journey.

Train from New York

Leave New York via Pa. R.R. 3:34 p. m., Saturday, April 8.
Arrive Washington 9:15 p. m.
Leave Washington via Southern Railway 9:45 p. m.
Arrive Birmingham 10:25 p. m., Sunday, April 9.
Leave Birmingham 10:35 p. m., Monday, April 10.
Arrive New Orleans 9:40 a. m., Tuesday, April 11.

Full information concerning trains and reservations may be obtained from W. V. Kibbe, District Passenger Solicitor of the Pennsylvania Railroad Co., 501 Fifth Avenue, New York.

TRAINS FROM CHICAGO AND CINCINNATI

The Executive Committee of the Cincinnati Section has designated the train leaving Cincinnati on the Queen and Crescent Road at 8 a. m. Sunday, April 9, as the official train from Cincinnati. This train is scheduled to arrive in Birmingham Sunday night as a part of the same train on which the New York members will travel, as mentioned above.

The Committee of the Chicago Section of the Society proposes the schedule given below, with the idea of accepting the Birmingham invitation and at the same time having the company of the Cincinnati Section from that city to New Orleans, and also of joining the New York Section at Birmingham.

Train from Chicago

Leave Chicago, Big Four, 11:45 p. m., Saturday, April 8.
Arrive Cincinnati, Big Four, 7:55 a. m., Sunday, April 9.
Leave Cincinnati, Queen & Crescent 8:00 a. m., Sunday.
Arrive Birmingham, Queen & Crescent 10:25 p. m., Sunday.
Leave Birmingham, Queen & Crescent 10:35 p. m., Monday, April 10.
Arrive New Orleans, Queen & Crescent 9:40 a. m., Tuesday, April 11.

The route between Cincinnati and Birmingham is via Chattanooga, at which point the trains bearing the New York Section and Chicago Section will be consolidated, thus affording an opportunity for visiting en route between Chattanooga and Birmingham. The time of arrival at Chattanooga of the New York Section will be 5.55 p. m. and of the Chicago Section 6.10 p. m.

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Terminal Station, New Orleans

TRIP BY BOAT

For those desiring to go by boat, the Southern Pacific Company offer accommodations on their steamer Proteus, which leaves New York at 12.00 o'clock noon on Wednesday, April 5, arriving at New Orleans on Monday, April 10, at 10.30 a. m. This offers a delightful five day voyage in a first class steamer, excellent cuisine, courteous attention, a restful trip. For those desiring to return by boat, it may be stated that a boat leaves New Orleans for New York on Saturday, April 15, at 10.00 a.m., and is due to arrive in New York Thursday, April 20, at 7.00 a.m. No official train schedule is being arranged for the return trip.

Reservations for the boat trip, going or coming, may be obtained from J. M. Adler, Passenger Agent, 1158 Broadway, New York.

FARES

The individual round trip by rail between New York and New Orleans is $56.30. Pullman fare from New York to New Orleans is $8.00 for lower berth, $6.40 for upper berth.

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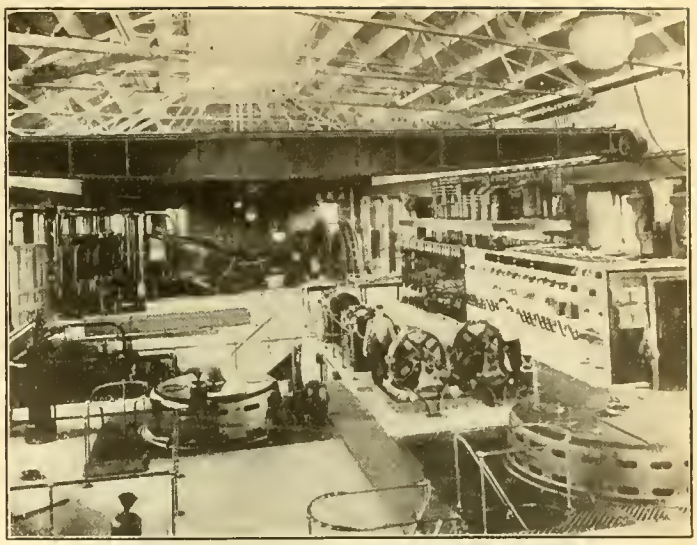
Cotton on the Levee



Drainage Station No. 1

There is practically no reduction for large parties, the rate for ten or more going and returning by rail being $55.38.

The round trip fare between Chicago and New Orleans is $37.40.

The round trip fare, either going one way or both ways by boat, between New York and New Orleans, is $75.00. This includes meals and berth on the steamer and provides also for those starting from an inland city, such as Cincinnati, to go by rail to New Orleans, returning to New York by boat and thence by rail to the point of starting. For parties of ten or more going on one ticket by rail and returning by steamer, the round trip is $70.19.

A charge of $2.00 per capita will be made for parking the cars for occupancy at Birmingham.

HOTELS

The Committee on Hotels of the New Orleans Committee of Arrangements has selected the Grunewald Hotel as headquarters for the Spring Meeting. The rates are as given below and members are requested to write direct to the hotel for reservations. The Grunewald has sufficient capacity to accommodate all visiting members, but in case any should prefer to stay at another hotel, rates are also appended for the three others recommended by the committee, all within three squares of the headquarters. The rates are as follows, on the European plan:

HOTEL GRUNEWALD

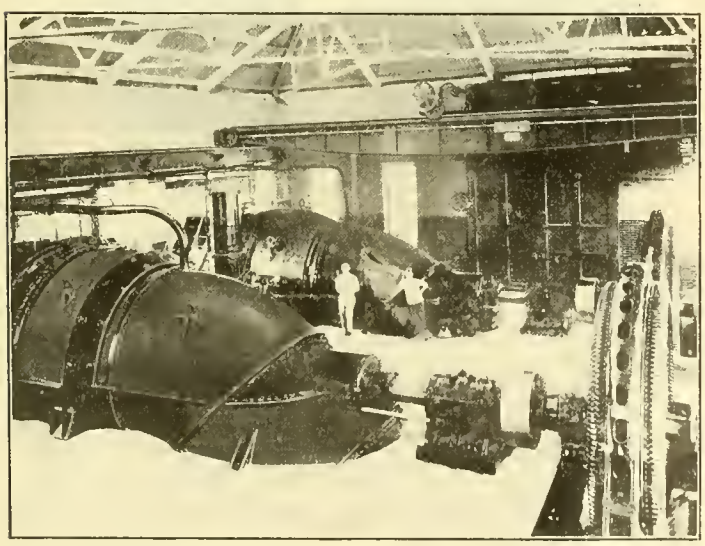
New Building	
Rooms without bath, one person	$1.50 per day and up
Rooms with bath, one person	3.00 per day and up
Rooms without bath, two persons	2.50 per day and up
Rooms with bath, two persons	4.00 per day and up
Main or Old Building	
Rooms without bath, one person	$1.00 per day and up
Rooms with bath, one person	2.50 per day and up
Rooms without bath, two persons	2.00 per day and up
Rooms with bath, two persons	3.50 per day and up

ST. CHARLES HOTEL

Room with detached bath, one person	$1.50 per day and up
Room with bath, one person	2.50 per day and up
Room with detached bath, two persons	2.50 per day and up
Room with bath, two persons	4.00 per day and up
Parlor suites	10.00 per day and up

HOTEL DE SOTO

Room without bath, one person	$1.50 per day and up
Room without bath, two persons	2.00 per day and up
Room with bath, one person	2.00 per day and up
Room with bath, two persons	3.00 per day and up
Rooms with connecting bath, two persons in each room	3.00 per day per room



12-Ft. Screw Pumps, Drainage Station No. 1

Discharge from One 12-Ft. Drainage Pump

Coquille, New Orleans.

Courtyard in French Quarter

COSMOPOLITAN HOTEL

Room with bath, one person	$2.00 per day
Room with bath, two persons	3.00 per day
Room without bath, one person	1.00 per day

ENGINEERING FEATURES AT NEW ORLEANS

Interest in New Orleans from an engineering standpoint centers in the accomplishments of the past few years toward securing facilities adequate for handling the commerce of the Mississippi Valley with the outside world. In this respect the city and state have worked together and along with this development have come marked advances in the social and educational life of the community, through the modernization of the city government, the completion of elaborate systems of sanitation, the drainage of large contributory areas of land and the splendid growth of various educational institutions.

New Orleans has spent $28,000,000 in one of the most complete systems of sanitation in the world, comprising water supply, sewerage and drainage systems.

Coquille, New Orleans.

A Spot of Rare Beauty

Copyright, Detroit Publishing Co.

St. Charles Avenue, New Orleans

The water supply includes an extensive system of sedimentation and filtration, with two main pumping stations of 80,000 gallons per day capacity and several hundred miles of mains.

Coquille, New Orleans.

Tropical Foliage at New Orleans

The sewerage system, with two large pumping plants, has been in operation since 1905.

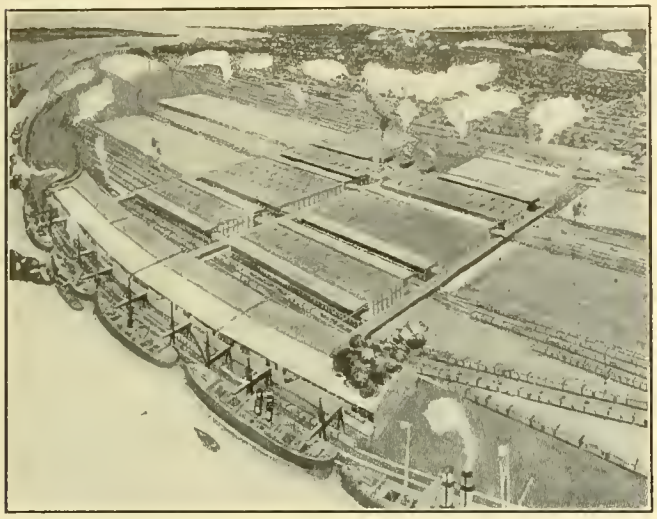
Immediately about New Orleans over $20,000,000 are being expended in draining the wet lands with most favorable conditions resulting as to health and the possibilities of intensive cultivation for farm and garden products. The inspection of this drainage area is one of the visits planned for the Spring Meeting. This project, and that for water supply, have called for pumping plants of immense capacity which are of prime interest to the engineer.

The river front at New Orleans is publicly owned and has been rendered doubly useful by a municipally-owned belt line

connecting the various trunk lines, wharves and manufacturing plants of the city. A large sum has been expended in the construction of modern docks, wharves and steel sheds for the handling of freight. The recently built state warehouses for the storage and handling of cotton constitute one of the great institutions of the country for facilitating transportation.

These warehouses required an expenditure of $3,000,000 and were constructed at a minimum cost, the determination of which involved a careful study of several factors, such as the ratio of storage capacity to amount of cotton handled, the questions of single or multi-story buildings, the height to which the bales would be piled or tiered, and the mechanical handling of the cotton. One of the devices contributing to the success of the plan as developed is a mechanical "bale-puller" for the purpose of extracting any bale from any pile without moving any other bale.

Because of public ownership it has not been possible for an



An Excursion Is Planned to the Immense Cotton Warehouses Recently Constructed at New Orleans

industry to erect buildings on the batture of the river except for the purpose of "commerce and navigation." In consequence, another important development is now underway in the nature of a ship canal connecting the gulf and the river which will give opportunity for waterside location for the manufacturer, besides increased facilities in receiving his raw materials and in shipping his products.

FEATURES OF GENERAL INTEREST

Besides the engineering features of New Orleans, the visitors at the Spring Meeting will find many delightful places to visit in the city, as evidenced by the several glimpses in the illustrations appearing in this number. The quaintness of the French quarter with its courtyards, antique stores and famous restaurants, the tropical vegetation, the parks and many beautiful streets, cause the city to rank high among the vacation places of the country. There are public buildings to be visited, the Chalmette Monument, the Cathedral and old residences, many of them of historic interest.

Tulane University, which has been a potent educational factor in Louisiana, is of interest. Newcomb College also appeals to visitors because of its art school, where are produced by the students various art objects, famous among which is the Newcomb pottery.

NOMINATING COMMITTEE

In making a study of the situation, President Jacobus found that no particular method is outlined for selecting five members for the Nominating Committee, but that it has been the practice to select members from different geographical sections of the country, as it would seem that this is the best way of securing the views of the membership at large. He wished to avail himself of the splendid organization and interest of the Sections and with this in mind formed five groups of the different geographic sections of the Society, without respect to the number of members in those sections, and suggested that each of the groups agree on a single candidate, where practicable, to be submitted as a suggestion for appointment on the Committee. The sections were grouped in the following order:

Group 1—San Francisco and Los Angeles
Group 2—Atlanta, Birmingham, St. Louis and Cincinnati
Group 3—Chicago, Milwaukee and Minnesota
Group 4—Boston, New Haven and Worcester
Group 5—New York, Philadelphia and Buffalo

Great interest has been manifested and the President, while not bound to accept the nominations made by the Sections, has in each case taken pleasure in doing so. The nominations are as follows:

Group 1—J. T. Whittlesey, of San Francisco
Group 2—Prof. E. H. Ohle, of St. Louis
Group 3—H. M. Montgomery, of Chicago
Group 4—Walter B. Snow, of Boston
Group 5—D. Robert Yarnall, of Philadelphia

The object of pursuing the above method, as was brought out in an address by the President at the joint meeting of the Chairmen of the Sections held at the time of the Annual Meeting, is to secure the greatest possible democracy throughout the Society and at the same time encourage the selection of those men who by virtue of their high professional standing will in turn choose similar men for officers of the Society. It has been suggested that the Nominating Committee assemble at the Spring Meeting of the Society at New Orleans.

COUNCIL NOTES

At the meeting of the Council held on February 11, 1916, there were present: D. S. Jacobus, *President*, John H. Barr, Robert M. Dixon, *Chairman of Finance Committee*, Arthur M. Greene, Jr., James Hartness, Henry Hess, Frederick R. Hutton, William B. Jackson, Charles T. Main, Spencer Miller, H. de B. Parsons, J. E. Sague, John A. Stevens, Max Toltz, E. H. Whitlock, William H. Wiley, *Treasurer*, and Calvin W. Rice, *Secretary*.

A letter from Prof. P. F. Walker relative to an agitation to discontinue the Fahrenheit thermometer scale was referred to the Committee on Research. This is printed in the Correspondence Section.

Roy E. Brakeman, *Chairman*, Charles B. Davis, *Vice-Chairman*, Paul Wright, *Secretary-Treasurer*, J. Henry Klinck and Frank G. Cutler were appointed as a Local Sections Committee in Birmingham; Emmett B. Carter, *Chairman*, W. R. Jones, *Secretary*, Charles L. Bruff, Robt. H. Fernald, Jas. E. Gibson, Jos. A. Steinmetz were appointed as a Local Sections Committee in Philadelphia; A. D. Blake was appointed Secretary of the New York Sections Committee.

The President announced the appointment of D. C. Jackson, *Chairman*, A. H. Kruesi, R. J. S. Pigott, John A. Stevens and B. F. Wood as a committee to coöperate with the subcommittee of the Committee on Standards of the American Institute of Electrical Engineers.

On invitation from the American Institute of Electrical Engineers, soliciting the coöperation of this Society in a proposed joint Pan American Engineering Committee, William H. Bixby, Charles T. Plunkett, C. C. Thomas, Ambrose Swasey and S. W. Stratton were appointed as a committee of our Society.

Major William H. Wiley, Chairman of the Society's Committee of the Joint Committee on Engineer Reserve Corps, reported that this Committee had appeared before the House Committee on Military Affairs and urged with success the inclusion in pending legislation of a provision for a reserve corps of civilian engineers.

A communication from the American Institute of Electrical Engineers regarding the adoption of the metric system in this country was referred to a committee previously constituted to report on these matters.

Calvin W. Rice, *Secretary.*

ENGINEERING FOUNDATION

With its meeting of January 1916, the Engineering Foundation Board completed the first year of its activities. The Board at first was mainly concerned with the preparation of rules of administrative procedure based upon the by-laws of the United Engineering Society under whose auspices the foundation conducts its work. During the summer and early autumn, however, it was able to turn to the consideration of applications for the support of research work, or other undertakings coming within the objects of the foundation.

A committee was created for this purpose consisting of A. R. Ledoux, Alex. C. Humphreys, Past-President, Am.Soc. M.E., M. I. Pupin and J. Waldo Smith, Mem.Am.Soc.M.E., —names which are representative of a wide range of expert knowledge. The applications in hand were considered in sub-committee by assignment to the ones most familiar with the respective subjects.

Sixteen applications have been received. Two were in the class where accepted scientific principles were antagonized by propositions to secure energy greater in amount than would be expended in its production; two were for the attainment of results purely commercial in character and which clearly should be promoted by manufacturers rather than by a scientific board; two were for investigations whose financial requirements were greater than the limitations of income in the hands of the foundation would permit it to consider; and two were for researches already in competent hands and for work well in progress at these establishments. Three of the applications have been deferred for further information and two were not presented in sufficiently complete form to permit of intelligent action. This leaves three upon which the board has taken provisional favorable action of which full report will be made when the final decision on them has been arrived at.

Certain important questions of principle and policy have come to the surface in the discussion of these applications. The one of perhaps widest interest is the question of ownership and development of any patent monopoly which might come to the surface under researches in progress. It was the sense of the board that it was not a business body and could not properly own or license under a patent monopoly which it might own. On the other hand, it might be the duty of the board to prevent monopoly by others by securing patent protection and then making the use of such patent the property of the scientific and industrial public, as is the obligation of officers of the federal government in their respective lines. The question is an interesting one.

1916 YEAR BOOK

With the membership increasing at the rate of seven hundred or eight hundred a year, the problem of issuing the Year Book without sacrificing the features of usefulness which have for several years past characterized the volume becomes increasingly difficult.

First of all, of course, accuracy of name and address is to be desired; second, compactness, so that the book may be carried conveniently in traveling; and third, such an arrangement of the alphabetical and geographical lists as will serve all reasonable needs.

Members have already received the Year Book for 1916 and it will be noted that whereas there are over 700 more names and 1400 more entries than in the previous Year Book, there has actually been a reduction of 65 pages. This reduction was accomplished in part by a re-editing of the entire membership lists and by the use of a condensed but legible type face. Paper manufactured for this book and somewhat lighter in weight than formerly was also employed; by this still greater compactness was secured.

It will be of interest to call attention to the scheme of the alphabetical and geographical lists of this Year Book. In the alphabetical list are given the grade of membership, title and business connections, business and residence addresses. In the geographical list, however, such complete information is not needed, but at the same time it is believed that more information should be printed here than would be comprised in the mere alphabetical listing of the names under each town or city, as is the practice of societies. If a member is visiting a certain city for business purposes, the information which he is most likely to want to draw from the Year Book is the names of members located in that city and the firms with which they are connected. This information, therefore, is given in the geographical list. Every member of The American Society of Mechanical Engineers receives a copy of this complete Year Book, cloth bound.

SECRETARY AT LOCAL MEETINGS

On February 7, the Secretary visited the Student Branch at the University of Maine, Orono; on February 8, the Boston Section of the Society, and on February 9, the Student Branch of Massachusetts Institute of Technology, Boston, Mass.

At the University of Maine, following an address by Dean Boardman, he gave a talk to the engineering students, in which he outlined the work of student branches of the Society and explained the extraordinary service which the engineering profession is giving the nation in connection with industrial preparedness.

In Boston, the Secretary was the guest at the enthusiastic meeting of the Boston Section of the Society, with the Boston Society of Civil Engineers and the American Institute of Electrical Engineers on the occasion of the seventh annual joint banquet of these organizations held in the new Boston City Club, an account of which appears elsewhere. It is seldom that meetings of engineers are held in any city of the country where so large a number get together and so splendid a spirit of courtesy is shown as at these events in Boston. At this dinner, there were over 500 engineers present, men of large affairs, with diversified interests, but having at heart the one

common interest of the engineering profession at large through their relations with the municipality, the state and the nation.

On Wednesday noon, February 9, a few words were extended to the young men of the Technology Christian Association and the Student Engineering Society in the Technology Union, emphasizing the value to the students of the work of the Christian Association in teaching English, drawing, mathematics to the working men. The absolute necessity for all executives to understand men makes it essential that engineers undertake early in their career all those duties which bring them in touch with men. Nothing can be more desirable than rendering a service to working men which will at the same time make them good citizens.

Mr. Rice was subsequently shown over the new Technology buildings and had the satisfaction of seeing the prospective new headquarters for the student branch in the mechanical engineering department.

CIVIL ENGINEERS INVITED TO SHARE ENGINEERING SOCIETIES BUILDING

Negotiations have been in progress between the United Engineering Society, representing the American Institute of Mining Engineers, the American Institute of Electrical Engineers, and The American Society of Mechanical Engineers on the one hand, and the American Society of Civil Engineers on the other, in connection with an invitation extended on June 28, 1915, to the Civil Engineers to share the Engineering Societies Building. These negotiations have necessarily been confined in their preliminary stages to the governing boards of the societies. We are now happy to state that the invitation has finally resulted in a report on the part of the special committee of the Civil Engineers, consisting of Clemens Herschel, *Chairman*, Robert Ridgway, Charles Warren Hunt, Charles F. Loweth and Past-Presidents John A. Ockerson, George F. Swain and Hunter McDonald, that the matter of removing the headquarters from the house on West 57th Street to the Engineering Societies Building favoring the subject be submitted to letter ballot of the entire membership of the Civil Engineers.

In general, if the Civil Engineers should sell their property, they would realize approximately $325,000, and their share of the cost of the land and other expenses in connection with the Engineering Societies Building would be about $240,000. They would become a joint owner with the three other societies in a property worth $1,967,332, one-quarter of which would be $491,833. In other words, roughly speaking, by a payment of $250,000, they would have an equity of $500,000 and $100,000 in bank. So much for the financial side. On the material side there would be greater hall capacity for their annual meetings which are now seriously taxing their headquarters.

Further, there is now a duplication of effort in the maintenance of their libraries, and it is an open secret that should the Civil Engineers coöperate in the administration of a joint Library an endowment of $500,000 will be forthcoming. It is not suggested that the Civil Engineers yield title to their books for these benefits, but place them in the same room with the books of the other engineering societies, in which case they will be cared for by the staff of the United Engineering Society and the library as a whole greatly enhanced in value. This would place the joint Library in a unique position on this continent, if not in the world.

Still another benefit would be more frequent conferences of the officers of the national societies, through the natural facility of such conferences, in all matters pertaining to the welfare of the engineering profession as a whole.

There are now approximately two vacant floors in the Engineering Societies Building, occasioned by the recent removal of two societies, one of which wished a ground floor on a prominent street for exhibition purposes, and the general restriction of the building to purely engineering activities, which limits the choice of occupants of the building. It is now possible for the Civil Engineers to come into the building and have similar suites to the other founder societies. Should these accommodations be insufficient, however, the founder societies have generously offered to build an addition on the top of the building. This addition, it is estimated, will cost the entire sum of $240,000 which the Civil Engineers would pay as their share of ownership. It is reasonably hoped, however, that one or more floors in the present building, arranged to suit the Civil Engineers and duplicating their present facilities, will be adequate.

The engineering profession is demonstrating daily its capacity for service to the nation and society generally, and this outward evidence of coöperation points toward an ideal which all hope may be attained.

INDUSTRIAL PREPAREDNESS

As a result of the invitation from the President of the United States which was published in the February Journal, the Council selected at its last regular meeting, and at a special meeting called for the purpose, the names for directors of the industrial census in each of the states of the Union and the Territory of Alaska and the District of Columbia. There has also been a conference of the committee representing the Society with the committees representing the other four engineering societies who jointly have been invited by the President to undertake this great work.

This census will in reality be the most important undertaking that the government has ever essayed in the matter of understanding the resources of the country, not only for defense but for peace, and the engineers are to be considered particularly fortunate in having received the invitation and in being recognized as an instrument for the service of the nation. It now behooves the engineering profession to appreciate that with this great honor goes great responsibility and that personal sacrifice and service of the highest order is the price that must be paid for further honors.

The main elements involved in industrial preparedness are men, transportation and materials, and it falls to the lot of the engineer to furnish two of these,—transportation and materials.

The following circular issued by the Naval Consulting Board accompanied the letters sent by the Council to the members of the Society in each of the several states of the Union:

For the first time in the history of this country, engineers have been called as a body to its aid. Their service is needed by the Government in the performance of a most important patriotic work. They have been asked to aid in the laying of the foundations of our structure of national defence. Upon every one of them there rests a personal responsibility. The Country needs their service, the President has asked for it, and the governing bodies of the Engineering Societies have confidently pledged it. It is earnestly hoped that each and every one will find it possible to accept this nomination by his Society and to co-operate in this non-partisan, non-political and wholly patriotic work.

Brief outlines of Plan for Inventory of Industrial Re-

sources Available for the Support of the Army and Navy of the United States:

1. Selection by each of the five great technical societies of one American Citizen from each State in the Union, as per President Wilson's request of January 13th.
2. The formal appointment by the Secretary of the Navy of the men so selected as State Directors of the Organization for Industrial Preparedness and Associate Members of the Naval Consulting Board.
3. Each State Board of Directors consisting of five men thus appointed to organize for business—electing Chairman and Secretary.
4. The organization under each State Board of a corps of Field Aides selected from the combined membership of the five technical societies within that State.
5. The issuance by the Naval Consulting Board to each State Board of complete information as to the work in hand, the objects to be obtained, suggested methods of procedure, lists of members within the State of the five technical societies and all available data as to the industries of the State.
6. Examination by the State Board of their territory with refereuce to the number and geographical distribution of industries with relation to the Field Aides available for the Inventory.
7. Issuance by the State Boards to the Field Aides of Instructions and Blank Forms as supplied by the Naval Consulting Board.
8. Examination and checking by the State Boards of all completed field reports. Following up men to see that reports are sent in properly. Checking reports and supplying any data lacking before sending them to Consulting Board.
9. The continuance of the Organization thus formed in order to insure to the Government the backing of the full industrial strength of the country and to secure for the largest practicable number of industrial concerns such an amount of Government business as will keep them in touch with the requirements of the Army and Navy.

In order to obtain the necessary co-operation of manufacturers and the public in general, there will be released in due season for country wide distribution a statement giving an outline of the entire movement including, if permission is received, in the papers of each State portraits and biographical notes of the State Directors. Prior to this it is obviously desirable that no mention of this work should be made.

February 15th, 1916.

JUNIOR AND STUDENT PRIZES

The members of the Committees on Junior and Student Prizes, consisting of Robert H. Fernald, Chairman of the Junior Prize Committee, Fred E. Rogers and George B. Brand, and Frederick R. Hutton, Chairman of the Student Prize Committee, Robert H. Fernald and D. W. Kimbalt were reappointed by the Council for the year 1916.

Papers for the Junior Prize, which consists of fifty dollars in cash and an engraved certificate signed by the President and Secretary of the Society, are restricted to the Juniors of the Society. The two Student Prizes consist of twenty-five dollars each in cash and an eugraved certificate signed by the President and Secretary and are restricted to enrolled members of the Student Branches in good standing. As no award of the Student Prizes was made last year, it is within the power of the committee to award the accumulated prizes to more than two authors this year, provided the papers in competition are deemed of sufficient merit.

Papers must be submitted before June 30, the committees reporting their recommendations to the Council on or before October 1. It is hoped that a large number of papers will be submitted for the decision of the committees.

NAVAL CONSULTING BOARD

One of the most important meetings of the Naval Consulting Board yet held was that which convened at the New York Navy Yard, on February 9. The two representatives of the Society on the Board, Spencer Miller, Member of Council, and W. L. R. Emmet, were among those present.

Reports dealing with the problems of chemistry and physics applied to warfare, steam engineering, internal combustion motors, ordnances and explosives, mines and torpedoes, submarines and other matters vital to the administration and operation of a great navy were submitted by the various sub-committees.

Howard E. Coffin presented in detail the plan approved by President Wilson and worked out by a committee of the Board for the mobilization of the industries of the country.

Thomas A. Edison submitted the complete plans and specifications for the experimental laboratory for the Navy proposed by him at a previous meeting of the Board. The principal buildings provided for in the scheme are an administration building, a chemical and physical laboratory, a machine shop, an erecting shop, a forge building, a foundry, a pattern shop, a sheet metal shop and a power house.

Mr. Edison stated that the purpose of the design was to obtain quick work and thorough and efficient results. He said that in the laboratory a submarine engine, which now takes six months to build, could be completed in not more than six days.

Thomas Robins supplemented Mr. Edison's remarks, and said that the laboratory will afford a place for the testing of new devices without subjecting the vessel on which they are to be placed to any possibility of damage.

A BUSY PERIOD

The Engineering Societies Building in New York is a place of great activity during a large part of the winter season. Last month, especially, has witnessed very notable gatherings which have been largely attended and at which there was a full measure of enthusiasm. Three of these have been the conventions of the Illuminating Engineering Society, the American Institute of Electrical Engineers and the American Institute of Mining Engineers.

The midwinter convention of the Illuminating Engineeirng Society was held on February 10 and 11. This convention celebrated the tenth anniversary of the Society, which was signalized by the conferring of honorary membership on Thomas A. Edison, Hon.Mem.Am.Soc.M.E. The presentation was made by John W. Lieb, Mem.Am.Soc.M.E.

The fourth midwinter convention of the American Institute of Electrical Engineers was held on February 8 and 9. There were four technical sessions and a dinner-dance. The program was of a diversified character, the papers including communications on Municipally Operated Electric Utilities of Western Canada, by A. G. Christie; operation of the Norfolk & Western Railway, by F. E. Wynne, and Chattering Wheel Slip in Electric Motive Power, by G. M. Eaton.

The American Institute of Mining Engineers held its annual meeting February 14 to 17. Sessions were held on petroleum and gas; coal and coke; mining, conservation and non-metallic minerals; precious and base metals, and iron and steel. The reception and annual dinner were held at the Hotel Astor, and other features of the convention were excursions, alumni reunions, and a smoker.

Among the twenty-nine papers presented were the following

by members of our Society: Development of the Law Relating to the Use of Gas Compressors in Natural Gas Production, Samuel S. Wyer; Application of Electric Power to Mining Work in the Witwatersrand Area, South Africa, J. N. Bulkley; Manganese-Steel Castings in the Mining Industry, Walter S. McKee; Wasted Metal, Henry D. Hibbard and Edward L. Ford, and Manufacture and Tests of Silica Coke-Oven Brick, Kenneth Seaver.

The climax in the month's series of meetings, however, was the first of the military lectures for engineers which are elsewhere announced. This lecture was coincident with the meeting of the American Institute of Mining Engineers and more than 2300 engineers attempted to get into the auditoriums of the Engineering Societies Building to hear the speakers. An overflow meeting was held in the second largest hall in the building and several hundreds were turned away at the doors. Even the committee which arranged the lecture was astonished at the interest displayed and now three lecture courses have been organized to take care of the crowds that desire to attend.

COST OF ELECTRIC POWER

In response to an invitation from the American Institute of Electrical Engineers, the President was authorized to appoint a committee of five to coöperate with the American Institute of Electrical Engineers and similar committees of other societies on the determination of the cost of electric power. The following members of the Society were appointed: D. C. Jackson, A. H. Kruesi, R. J. S. Pigott, John A. Stevens and B. F. Wood. The National Electric Light Association and the American Electric Railway Engineering Association have also appointed committees to coöperate with the Electrical Engineers and our Society, and the first meeting of the joint committee was held February 9. Henry G. Stott was elected chairman and W. S. Gorsuch secretary of the joint committee.

LECTURES ON MILITARY ENGINEERING

Courses of free lectures on military engineering, organized by a group of engineers in coöperation with officers of the United States Army, are now being delivered in the Engineering Societies Building and in the building of the American Society of Civil Engineers, New York. Originally one course of seven lectures on Monday evenings during February and March was planned, and invitations to attend were extended to all engineers in New York and vicinity, but the number of applicants for admisison was so great that a second, and finally a third course had to be provided. This leads the committee to think that if similar courses could be arranged for in Local Section centers and elsewhere, they would be well attended by members who would in return receive the benefit of valuable information upon this important subject.

The topics of the lectures in New York include organization of engineers in war, the service of reconnaissance, fortifications, defences, lines of communication, camps and cantonments, military railways, etc. The lecturers are Captains Thomas M. Robins, Richard T. Coiner and Edward P. Ardery, Corps of Engineers, U. S. A.; and the Committee of Arrangements includes the following members of our Society: J. Waldo Smith, *Chairman*, Gano Dunn, W. L. Saunders, Bradley Stoughton, D. S. Jacobus, Calvin W. Rice, George Gibbs, Alex. C. Humphreys, John W. Lieb and W. H. Wiley. The Secretary of the committee is J. S. Langthorn, 250 W. 54th Street, New York City.

GREETINGS TO MINING ENGINEERS

On the occasion of the annual gathering of the American Institute of Mining Engineers, representing the President, Dr. Jacobus, Prof. Frederick R. Hutton, Honorary Secretary, Am.Soc.M.E., was the bearer of fraternal greetings and cordial good wishes from our Society.

Professor Hutton delivered an appropriate and timely address, the keynote of which was the natural bond between mining and mechanical engineers and a cogent plea for the strengthening of this bond in working out ideals of service to the country in these times of preparedness.

Opening aptly with the quotation from Robin Hood:

> The sword is a weapon to conquer fields,
> I honor the man who shakes it;
> But nought is the lad who the broadsword wields,
> Compared to the lad who makes it.

Professor Hutton showed how the mining engineer Lads "made" iron and steel, copper and other metals, without which the mechanical engineer could not "shake" the tools of his trade, while the mechanical engineer Lads made for the mining engineer his power plant and his hoisting machinery without which his work would have progressed but slowly.

Regarding defense, he said that the five factors to be considered are: 1, men; 2, fighting machines, artillery and tools; 3, transportation; 4, communications; 5, supplies, and that the engineer will be the dependence of the military arm in four. Since in preparations for defense engineers will have to come together more and more, he advocated us being already together.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION

The ninth annual convention of the National Society for the Promotion of Industrial Education was held in Minneapolis, Minn., on January 20-22, 1916, and William H. Kavanaugh, Mem.Am.Soc.M.E., was in attendance as Honorary Vice-President of the Society. The opening session was presided over by the Hon. William C. Redfield, U. S. Secretary of Commerce, and president of the organization. The principal paper of the session was presented by David Snedden, Commissioner of Education for Massachusetts, who urged compulsory vocational education. The session on the 21st was given over to a study of the recently completed industrial survey of Minneapolis. This survey was made possible by a trust fund of more than $5,000,000 left by the will of the late William Hood Dunwoody for purposes of industrial education. Before undertaking to put into effect the provisions under which this fund was given, the trustees of the fund desired complete information as to the kind of vocational education most needed by the Society of Minneapolis, and facts as to the ways in which they could coöperate with other educational agencies and institutions of the city and state. Early in 1915 the superintendent of schools together with the Board of Education and trustees of the Dunwoody Institute secured the coöperation of various local agencies in asking the National Society for the Promotion of Industrial Education to come to Minneapolis to make this survey and hold its annual convention there. The survey was begun on May 1, 1915, under the direction of the National Society's Survey Committee of which Charles R. Richards, Director of Cooper Union, and Mem.Am.

Soc.M.E., is chairman, and the local Minneapolis Survey Committee with C. A. Prosser, then Secretary of the National Society, as director of the survey. This survey has met with the hearty support of every interest in the city. The report of this survey forms Bulletin No. 21 of the National Society for the Promotion of Industrial Education, and covers nearly 700 pages. At the meeting, Dr. Prosser explained in detail the circumstances attending the projection and making of the survey, and C. R. Richards discussed in a general way the recommendations of the survey. Recommendations bearing on special phases of the report were discussed by various speakers.

The session on January 22 included a series of talks on various phases of industrial education, one of the most interesting of which was by Dr. G. E. Barnett of Johns Hopkins University, who spoke on the Possibilities and Accomplishments of Trade Agreement in Industrial Education. The convention was brought to a close by the business meeting, at which a resolution, endorsing the Smith-Hughes bill, which provides for federal aid to industrial education, was passed. It was the unanimous opinion of those in attendance that the industrial survey of Minneapolis was by far the most important feature of the meeting. Charles Richards is quoted as saying that the survey gives Minneapolis something to build on, and is the best asset any city ever gained for itself; it will save hundreds of thousands of dollars in avoiding mistakes.

ANNUAL DINNER OF BOSTON ENGINEERS

The engineers of Boston scored another triumph in their plan for coöperative meetings, on the occasion of the seventh annual banquet of the Boston Society of Civil Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, held on February 8, 1916. More than 500 engineers were present.

Charles L. Edgar, president of the Edison Electric Illuminating Company of Boston, acted as toastmaster. The speakers were Governor Samuel W. McCall, of Massachusetts; Col. W. E. Craighill, of the Corps of Engineers, U. S. A.; William Barclay Parsons, Chairman of the Joint Committee of the National Engineering Societies appointed in connection with the formation of a Reserve Corps of Civilian Engineers; our Past Presidents John R. Freeman and Dr. John A. Brashear, and our Secretary, Calvin W. Rice.

With a list of speakers so closely identified with affairs of national importance, the addresses inevitably touched on certain of the great problems now before the country, particularly upon the subject of preparedness, and the proposed reserve corps of engineers.

The first speaker was Governor McCall, who spoke of the expansion of the science of engineering along scientific and economic lines, and of the service which engineers might thereby render to the state.

Mr. Rice, as representative of the national engineering societies, responded to the address by Governor McCall on The Engineer and the Commonwealth. He stated the various ways in which the societies are coöperating, illustrating that the movement of which Boston is such a fine example is not only spreading through the societies, but is the custom of the parent societies. Referring to industrial preparedness, he announced that the directors of the census for this movement would be appointed in the near future and to their duties would be attached great honor and importance.

Colonel Craighill spoke of the duties of engineers in national defense, saying that in the course of war, should Boston be attacked, it would require 25,000 men, working 10 days, to build 80 miles of trenches, at a cost of $2,000,000, this being requisite to protect Boston properly.

The next address was given by William Barclay Parsons, chairman of the joint committee of the national engineering societies to secure a reserve corps of civilian engineers for the Army. These men would serve, according to his plan, two weeks a year in the army, and hold commissions for five years. This would correspond to the present medical reserve corps.

John R. Freeman made a brief report upon the situation at Panama, where he was one of the three engineer members of the commission recently nominated by the National Academy of Sciences, and appointed by the President to report on the slides.

The closing address of the evening was by Dr. John A. Brashear, on An Evening's Journey Among the Stars.

THE MARCH MEETING OF THE CINCINNATI SECTION

On March 18 the Cincinnati Section will hold a joint meeting with the Engineers' Club of Cincinnati, which will be the most ambitious meeting yet attempted by the Section. It will continue from 2:30 in the afternoon until 10 o'clock in the evening, and at least four papers and possibly six will be presented. The meeting will occur at 25 E. 8th Street, adjourning at 5.30 for dinner at one of the hotels. J. B. Stanwood, chairman of the Section, will preside over the afternoon meeting, and Mr. Stanwood and Frank A. Raschig of the Engineers' Club will preside over the evening session, which will begin at 7:30 p.m. At 9:30 the session will adjourn and a Dutch lunch will be served, during which a further opportunity will be afforded for discussion and for general getting together. All of the members of the Society and their friends are cordially invited to any or all of the sessions. The papers which have been decided upon so far are as follows: Why Is An Engineer, by W. G. Franz, Mem.Am.Soc.M.E.; Volume Control for Motor Driven Air Compressors, by Paul Discrens, Mem.Am.Soc.M.E.; Recent Experiments with Boiler Furnaces, by Prof. John T. Faig, Mem.Am.Soc.M.E.; The Sales Engineer in his Relation to Production and Machine Design, by A. J. M. Baker, Mem.Am.Soc.M.E.; Probable Future Requirements in Machine Tools, by A. M. Sosa, member of the Engineers' Club of Cincinnati. Some interesting papers dealing with machine tools and production methods have also been promised, and a definite announcement of them will appear on the complete program which will be sent out later by the Section.

BUFFALO ENGINEERS TO HELP IN MUNICIPAL AFFAIRS

Last November four councilmen were elected to serve the city of Buffalo under the new commission form of government which has gone into effect in that city, and the engineers of Buffalo have been alive to the possibilities of effective coöperation with the city government in the conduct of the engineering work of the municipality.

On December 15, 1915, a meeting of the Engineering Society of Buffalo was addressed by C. E. Drayer, secretary of the Cleveland Engineering Society, on Engineers in Politics. Three of the councilmen attended this meeting and at the close Councilman Kreinheder, who has since taken charge of the Department of Public Works, indicated his desire to enlist the services of a committee from the Buffalo Society to work in coöperation with him on engineering problems. This meeting, and the paper by Mr. Drayer, stimulated the feeling

that it is incumbent upon engineers to lend their services for the public good, as is now done so extensively by other professional organizations, notably by the American Medical Association and the American Institute of Architects.

On February 2 a second meeting was held, addressed by Morris L. Cooke, acting director of the Utilities Bureau of Philadelphia, on Public Service. There were over 300 engineers present and the meeting aroused much enthusiasm and was given a large amount of space in the daily press of Buffalo.

Following the December meeting mentioned above, the proposed committee to coöperate with the city council was appointed, consisting of John Younger, president of the Engineering Society of Buffalo, David C. Howard and David W. Sowers, all members of The American Society of Mechanical Engineers. Mr. Younger, in a communication to The Journal, writes: "You may be sure that this is only the first step to have our engineering society recognized as one of the factors in civic life. We propose at first that any members having suggestions or ideas send them in to this committee, who will put them in workable shape before transmitting them to the council. We will also have referred to us matters of engineering interest that are the problems of the council and this final committee will, in all probability, appoint some committees, of an investigating nature, who will present their results in the form of reports. Naturally, at first we shall attempt to go slowly and gain the confidence of the council by doing what we are asked, rather than inflicting our presence on them to an unnecessary degree.

I feel sure that this practical outcome of the various lectures that have been delivered during the past year and a half by various members of the Society will be an incentive to the societies in other cities to make still further efforts to have their presence known."

NOTES

The Committee on Meetings is already considering plans for the next Annual Meeting, and desires to announce that papers which are to be contributed should be in hand by September 20, 1916. On account of the time required for all of the members of the Committee on Meetings to read the papers submitted, and because of the insistence of the membership that the accepted papers be printed and distributed well in advance of the meeting, any papers received after the date mentioned are liable to be held over for a later meeting. In view of the fact that the date announced is immediately following the summer season, which is the usual vacation period, the members are urged to prepare papers during the coming spring so far as possible, and to submit them early in the summer.

Last year a group of juniors and seniors in the mechanical engineering course at the University of Illinois met and organized a professional engineering fraternity now known as Pi Tau Sigma. The aim of the society is to foster high engineering ideals, and to promote the mutual welfare of its members. The fraternity has laid plans for a national organization.

The question of the advisability of adopting the metric system as the practical standard in engineering in this country has been brought up by the American Institute of Electrical Engineers. The Institute has invited our Society to appoint two representatives on a joint committee of the national engineering societies to prepare a report upon this important subject. Meanwhile, the Council invites correspondence from members expressing their opinions as to whether this change of fundamental units would be advantageous.

Major William H. Wiley, Chairman of our Committee on the Reserve Corps of Civilian Engineers, reported at the last meeting of the Council that the greatest enthusiasm had prevailed on the part of the House Committee on Military Affairs when the chairmen of the committees of each of the engineering societies presented the plan for an Engineers' Reserve Corps. That such a group of citizens should be desirous of serving the United States without compensation made a deep impression. The committee of our Society consists of Major William H. Wiley, *Chairman*, W. F. M. Goss, H. A. Gillis and Alex. C. Humphreys.

H. J. Freyn, chairman of the Sub-Committee on Gas Power, has called a meeting of that committee in Chicago to make preliminary plans for a Gas Power Session at the next Annual Meeting, and it is expected that meetings of other subcommittees will be held in the near future to make similar plans. A feature of the last Annual Meeting was the large number of papers for which committees were responsible. More than half of the papers read were arranged for and selected by committees of experts in their respective fields. A sustained interest by a wide circle of the membership and authoritative treatment of important subjects are two of the desirable consequences.

At the annual meeting of the Board of Trustees of the United Engineering Society on January 27, Charles F. Rand was elected President, H. H. Barnes, Jr., First Vice-President, H. G. Stott, Second Vice-President, Frederick R. Hutton, Secretary, Joseph Struthers, Treasurer, and Samuel Sheldon, Assistant Treasurer. Henry G. Stott was appointed as the representative of this Society, succeeding Jesse M. Smith; Samuel Sheldon representative of the American Institute of Electrical Engineers, succeeding Charles E. Scribner, and W. L. Saunders, representative of the American Institute of Mining Engineers, succeeding Joseph Struthers.

The papers given at the International Engineering Congress at San Francisco are being published in a series of eleven volumes, each volume comprising contributions to one particular branch of engineering. The Secretary, W. A. Cattell, 425 Foxcroft Building, San Francisco, Cal., announces that volume six on mechanical engineering is now being distributed. This volume contains 18 papers on founding, flanging, tools, boilers, engines, turbines, compressed air, etc., and is handsomely printed. The price is $5.00. While this set of Transactions is sold by subscription, provision is made for a few additional copies for subsequent orders, but the number of such volumes is limited and it cannot be agreed in advance that orders for separate volumes can be filled.

With two large conventions held annually, and meetings of the Society in fifteen different cities between times, a large number of papers come to this office for publication. Occasionally there are papers which cannot be used in The Journal and for all such a file is kept in this office where the papers may be consulted by any one interested. This applies also to appendices of papers, logs of tests and other

detailed information when too voluminous for publication, or when not considered of sufficient general interest for the reader. Often duplicate blueprint copies of such information are available so that any member who is investigating a subject may send to Society headquarters for the additional data.

A meeting to be held at the Bureau of Mines Building, Washington, D. C., has been called for March 4 to complete a permanent organization in memory of the late Dr. Joseph A. Holmes, who was a member of this Society and Director of the Bureau of Mines. A previous meeting was held in January at which a temporary organization was effected and resolutions were passed looking toward the formation of a permanent organization to be known as the Joseph A. Holmes Safety First Organization. Gen. W. H. Bixby of Washington represented Dr. John A. Brashear and this Society at the first meeting.

It is expected that the movement will result in the establishment of an annual award of one or more medals together with honorariums, which will be termed "The Holmes Award," for the encouragement of those originating, developing and installing the most efficient "safety first" devices, appliances, or methods in the mineral industry; and also, special medals for the recognition of personal heroism or distinguished service in the mineral industry. Dr. Brashear is the Society's representative on the Memorial Committee and General Bixby will serve at all meetings of the committee held in Washington.

The heat treatment of steel has resolved itself to quite an extent into a problem of mechanical engineering. The study and analysis of stress and strain set up in heat treatment and the working out of methods and means to reduce these stresses and strains to a minimum, requires mechanical knowledge. Also further analysis of the results of heat treated steel in service requires more than metallurgical knowledge. In other words, the heat treating man and the mechanical engineer must work together. *Steel and Iron, January, 1916.*

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON APRIL 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grade are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The candidates will be balloted upon by the Council unless objection is received by April 10, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Anderson, Frederick C., Cons. Engr., Paper & Pulp Mill, Carthage, N. Y.
Atkinson, George K., Supt., The Cincinnati Planer Co., Cincinnati, Ohio
Bergen, Harry S., Asst. Supt., Toledo Scale Co., Toledo, Ohio
Carr, Edward W., Jr., Pres., E. W. Carr, Inc., New Orleans, La.
Clark, George A., Mech. Engr., Arnold Print Wks., No. Adams, Mass.
Dyett, Frank J., Mgr., The Frank J. Dyett Co., Ilion, N. Y.
Fitzgerald, Thomas J., Equipment Engr., Remington Arms Co., Eddystone, Pa.
Gale, Henry P., Ch. Engr., Oneida Steel Pulley Co., Oneida, N. Y.
Hessler, George M., Asst. Genl. Mas. Mech., Wisconsin Steel Co., So. Chicago, Ill.
Hinchey, H. Jno. O., with Buffalo Forge Co., Buffalo Steam Pump Co., Atlanta, Ga.
Kedy, Stiles F., Engr., The Columbia Mills, Inc., Minetto, N. Y.
Kennedy, Absalom M., Staff Engr., Lab. Thos. A. Edison, Orange, N. J.
Luhr, Charles W., Supt., Lab. Thos. A. Edison, W. Orange, N. J.
Molyneux, George E., Inventor, New York
Morrison, Jared P., Ch. Insptr., Hartford Steam Boiler I. & I. Co., St. Louis, Mo.
Moses, Frederick T., Vice-Pres. and Engr., Firemen's Mutual Ins. Co., of Providence, R. I., Detroit, Mich.
Mosman, Ernest, Mech. Engr., The Subers Fabric & Rubber Co., Cleveland, Ohio
Nye, Theodore H., Asst. Ch. Draftsman, Morgan Constr. Co., Worcester, Mass.
Okey, Perry, Prop., Okey Mfg. Co., Columbus, Ohio
Parker, Lindsay R., Engr. Stas., Toronto Hydro-Elec. System, Toronto, Ont., Can.
Pausin, Hugo R., Supt. Ord. Dept., E. W. Bliss Co., Brooklyn, N. Y.
Plumb, Frederic H., Mgr. Motor Pump and Eng. Dept., The Standard Supply & Equipment Co., Philadelphia, Pa.
Pratt, Edward W., Asst. Supt. Motive Pwr. and Mchy., Chicago & No. Western Rwy Co., Chicago, Ill.
Ramsey, George W., Patent Lawyer, Lecturer on Patent Laws, George Washington Univ., Washington, D. C.
Smith, Rodney W., Ch. Engr., Board of Education, St. Louis, Mo.
Thomas, Percy H., Cons. Engr., New York
Turnbull, Myrton J., Cons. Engr., Philadelphia, Pa.
Williams, Edward G., Vice-Pres., the J. G. White Engrg. Corp., New York
Ware, Corvin E., Mgr. N. Y. Office, Hoppes Mfg. Co., New York
Woodroffe, George H., Engr. of Tests, The Parkesburg Iron Co., Parkesburg, Pa.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Arkell, William C., Efficiency Expert, Beech-Nut Pkg. Co., Canajoharie, N. Y.
Bates, Harry H., Boiler Room Foreman, Norfolk & Western Rwy. Co., Bramwell, W. Va.

Budwell, Leigh, Insptr., Norfolk & Western Rwy., Bramwell, W. Va.
Cox, James W., Jr., Supt., The Albany Felt Co., Albany, N. Y.
Davis, Calvin E., Test Engr., Amer. Engrg. Co., Philadelphia, Pa.
Dyer, Percy A., Mch. Tool Specialist, Genl. Elec. Co., New York
Eaton, Philip B., Naval Engr., 2nd Lieut. of Engrs., U. S. Coast Guard, San Francisco, Cal.
Gauss, Henry F., Asst. Mech. Engr., Operating Section, Water Div., Dept. of Public Utilities, St. Louis, Mo.
Kraus, Sydney M., Lieut. (JG), U. S. Navy, Columbia Univ., New York
Suttill, Albert G., Ch. Engr., James Boyd & Bro., Inc., Philadelphia, Pa.
Trimmer, James W., Prod. Dept., Estimator, N. Y. Shipbuilding Co., Camden, N. J.
Warden, Guy L., Pwr. Supt., E. I. du Pont de Nemours & Co., City Point, Va.

FOR CONSIDERATION AS JUNIOR

Anderson, Herbert W., Mech. Engr. and Insptr., Wizard Co., Boston, Mass.
Bailey, Alton A., Field Insptr., with M. E. Cooley, Appraiser, Newark, N. J.
Barron, Alexander F., Draftsman, Amer. Smelting & Refining Co., Maurer, N. J.
Bunzl, Walter G., Student, Columbia Univ., New York
Carter, Chester A., Irrigation Engr., with Carter Bros., Garden City, Kan.
Crooks, Stanley B., Asst. Dist. Supt., Prod. Dept., Quapaw Gas Co., Bartlesville, Okla.
Dunn, Lester S., Engrg. Dept., Brighton Mills, Passaic, N. J.
Duryee, Andrew B., Mech. Engr., Gerstendorfer Bros., New York
Franket, William F., With Remington Arms & Ammunition Co., Derby, Conn.
Gelder, John T., with Penn. R.R., Fort Wayne, Ind.
Greenwald, Louis, Student, Columbia University, New York
Heileman, Frank A., Foreman, Lt. and Heat Sta., Univ. of Mo., Columbia, Mo.
Helander, Linn, with Crucible Steel Co., Midland, Pa.
Johnstone, Robert M., Designing Engr., Robert Gair Co., Brooklyn, N. Y.
Stepanek, Emil, Engr. Tractor Wks., Internatl. Harvester Corp. of Amer., Chicago, Ill.
Sterling, Claude H., Draftsman, Thomas B. Jeffery Co., Kenosha, Wis.
Taylor, Cyrus J., Field Insptr., with M. E. Cooley, Appraiser, Newark, N. J.
Wong, Jee-kwun, Student Engrg. and Metallography, Univ. of Minn., Minneapolis, Minn.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Armstrong, William M., Vice-Pres., Corrugated Bar Co., Buffalo, N. Y.
Brengel, Frederick J., Asst. Supt., Safety Car Heating & Lighting Co., Jersey City, N. J.
Fitz, Ervin M., Elec. Engr., Penn. Lines West of Pittsburgh, Pittsburgh, Pa.
Massey, George B., Cons. Engr., Geo. B. Massey Co., Chicago, Ill.

PROMOTION FROM ASSOCIATE

Birdsey, Charles R., Ch. Engr., United States Gypsum Co., Chicago, Ill.
Crane, Arthur M., Charge Pressure Filter Dept., New Continental Jewell Filtration Co., New York

SUMMARY

New applications	60
Applications for change of grading:	
Promotion from Junior	4
Promotion from Associate	2
Total	66

SUMMARY SHOWING AVERAGE AGE AND POSITIONS OF APPLICANTS ON BALLOTS CLOSING

FEBRUARY 29 AND MARCH 21, 1916

Average Age of Applicants:	
Members	40
Associates	40
Associate-Members	32
Juniors	25
Positions held by Applicants:	
Executives, including Presidents, Treasurers, Directors, Members of Firms, General Managers	10
Professors and Instructors	8
Superintendents, Assistants, Mechanical Superintendent, etc	14
Consulting, Contracting and Constructing Engineers	4
Chief Engineers or Assistants	14
Mechanical Engineers, Engineers, Assistant Engineers	28
Chief Draftsmen, Asst. Ch. Draftsmen, Designing Engineers, Estimators	14
Managers, Asst. Managers, Sales Managers, Sales Engineers	36
Other classifications	36
Total	142

GEOGRAPHICAL INDEX

(Applications for promotion from any grade, other than Junior, will be indicated by the initials of that grade)

California
San Francisco—Eaton, P. B.
Connecticut
Derby—Franket, W. F.
District of Columbia
Washington—Ramsey, G. W.
Georgia
Atlanta—Hinchey, H. J. O.
Illinois
Chicago—Birdsey, C. R. (A.)
Hessler, G. M.
Massey, G. B. (J.)
Pratt, E. W.
Stepanek, E.
Indiana
Fort Wayne—Gelder, J. T.
Kansas
Garden City—Carter, C. A.
Louisiana
New Orleans—Carr, E. W., Jr.
Massachusetts
Boston—Anderson, H. W.
No. Adams—Clark, G. A.
Worcester—Nye, T. H.
Michigan
Detroit—Moses, F. T.
Minnesota
Minneapolis—Wong, Jee-kwun
Missouri
Columbia—Heileman, F. A.
St. Louis—Gauss, H. F.
Morrison, J. P.
Smith, R. W.
New Jersey
Bayonne—Molyneux, G. E.
Camden—Trimmer, J. W.
Jersey City—Brengel, F. J. (J.)
Maurer—Barron, A. F.
Newark—Bailey, A. A.
Taylor, C. J.
Orange—Kennedy, A. M.
Luhr, C. W.
Passaic—Dunn, L. S.
New York
Albany—Cox, J. W., Jr.
Buffalo—Armstrong, W. M. (J.)
Canojoharie—Arkell, W. C.
Carthage—Anderson, F. C.
Cazenovia—Davis, C. E.
Ilion—Dyett, F. J.
Minetto—Kedy, S. F.
New York—Bunzl, W. G.
Crane, A. M. (A.)
Duryee, A. B.
Dyer, P. A.
Greenwald, Louis.
Johnstone, R. M.
Krauss, S. M.
Pausin, H. R.
New York (Cont'd.)—Thomas, P. H.
Ware, C. E.
Williams, E. G.
Oneida—Gale, H. P.
Ohio
Cincinnati—Atkinson, G. K.
Cleveland—Mosman, E.
Columbus—Okey, Perry.
Toledo—Bergen, H. S.
Oklahoma
Bartlesville—Crooks, S. B.
Pennsylvania
Eddystone—Fitzgerald, T. J.
Midland—Helander, L.
Parkesburg—Woodroffe, G. H.
Philadelphia—Plumb, F. H.
Suttill, A. G.
Turnbull, Myrton J.
Pittsburgh—Fitz, E. M. (J.)
Virginia
City Point—Warden, Guy L.
West Virginia
Bramwell—Bates, H. H.
Budwell, L.
Wisconsin
Kenosha—Sterling, C. H.
Canada
Toronto—Parker, L. R.

PERSONALS

THIS department is intended for items about members of the Society, their professional work and incidents concerning them which may be of interest to the membership in general. Items are solicited upon important engineering developments in which members have been associated, and also newspaper clippings or manuscripts of addresses delivered by members at meetings of any kind are desired. It is hoped that every member of the Society will furnish an interesting item occasionally for publication in the Journal.

Maynard D. Church has been promoted to the position of chief engineer of the Terry Steam Turbine Company of Hartford, Conn. His previous position with the company was that of assistant engineer.

William B. Rawson has accepted a position with the Canfield Oil Company of Cleveland, O., in the capacity of engineer and purchasing agent. He was formerly associated with the Canada Cement Company of Montreal, Canada.

G. L. Kothny has terminated his connection with the Westinghouse Machine Company, Pittsburgh, Pa., and has joined the staff of the C. H. Wheeler Manufacturing Company, Philadelphia, Pa., in the capacity of consulting engineer.

Jiles W. Haney has resigned the position of chief engineer of the Commerce Power Company, Kansas City, Mo., to accept the position of instructor in mechanical engineering at the University of Missouri.

Henry R. Gilson, formerly associated with the National Metal Molding Company, Ambridge, Pa., has entered the employ of the Ross Rifle Company of Quebec, Canada.

Joseph J. Nelis gave a lecture on January 31 to the Nashville section of the Engineering Association of the South on past, present and future steam generation, giving a brief resumé of past and present practice, also the probable future trend in boiler and furnace design. The lecture ended with a strong plea for the coöperation of the Engineering Association of the South in getting the Am.Soc.M.E. Boiler Code adopted in the southern states and particularly in the city of Nashville, which has now under consideration the changing of their building and boiler inspection code.

Reginald Trautschold is the author of an article on Power-House Chimney Design for Bituminous Coal which is published in the February 5 issue of *Coal Age*. Mr. Trautschold has also contributed to this issue a brief article on Central Testing Laboratories for New York City.

J. D. Bowles, superintendent of the electric department of the Springfield Gas and Electrical Company of Springfield, Mo., has been named chairman of a committee of the Association of the Missouri Public Utilities Companies to draft uniform rules and regulations governing the construction of overhead and underground lines maintained by the electric light and traction companies of Missouri.

Arthur M. Greene, Jr., Manager, Am.Soc.M.E., delivered a lecture at The Franklin Institute, Philadelphia, on February 6, on The Development of the Pumping Engine.

Dr. John A. Brashear, Past-President, Am.Soc.M.E., presented an interesting illustrated lecture on Astronomy on February 11, before the members of the Rochester Engineering Society, the Association for the Advancement of Applied Optics, the American Chemical Society and the American Institute of Electrical Engineers, at Sibley Hall, Rochester, N. Y. A dinner before the lecture was served in Dr. Brashear's honor at the Rochester Club.

A. F. Yarrow, Hon.Mem.Am.Soc.M.E., the British shipbuilder, has been created a baronet. Sir Yarrow is head of the firm of Yarrow and Company, Ltd., Glasgow, Scotland, and of Yarrows, Ltd., Vancouver, B. C., and has taken a prominent part in the war in regard to the production of submarines, torpedo boat destroyers, etc., and has recently established an experimental tank at the National Physical Laboratory in England, for the elucidation of propeller problems, for the use of any shipbuilder.

Morgan Brooks presented a paper on Relation of Lighting to Architectural Interiors at the mid-winter convention of the Illuminating Engineering Society held in New York, February 10 and 11.

Municipally Operated Electrical Utilities of Western Canada was the subject of a paper presented by Prof. A. G. Christie at the convention of the American Institute of Electrical Engineers in New York, February 8 and 9.

H. H. Vaughan, president of the Montreal Ammunition Co., Ltd., has been elected a director and a vice-president of the Dominion Bridge Company, Ltd.

A. W. Wheatley, vice-president of the Canadian Locomotive Company, Kingston, Ontario, has been appointed president of the Lima Locomotive Corporation, Lima, O.

W. Trinks has contributed an article on the Features of Rolling Mill Reversing Engines to the February issue of *The Blast Furnace and Steel Plant*.

Col. E. A. Stevens, Commissioner of Public Roads of New Jersey, has been elected president of the American Road Builders' Association. The election took place recently at a meeting of the Association in the Automobile Club of America, New York. The Association is composed of highway engineers and others concerned purely with the practical side of road work, and has a membership of about 800.

H. E. Elrod, consulting engineer of Dallas, Tex., has been retained to investigate the waterworks and electric light plants of Sherman, Tex., for the purpose of increasing their capacities.

William S. Twining, formerly consulting engineer of the Department of City Transit of Philadelphia as the representative of Ford, Bacon and Davis, has been appointed director of that department by Mayor Smith.

Prof. William H. Burr has reached the age of retirement, after 22 years of continuous service as professor of civil engineering at Columbia University, and the Board of Trustees announced on February 7 that his active work at the University will cease at the end of the present academic year.

How to Go After South American Trade is the subject of an article by R. W. Gifford published in the February issue of *Machinery*.

Electrochemical War Supplies by Lawrence Addicks was one of the papers presented at the symposium on Electrochemical War Supplies given at the meeting of the New York Section of the American Electrochemical Society held jointly with the New York Section of the American Chemical Society and the Society of Chemical Industry at the Chemist Club, February 11.

An article on Lining Up American Industries for Defense by William L. Saunders was published in the February 6 supplement of the *New York Times*. The article contained a detailed description of the purposes of the industrial committee to be appointed as a coöperative part of the Naval Consulting Board of which Mr. Saunders is a member, and also a discussion of the independence of this country on the Chilean nitrate field for the raw material for the manufacture of nitric acid, which is the base of all military explosives.

A. A. Potter is the co-author with S. L. Simmering of an article on Economics of Stoker, Economizer and Superheater which appears in the February 12 issue of the *Electrical World*. The article deals with points to be considered when selecting and installing apparatus to improve boiler room operations, including possible benefits and cost in the average plant.

Emerson McMillen, president of the American Light and Traction Company, New York, has given a second scholarship in the engineering department of the University of Detroit.

Harry J. Klotz presented a paper on Boiler Efficiency at the 15th annual convention of the Illinois State Electrical Association, held at Champaign, Ill., February 23 and 24, At this convention papers were also presented by J. Paul Clayton on Electric Cooking and by Morgan Brooks on Making Rates for Towns of 2500 and under.

Among the papers read at the annual meeting of the Central Electric Railway Association on February 24 and 25 at Dayton, O., was one by J. Rowland Brown on Gas-Weld Rail Bonding.

George L. Wall has resigned as vice-president and manager of the Lima Locomotive Corporation, Lima, O., to devote his attention to the chairmanship of the sub-committee of the American Railway Association on designs and specifications for proposed standard box cars.

William F. Lathrop has become connected with the Woodmansee-Davidson Engineering Company of Chicago, Ill., in charge of their Milwaukee office. He was formerly in the employ of the Milwaukee Electric Railway and Lighting Company, Milwaukee, Wis., as assistant to chief engineer of power plant.

Louis M. Zach has accepted a position in the engineering department of the International Smelting & Refining Company at Tooele, Utah.

John W. Morton has become associated with the Semet-Solvay Company of Syracuse, N. Y., in the by-product department. He was formerly with the McIntosh and Seymour Corporation, Auburn, N. Y., in the capacity of designer.

Robert M. Hale, until recently with the U. S. Smelting Company of Kansas City, Mo., as construction engineer, has entered the employ of the J. B. Kirk Gas and Smelting Company, Iola, Kan., as chief engineer.

Glen B. Hastings, Chicago, Ill., has been appointed representative of Hamilton and Hansell of New York, for the sale of the Rennerfelt electric furnace in the states of the middle west.

Waldo H. Marshall, president of the American Locomotive Company and first vice-president of the Merchants' Association of New York, has been appointed to the executive committee of the Merchants' Association succeeding Irving T. Bush.

Notes on Electric Power Development presented by E. M. Herr at a meeting of the Railway Club of Pittsburgh, is published in the February 1 issue of *Practical Engineer*.

John E. Muhlfeld presented a paper on Pulverized Fuel for Locomotives at the February 18 meeting of the New York Railroad Club in New York.

George W. Bacon of the engineering firm of Ford, Bacon and Davis, New York, has joined the export department of J. P. Morgan and Company. Although retaining his connection with the engineering firm, Mr. Bacon will devote all his time to the Morgan interests, the export department of which is engaged in buying supplies for the Allies.

George Gibbs was elected vice-president of the American Institute of Consulting Engineers, February 2.

Sanford E. Thompson presented a paper on Need Accurate Estimates Based on Unit Costs at the February 14 to 17 convention of the American Concrete Institute held in Chicago.

An address on Public Duties of an Engineering Society was given by F. H. Newell at the 21st annual meeting of the Minnesota Surveyors and Engineers' Society held at St. Paul, February 10 to 12.

Julio F. Sorzano, President of the Pan-American Chamber of Commerce, and Alexander C. Humphreys, Past-President, Am.Soc.M.E., and President of Stevens Institute of Technology, have been elected by the New York Chamber of Commerce as members of its Standing Committee on Commercial Education, to serve until May 1918 and 1919, respectively.

J. Wallace Taylor has accepted a position with the Invincible Machine Company, Walkerville, Ontario, Canada, as superintendent. He was until recently affiliated with the Harris Automatic Press Company, Niles, O., in the capacity of chief engineer.

R. A. Lee has been appointed special engineer of The Barrett Manufacturing Company, New York, being head of the department devoted to distillation work. His former position with the company was in the manufacturing department as engineer.

A. H. Fox Gun Company of Philadelphia, Pa., have added to their organization Conrad V. Hahn, formerly instructor in engineering at Temple University and University of Pennsylvania, and until recently affiliated with the Bell Telephone Company of Pennsylvania in the traffic engineering division. He will be assistant to the vice-president and have charge of one of the Philadelphia plants.

James D. Andrew, superintendent of the station engineering department of the Edison Electric Illuminating Company of Boston, Mass., is now on leave of absence in Chile where he will make a report on the 40,000-kw. power plant of the Chile Copper Company, the owners of which are considering making a large extension.

Peter Junkersfeld spoke before the Monday Luncheon Club of the Chicago Telephone Company, February 14, on Electric Service in Chicago.

A. Lewis Jenkins is the author of Formulæ and Alignment Charts for Taper Press Fits, which appears in the February 17 number of the *American Machinist*.

A New Electro-Hydraulic Shovel by Frank H. Armstrong, presented at the February meeting of the American Institute of Electrical Engineers, is published in the February 17 issue of the *Iron Trade Review*.

Guy L. Bayley has contributed an article on the Design of Million-Volt Experimental Transformer to the February 19 issue of *Electrical World*. This article deals with the construction and operation of an unusual type of high-tension unit displayed at the Panama-Pacific International Exposition.

NECROLOGY

ALFRED WILLIAMSON

Alfred Williamson was born in New York City on July 12, 1880. His early education was received in the public schools of New York City, after which he took a course in mechanical engineering at Columbia University, graduating in 1902. He then entered the service of the New York Central and Hudson River Railroad Company as a special apprentice in their West Albany shops. In 1904, he was employed in the turbine construction department of the General Electric Company in Schenectady, N. Y., but in 1905 he returned to Columbia and took up post-graduate work. In the latter part of that year, he was employed on the work of the Metropolitan Street Railway Company, but in the following year he entered the employ of the Department of Water Supply of New York as a mechanical engineer. From 1910 he was in charge of the pumping stations, Manhattan and the Bronx.

Mr. Williamson became a member of this Society in 1902. He died at his home in Bronxville, N. Y., on December 26, 1915.

LUCIEN MAXWELL BRIGHAM

Lucien Maxwell Brigham was born in Brooklyn, N. Y., on June 6, 1874. He received his education in the schools of Brooklyn. Mr. Brigham's entire business career was with the firm of Maxwell, Manning and Moore, in which firm he first became an employee in 1894. He acted in the later years of his life in the capacity of sales manager of the brass goods department, and during the last five years he was a member of the board of business associates in the carrying on of his department.

Mr. Brigham was a member of the Engineers' Club, the Railroad Club, and several social clubs. He became a member of this Society in 1906. Mr. Brigham died at his home in Orange, New Jersey, on December 11, 1915.

WILLIAM F. SARGENT

William F. Sargent was born in New Haven, Conn., on June 27, 1882. He received his education in the public schools of New Haven and the Boardman Training School from which he graduated in 1901. From September, 1901, until May, 1902, he was in the employ of the Winchester Repeating Arms Co. While there his work consisted of mechanical drawing, surveying for new buildings and roads, laying out machines in factory additions and general machine design. In June, 1902, he accepted a position with the Bigelow Company, with which company he was connected until the time of his death. For five years he was chief draftsman and later was made sales engineer and estimator. Mr. Sargent became a member of this Society in 1914. He died at his home in New Haven on December 7, 1915.

JOHN ALEXANDER HILL

John Alexander Hill, president of the Hill Publishing Company, was born in Sandgate near Bennington, Vermont, on February 22, 1858. His parents very soon after moved to central Wisconsin, and it was there that he received his early education. When he was 14 years of age, Mr. Hill started work in a country printing office and later became half owner of a machine shop. In 1878 he removed to Colorado and ran a locomotive on the Denver & Rio Grande R. R. He was soon made a roundhouse foreman and later assistant superintendent of motive power.

Mr. Hill had a great fondness for journalism and in 1885 he founded the Daily Press of Pueblo, Colo. At this period he contributed a number of articles to Locomotive Engineering, published in New York by a company which also published the American Machinist. In 1888 Mr. Hill was invited to come to New York and take charge of Locomotive Engineering. Shortly after this he associated himself with Angus Sinclair, purchased the journal from its owners, and undertook to carry it on as a separate publication. In 1896 Mr. Hill sold his interest in Locomotive Engineering and purchased the American Machinist. Mr. Hill later bought other publications, including Power, Engineering and Mining Journal, Engineering News, and Coal Age. To carry on these various publications he organized the Hill Publishing Company.

The printing and publication of the company's magazines is all carried out in one building which was completed in 1914 and was planned and built not only to suit the convenience and economy of the printing and publishing business but also to provide for the safety, comfort and health of the army of workers housed in it.

Mr. Hill was Vice-President of the Machinery Club, member of the Engineers' Club of New York City, and Railroad Club, and Campfire Club. He became a member of this Society in 1913. Mr. Hill died on January 24, 1916.

WILLIAM BARKER RUGGLES

William Barker Ruggles was born in Bath, N. Y., on December 17, 1861. He received his early education in Bath, and graduated from Cornell University in 1883. He then became associated with the West Shore Railroad, working at Frankfort, N. Y., and elsewhere, and later with the American Casualty Company. In 1893 he founded the Ruggles-Coles Engineering Company. He was the inventor of the Ruggles-Coles double-shell dryer and was president of the Ruggles-Coles Engineering Company up to the time of his death. He was also president of the Novella Cement Company, Niagara Cement Company, and a director of the Buffalo Potash and Cement Corporation.

Mr. Ruggles was a member of the Engineers' Club, the Machinery Club, the Psi Upsilon and Cornell University Clubs of New York and a trustee of Trinity Church of Bayonne, N. J. He became a member of this Society in 1905. He died at his home in Bayonne, N. J., on January 23, 1916.

GEORGE HARWOOD CUSHING

George Harwood Cushing, superintendent of the North and South plants of the H. B. Smith Company of Westfield, Mass., was born in Worcester, Mass., on October 13, 1860. He graduated from the Worcester Polytechnic Institute in 1884. For a number of years he was assistant superintendent of the H. B. Smith plants, was superintendent of a pump plant at Seneca Falls, N. Y., for thirteen years, and was in charge of a foundry at Montreal, Canada, for two years. In 1906 he returned to the H. B. Smith Company at Westfield.

Mr. Cushing became a member of this Society in 1891. He died at his home in Westfield on January 6, 1916.

PAUL G. ROESTI

Paul G. Roesti was born in Berne, Switzerland, in April, 1878. He received his early education in the public schools of his native city. After graduating in mechanical engineering from the technical school at Berne, Switzerland, in 1896, he was employed for two years in the engineering offices of Frickart in Munich, Bavaria, and one year with Sulzer Bros. in Winterthur, Switzerland, working on Corliss and poppet valve steam engines.

In 1899 he entered the Swiss Technical High School at Zurich, Switzerland, from which he graduated in 1903. He then came to this country and was employed by the Buffalo

Forge Company as a designer of steam engines, centrifugal pumps and blowers. In 1904 he took a position with Beckstrom Smith Steam-turbine Co. and Filer and Stowell Company as mechanical engineer and designer of steam turbines and steam engines, remaining with them until 1907 when he became a designing engineer with A. O. Smith Co., Milwaukee, manufacturers of automobiles. He was later made chief engineer of this company.

In 1911 he returned to Switzerland to accept a position with Sulzer Bros. as chief designer in the high-speed Diesel engine department, and he there designed and standardized several new types of engines. He gave up this position in 1915 on account of poor health. He died in California on December 23, 1915.

Mr. Roesti was a member of the German Engineers' Society, and the Swiss Engineers' and Architects' Society. He became a member of this Society in 1914.

AUSTIN D. MIXSELL

Austin D. Mixsell was born in Easton, Pa., on October 20, 1873. He received his education in the schools of Easton and at the Penn Charter School in Philadelphia. He went to Bethlehem in 1892 and was employed in the freight office of the Lehigh Valley R.R. In 1898, he entered the employ of the Bethlehem Steel Company, working in the general superintendent's office and in the sales department, and later was made the representative of that company in New York City. In 1909, he was appointed general sales agent of the Company and in 1915, was elected a vice-president. At the same time, he became a member of the Board of Directors of the Company. He was also president of the Dietrick and Harvey Machine Co. which became a subsidiary of the Bethlehem Steel Company.

Mr. Mixsell was a member of the Bethlehem Club, Bethlehem, Pa., the Union League Club, Philadelphia, the Manufacturers' Club, Philadelphia, the Engineers' Club, New York, the Railroad Club, New York, the American Society for Testing Materials, the American Iron and Steel Institute as an Executive member, and the American Steel Foundries Society. He became a member of this Society in 1913. He died at his home in Bethlehem on January 15, 1916.

GARRETT W. SIMPKINSON

Garrett W. Simpkinson was born in Cincinnati, Ohio, on August 17, 1860. He received his early education in the schools of Cincinnati and later was instructed privately in certain branches of engineering. He served four years as pattern maker and four years in the drafting department of the Lane & Bodley Co. He then entered the employ of The Stilwell and Bierce Mfg. Co., Dayton, Ohio, in charge of the drafting and pattern departments. Several years later, he returned to Cincinnati to assist in building the first cable railway in that city, designing track and curve constructions as well as the mechanical details of the driving stations. After the completion of this work, he returned to the Lane & Bodley Co. and for a time had charge of their drafting department and pattern shop. In 1888, he became associated with Bert L. Baldwin, Mem. Am. Soc. M. E., in designing and constructing inclined plane and electric railways and plants in and near Cincinnati and made a specialty of machine shop and foundry design and construction, as well as structural and architectural engineering. He became a member of the firm in 1900.

For several years, Mr. Simpkinson instructed evening classes in mechanical drawing and mechanics of engineering at the Ohio Mechanics Institute, Cincinnati, Ohio. He was a member of the Cincinnati Engineers' Club and a member of this Society since 1912. Mr. Simpkinson died at his home in Cincinnati on January 22, 1916.

PER H. SCHEDIN

Per H. Schedin was born in September, 1871, in Stockholm, Sweden. He received his education in the Technical School and College of Mining in Stockholm and his mechanical training from the Stridsburg Saw Works, Trolhattan. From 1891 to 1893, he was chemist and foreman in the open hearth department of the Gullofors Steel Works, Sweden. In January, 1894, he accepted a position with the Midvale Steel Company, Philadelphia, starting work in the machine shops and rising to the position of chief draftsman and designing engineer.

Mr. Schedin was a member of the Engineering Society of Western Pennsylvania and of the Midvale Engineering Society. He became a member of this Society in 1913. He died at his home in Nicetown, Philadelphia, on January 22, 1916.

HOLSTEIN DE HAVEN BRIGHT

Holstein De Haven Bright was born in Philadelphia, Pa., on June 30, 1880. He was educated at the William Penn Charter School in Philadelphia and then entered The Baldwin Locomotive Works as an apprentice. He rose rapidly and in a few years was placed in charge of the upkeep of the works. He was then transferred to be assistant secretary of the Standard Steel Works Company, a subsidiary of The Baldwin Locomotive Works. He also organized the sales department of the subsidiary company.

In 1912, he resigned to accept the presidency of the Southwark Foundry and Machine Co., Philadelphia, which position he held until 1914, when he retired because of ill health. He died in Philadelphia on November 2, 1915.

Mr. Bright was a member of the Union League and Meridian Clubs in Philadelphia and the Merion Cricket Club. He became a member of this Society in 1905.

FRANK HASTINGS VARNEY

Frank Hastings Varney was born at San Jose, California, on September 15, 1872. His parents later moved to San Francisco where he received his public school education and where his business life commenced. His engineering work began in 1894 when at the age of twenty-two he became engineer of the Harbor Light & Power Co., a position which included practically all duties from lineman to manager of the 25 kw. station and lighting system. The following year, this concern was absorbed by the Edison Company and he was transferred to the new Stevenson Street plant of that company, by 1898 advancing to station foreman. The plant was then purchased by the San Francisco Gas & Electric Company and he was made chief electrician in charge of their three local steam electric generating stations. In 1900, Mr. Varney was made superintendent of all steam and electric stations, and the distributing system. When this rapidly growing company absorbed the Independent Company, he was made superintendent of generating stations and sub-stations, and the company later becoming part of the Pacific Gas & Electric Company, Mr. Varney was in 1907 made chief engineer of operating and maintenance of steam stations, which position he held at the time of his death. It is interesting to note that in his last position he had control of an output of 90,000 kw.

Mr. Varney became a member of the Society in 1909 and was a member of the American Institute of Electrical Engineers, the National Electric Light Association, and the Engineers' Club of San Francisco. He died at his home in San Francisco on January 21, 1916, after several months' illness.

SOCIETY MEETINGS

IT is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

NEW YORK, JANUARY 11

At the January meeting of the New York Local Section Walter N. Polakov presented a paper on Standardization of Power Plant Operating Costs, which attracted unusual interest, there being nearly 400 in attendance at the meeting. The purpose of the paper was to outline a method by which the owner of a power plant can, without the necessity of study of technical details of operation, judge how close the actual performance of the plant is to the possible minimum cost at any time and under any circumstances. Mr. Polakov, in his experience in power plant operation, has developed a very interesting method of power plant accounting, in which all variable factors beyond operating control are automatically adjusted, and the result is that his methods of standardization of costs offer some interesting advantages.

This meeting of the New York Local Section marked the introduction of an important innovation in the local activities of the Society in New York. In the endeavor to develop increased interest in the local meetings among the members in the vicinity, an invitation was extended to a large number of local members to take part in the work by serving as committee members on three sub-committees that were appointed under the New York Local Section Committee. These consisted of sub-committees on entertainment, acquaintanceship and excursions, and a large number responded. Tentative plans were laid for a smoker and an excursion, and possibly some other form of local entertainment in addition to the regular monthly meetings.

MINNESOTA, JANUARY 20

One of the largest and best meetings in the history of the Minnesota Section was held on January 20, in the form of a banquet, which was attended by 116 members and their ladies. O. A. Eberhardt, ex-governor, who had been scheduled for an address, was called out of the city at the last minute, so his place at the speakers' table was taken by George H. Herrold. The principal speaker of the evening was Charles W. Tubby, Chairman of the Minnesota Section, who gave a history of the Minnesota Section and told of some of the future plans of the Section looking towards coöperation with other engineering bodies to promote engineering as a profession. Prof. Wm. H. Kavanaugh spoke interestingly on engineering education and brought out his various points with some very clever Irish stories. C. L. Pillsbury spoke of the value of engineering societies and indicated how they would prove to be a very valuable asset to the professional engineer. Mr. Pillsbury also referred to some of his experiences on appraisal work and his work in Washington, D. C. Max Toltz, on behalf of the Minnesota Section, presented Gebhard Bohn, Sr., with a beautiful leather-covered certificate which was in the form of a testimonial to commemorate the pleasant occasion during the Spring Meeting of the Society in St. Paul-Minneapolis in June, 1914., when Mr. Bohn, while not a member of the Society, entertained the visiting members and guests of the Society at his beautiful summer home at Lake Minnetonka. Mr. Bohn, in a few well chosen words, thanked the Minnesota Section for remembering him in such a unique

MENU CARD AND PROGRAM FOR BANQUET OF THE MINNESOTA SECTION

way and expressed a desire to be present at the future meetings of the Section.

The social features of the meeting were emphasized by the banquet program, and much interest was created by the unusually attractive invitations and combined program and menu cards used at the banquet, which were beautifully drawn with an emblem embracing the Am.Soc.M.E. members' badge and the name of the Society and Section as the central feature. The card containing menu and program is reproduced herewith. The invitation sheet was in the form of a drawing with a similar badge emblem centered at the top, with a modern large heavy duty gas engine on the one side and a heavy Mallet-type locomotive on the other. Both of these cards were distributed in blue-print form.

CINCINNATI, JANUARY 21

A joint meeting of the Engineers' Club of Cincinnati and the Cincinnati Section of The American Society of Mechanical Engineers was held on January 21. The Committee on Concrete, consisting of eight members who have been work-

ing for about eight months, presented a report of its investigations. The report detailed an investigation of five different sorts of beams of full size as ordinarily used in construction of supporting floor slabs. Various methods for reinforcing these beams were used. A testing machine was devised by which loads of 100,000 lb. and upwards could be applied at the center of these beams. During the progress of each test the beams were calcined and the surfaces examined very closely with reading glasses to discover cracks. As soon as a crack was discovered, it was marked and the load corresponding to the crack was indicated. The tests showed remarkably high values and the report caused a vigorous discussion on the advisability of raising the safe loads for concrete beams.

An investigation dealing with concrete made up of materials found in the vicinity of Cincinnati was detailed by Prof. C. C. Myers, Mem.Am.Soc.M.E. and a member of the Concrete Committee. This portion of the report was particularly interesting to the members because it gave definite and carefully determined values for the various materials that may be obtained in the vicinity of Cincinnati at reasonable prices. One of the results that was shown with remarkable clearness was the great advantage to be derived from properly graduating in size the sand and gravel.

BIRMINGHAM, JANUARY 26

An informal meeting in the form of a dinner was held by the members of the Birmingham Section on January 26. Letters were read and discussed concerning the appointment of a member to the Naval Board; concerning the routing of trains suggested by Mr. Rice to bring those from the East through Birmingham; concerning the appointment of a delegate for the nominating committee; and an announcement of the territory which had been assigned to the Birmingham Section by the Membership Committee to comprise the district from which they can draw new members for the Section. The question of the entertainment of the visiting members on their way to New Orleans was discussed, and the members of Birmingham are more than glad and ready to show their visiting members how to spend a very pleasant and profitable day in Birmingham.

PROVIDENCE, JANUARY 26

The January meeting of the Providence Association of Mechanical Engineers was held on January 26 in the Engineering Building of Brown University. Franklin H. Wentworth, Secretary of The National Fire Protection Association, spoke on the work of the Underwriters' Laboratories in the direction of fire protection. He spoke of the enormous waste in this country from fire, and referred to the growth of the understanding of the need of fire protection. His talk was illustrated by moving pictures showing the workings of the Underwriters' Laboratories.

BUFFALO, FEBRUARY 2

A meeting of the Engineering Society of Buffalo was held on February 2, at which Morris L. Cooke, Mem.Am.Soc.M.E. and for four years Director of Public Works in Philadelphia, gave an address on Public Service Problems. His address dealt with questions relating to the advisability of establishing in Buffalo a municipal asphalt plant, means of preventing waste of water, electric light rates and other municipal problems. After a free discussion, these questions were referred to a city affairs committee, consisting of John Younger, president of the Engineering Society of Buffalo, David C. Howard and David W. Somers. This committee is to act as a clearing house for all suggestions and complaints of members relating to city affairs; to give its services in conference with any of the departments that make up the commission government; to furnish to the city government sub-committees to act without compensation in consulting or investigating capacities.

Mr. Cooke then spoke of the engineering profession and its relation to public service. He said that he was the first engineer to be the director of public works in Philadelphia, and that his successor is also an engineer, and that of the 70 city managers in Philadelphia nearly all are engineers.

A number of lantern slides followed showing how various municipal activities in Philadelphia were advertised during the administration of Mr. Cooke.

ST. LOUIS, FEBRUARY 6

A joint meeting of the local engineering societies was held on February 9, with an attendance of 105. F. W. Doolittle, Consulting Engineer of New York City, spoke on the Cleveland Street Railway situation. His paper was illustrated and brought out considerable interesting discussion.

BIRMINGHAM, FEBRUARY 7

A meeting of the Birmingham Local Section was held on February 7, at which the following committees were appointed: Executive Committee: R. E. Brakeman, *Chairman;* C. B. Davis, Vice-Chairman; Paul Wright, Secretary-Treasurer; F. G. Cutler and J. Henry Klinck, members; Committee on Program and Papers; J. Henry Klinck, *Chairman;* Richard Faull, E. B. Van Keuren, M. J. Lide; Membership Committee: C. B. Davis, H. A. Moon, W. L. Rouche, C. D. Barr and O. G. Thurlow, members.

After some general discussion, Major General Leonard Wood spoke on Preparedness and the coming Military Training Camp to be held at Chattanooga this coming summer.

BOSTON, FEBRUARY 8

The seventh annual banquet of the Boston Section of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Boston Society of Civil Engineers was held on February 8. About 600 members were present and the meeting was unusually successful in every way. The speakers were His Excellency Samuel W. McCall, Governor of Massachusetts; Col. W. E. Craighill of the Corps of Engineers, U.S.A.; William Barclay Parsons, Consulting Engineer, New York City; John R. Freeman, and Dr. John A. Brashear, Past Presidents of the Am.Soc. M.E., and Calvin W. Rice, Secretary of the Am.Soc.M.E.

NEW YORK, FEBRUARY 8

An unusually large attendance marked the February meeting of the New York Local Section, at which T. Russell Robinson, statistical engineer for W. S. Barstow & Co., Inc., New York, read a paper on Ways of Presenting Data for Executive Purposes. Mr. Robinson takes the position that all the data which the engineer can gather on costs, performance of equipment, output and other information of industrial interest, are of little use in securing appropriations from directors, or investments from financiers, until he can present his findings in a way that can be comprehended. He showed in an interesting manner how effective graphical

methods are for this purpose and he proved that graphical methods are applicable to practically all forms of data presentation. The paper was illustrated by lantern slides and drew out an extended discussion.

This meeting was the first in which the newly-appointed sub-committees of the New York local committee on entertainment, acquaintanceship and excursions were brought actively together. In order to bring the local members into closer relationship, the acquaintance committee arranged for an informal dinner preceding the meeting of the evening at which about 125 were in attendance. This was effective in bringing the new committee closely into touch with their work, and at the dinner plans were laid for an active campaign for developing interest in the New York local meetings. Over 400 were in attendance at the meeting of the evening.

ST. LOUIS, FEBRUARY 9

On February 2, there was a joint meeting of the Engineers' Club of St. Louis with the local societies. J. B. Marcellus, engineer of the Association of the American Portland Cement Manufacturers, spoke on Recent Practice on Concrete Roads. His talk was illustrated by several slides and motion picture reels. There were 62 present.

MILWAUKEE, FEBRUARY 10

A meeting of the Milwaukee Engineers' Society which represents the local engineering society, The American Institute of Electrical Engineers, The American Society of Mechanical Engineers and The American Chemical Society, was held on February 10 under the auspices of the Milwaukee Section of the American Institute of Electrical Engineers. Arthur Simon, Mem.Am.Soc.M.E., and electrical engineer of the Cutler-Hammer Mfg. Co., read a paper on The Design and Application of Electro Magnets for Industrial Purposes. He discussed the essential features which determine the design of the magnets and the possible modifications of the design. He showed that the secondary phenomena such as the leakage of the magnetic circuit and the saturation of the iron, very often overshadowed the basic phenomena of electro magnetic induction, and that by properly controlling these factors the characteristics of the magnet can be changed to suit particular purposes.

The speaker also discussed in detail the peculiarities of the alternating current magnet which presents a far more serious problem than the direct current magnet both from the standpoint of mechanical construction and electrical design; the extreme limitations of the alternating current magnet due to hysteresis and eddy-current losses in the iron and to the variation of the self-induction of the magnetic circuit with the movement of the armature. In closing the speaker showed the application of some magnets for heavy current switches which control electric circuits, and also several types of direct and alternating current magnets for brakes such as are used on cranes, elevators and similar apparatus. Moving pictures illustrating the use of a 62 in. lifting magnet in the yards of a steel mill for handling pig iron, scrap, and other material, closed the lecture.

In the discussion structural features of some of the magnets shown were brought out. An interesting application of electro-magnets for shifting the gears of automobiles and the use of magnets for the operation of clutches were discussed. Mention was made of a magnetic clutch transmitting 2000 h.p. at a speed of 100 r.p.m. This is said to be the largest magnet clutch thus far constructed. A buffet lunch at which the discussion was continued informally among the members closed the evening.

MINNESOTA, FEBRUARY 10

The February meeting of the Minnesota Section of the Society was held at the University of Minnesota on February 10, at which George P. Diekmann, chief chemist of the Northwestern States Portland Cement Company, Mason City, Iowa, gave a very instructive illustrated lecture on The Modern Manufacture of Portland Cement. He showed 85 different slides which illustrated the process of manufacture in detail from the time the material is handled by steam shovel to the finished product. His pictures were of unusual interest because they were taken before the Mason City Plant was completed, and in this way gave a better idea of the enormous amount of equipment that is required for cement manufacture.

Mr. Diekmann then discussed the chemical side of Portland Cement. With reference to the various elements that are necessary to produce a good brand of cement, he said that silica lime, alumina and iron must be present in particular ratios in order that a certain chemical action be produced. The ratio of lime to silica should be from (2.8 to 3.2) to 1 and alumina to iron (2.5 to 3.5) to 1. Mr. Diekmann said that the chemical composition of Portland cement is very uniform and is usually as follows: Silica, 20 to 23 per cent; alumina, 5 to 8.5 per cent; iron oxide, 1 to 4 per cent; lime, 60 to 64 per cent; magnesia, 0.5 to 3.5 per cent; sulphuric acid, 1.5 to 2.5 per cent. Mr. Diekmann also spoke of the effects that each element has on the setting of cement and formulae that might be used for calculating the proper proportions in the raw mixture. Mr. Diekmann's lecture was discussed by about ten of the members present. The main questions raised were about the methods of sampling and testing cement residue on the sieves after the fineness test, and the question of value of water-proofing.

BOSTON, FEBRUARY 16

Under the scheme of coöperation existing among the engineering societies in Boston, a meeting was held by the Boston Society of Civil Engineers on February 16. Edward C. Sherman presented a paper illustrated with lantern slides on the Spillways of the Panama Canal.

BUFFALO, FEBRUARY 16

At a meeting of the Engineering Society of Buffalo, on February 16, C. T. Myers, Mem.Am.Soc.M.E., gave a lecture on the Uses of Modern Worm Gearing. Mr. Myers pointed out that worm gearing made by present processes is infinitely superior to the older types, some of which often had the teeth improperly formed. With present day worm gearing, efficiencies of 95 per cent can be readily obtained and the old idea that worm gearing was irreversible has been exploded. Mr. Myers laid stress on the fact that the worm gear had been developed to its present stage by its successful use on motor trucks.

STUDENT BRANCHES

BUCKNELL UNIVERSITY

At the regular monthly meeting of the Bucknell University Student Branch on February 7, Thomas L. James, '16, gave a very interesting talk on Scientific Management of Machine Shops. He discussed the old ways and the new ways of managing a shop, taking an old shop under the old system and converting it into a shop under a new system now in practice. A discussion of the subject followed by Professors Burpee and Kriner. There were 23 members in attendance.

BROOKLYN POLYTECHNIC INSTITUTE

The February meeting of the Brooklyn Polytechnic Institute Student Branch was held on February 11, in the form of a Ladies' Night consisting of a semi-technical lecture illustrated with slides and with moving pictures, and followed by a dance.

Lieut. Percy E. Barbour, C.A.C., N.G.S.M., spoke on Coast Defense. The enormous amount of territory in which the United States is interested was pointed out, and also the fact that the chief source of materials for our explosives are in the Chilean nitrate fields. The natural conclusion was the need of a larger fleet, especially on the Pacific Coast. The slides which followed depicted the types of battleships peculiar to the United States, Germany, and Great Britain. Lieut. Barbour explained that a dreadnought is an all big-gun ship, while the super-dreadnought, the most desirable of fighting vessels, is a battleship possessing a full complement of big guns and, in addition, the guns of the intermediate classes. He also described the working of typical coast defense guns, and gave the audience a good idea of the work of gun crews and range finders by an exposition of the ballistics and methods of range-finding and a description of the Whistler-Hearn plotting boards. The talk was followed by two reels of films which illustrated the pleasure and business of life in the camp at Fort Williams, Me.

The Brooklyn Rapid Transit Company, who donated the use of the moving picture machine, showed a film on Safety First. This is one of the films which this company has used in its campaign to minimize street car accidents.

LELAND STANFORD, JR., UNIVERSITY

The Leland Stanford, Jr., University Student Branch held a meeting on January 26, at which E. B. Anderson, a junior in the mechanical engineering department, gave a talk on the Owen Magnetic automobile. The description was illustrated by a sketch on the blackboard, showing the location of the transmission in the car, the manner in which the armatures of the generator and motor are connected to the propeller shaft, and the position of commutators and ball bearings. After showing the construction, Mr. Anderson explained the manner in which the car is started from rest and brought to full speed by different combinations of field windings and resistances, and the action when pulling up a heavy grade. Among the advantages of this electrical transmission for automobiles which were brought out were easy starting, freedom from gear shifting with its attendant clashing and jerks, great flexibility and smoothness of drive, automatic adjustment of the speed of the car to the grade, ability to climb very steep hills slowly when desired, the reducing of clutch, transmission and starting mechanisms to one unit, and the use of the transmission as a brake by means of a reversing switch. This paper was discussed by J. L. Reynolds, W. H. Warren, J. A. Shepard, H. F. Elliott, G. W. Elsey, E. O. Bennett, H. R. Hammett, H. C. Parker, C. E. Scholtz, and H. E. Waite. In the discussion, the ease of making repairs and the small need of repairing were featured.

THROOP COLLEGE OF TECHNOLOGY

W. W. Smith, chairman of the Los Angeles Section of the Am.Soc.M.E., gave an illustrated talk before the Student Branch of the Throop College of Technology on January 7 on Cooling Water for Condensers. Mr. Smith compared the various methods of cooling condenser water used at present, and gave the limiting factors and difficulties met with in each.

UNIVERSITY OF ARKANSAS

The mechanical engineers of the University of Arkansas met on January 6 and reorganized the Student Branch of the Am.Soc.M.E. The following officers were elected: Prof. B. N. Wilson, honorary chairman; W. G. Horton, chairman; H. A. Coffield, vice-chairman; J. C. Moody, secretary; C. O. Bosemeyer, treasurer. The Branch has decided to hold joint meetings with the Student Branch of the A.I.E.E.

At the first joint meeting on January 18, W. G. Horton gave an illustrated lecture on the advancement of the steam engine. He began with a description of the steam turbine and discussed the various improvements leading up to the modern Corliss and compound engines. Two reels of motion pictures of the Pittsfield, Mass., electrical works were shown by the Electrical Engineering society.

At a meeting on February 1, J. C. Moody gave a paper on the different kinds of lubricants and their properties and the changes which they undergo with increase of temperature. Prof. W. B. Stelzner of the Electrical Engineering Department, in a short address, emphasized the importance of joint meetings of the Electrical and Mechanical societies. He declared that the work of the two classes of engineers are so closely related that an efficient engineer must have at least a general knowledge of both.

UNIVERSITY OF CALIFORNIA

The regular meeting of the Student Branch of the University of California was held on February 8, with an attendance of 17 members.

Three interesting papers were presented, the first by H. Greenwood, on Interior and Exterior Ballistics as Applied to Large Guns, in which he discussed the action of the shot within the gun and also in its path through space. M. Jones discussed the subject of Recoil Chambers on Field Pieces, and Prof. Raber, of the Department of Mechanics, spoke on The Student Engineer and Positions Held by Him, in which he showed the varied character of the positions held by graduates of mechanical engineering colleges.

Following a discussion of the papers presented during the evening, a banquet was held in honor of the new members.

UNIVERSITY OF COLORADO

A meeting of the University of Colorado Student Section was held on January 13. The paper of the evening, which was Rehabilitation of Power Plants, by H. V. O. Coes, Mem. Am.Soc.M.E., was read by Harvey Craig. The paper was illustrated with slides. Forty-two members and guests were present.

UNIVERSITY OF ILLINOIS

The work at the University of Illinois Student Branch started with renewed vigor at the beginning of the scholastic year, and was pushed during the entire semester by the members. This work consisted of a Mechanical Engineering Open House, a series of engineering lectures and the preliminary work on the papers which are to be presented the second semester of the year.

On October 15, 1915, the Mechanical Engineering Open House, which is now an annual affair, was held. All the shops and shop laboratories were in full blast and several interesting processes were performed for the visitors. In the foundry, a heat of cast iron, and several of brass and aluminum were run out, the molds being small ornamental paper weights which were finished immediately and given to the visitors. Three thousand of these souvenirs were distributed in this way. In the machine shops, small sheet metal ash and pin trays were stamped out and die-formed, and in the wood shop an attractive pencil holder was given to each of the visitors. These pencil holders were made by the men in the wood turning classes. An exhibition of different forms of Prest-o-lite welding was done, which proved to be quite an attraction.

In the Engineering Laboratory, the chief attraction seemed to be the artificial snow storm, which was made by mixing saturated air with the exhaust of a compressed air driven engine. Beside this, all the other apparatus of the laboratory was in operation as well as that of the power plant proper.

In connection with the Open House, several reels of moving pictures wholly of an engineering and educational nature were shown. Over 4500 people visited the shops and laboratories, and the Student Branch, as well as the department, consider the Open House quite a success.

At the beginning of the semester the faculty of the Mechanical Engineering Department of the College of Engineering donated a large, handsome silver trophy cup which will be presented to the member of the Branch who presents the best original paper before the Branch during the present school year. The papers will be judged in the following manner: After the paper is presented to the Branch, it will be passed upon by a committee of five of the younger instructors of the University. This committee will choose the five best papers and present them to another committee composed of three of the professors of the College of Engineering who are members of the Am.Soc.M.E. This committee will make the final award.

The series of lectures began on October 21, 1915, with a lecture by Mr. Hower. He took up the features of the sleeve valve motor from an engineering standpoint and gave a most delightfully interesting illustrated talk. About 300 were present. The second of these lectures was on November 4, 1915, given by George L. Willman, who spoke on the business side of engineering. The lecture was well attended and was instructive as well as interesting. On January 13, 1916, O. Monnett gave an illustrated talk on smokeless combustion and the methods of securing it. The last lecture was by W. A. Blonck, who talked on boiler practice in the United States and Foreign Countries. Mr. Blonck had a very complete set of slides which enhanced his lecture greatly.

The work of the next semester will deal largely with the presentation of student papers which have already been prepared, or are now in the process of preparation. An intense rivalry between the upperclassmen seems to indicate that a large number of papers will be entered in the contest for the faculty cup. It is the hope of the Branch that a cup will be donated each year, and there is every reason to believe it will be if the contest this year is a success.

UNIVERSITY OF KANSAS

The Student Branch of the University of Kansas has been meeting weekly at the home of Prof. A. H. Sluss, honorary chairman of the branch. On February 9, Prof. C. A. Haskins, State Sanitary Engineer, and Associate Professor of Civil Engineering, gave a valuable talk on Water Purification. Such gatherings as these, in which every man enrolled in the Mechanical Department is "invited and expected to attend," have been a very material influence in making the Branch grow in interest and numbers to a present membership of 37.

The Automobile Show in Kansas City, February 7-12, brought forth two very interesting talks at the meeting of February 16. B. O. Bower reported on Automobile Engines and C. W. Hagenbuck on Chassis Development.

The Senior inspection trip to Chicago, Gary, and Keokuk afforded sources for an interesting report on the routing system of the Western Electric Co. in Chicago, by S. E. Campbell, and a summary of the tractor manufacturing plant of the International Harvester Co. by J. E. Stillwell.

UNIVERSITY OF KENTUCKY

At a meeting of the Student Branch of the University of Kentucky on February 10 the following papers which have been presented before the Society at the Annual Meeting were read: The Heat Insulating Properties of Commercial Steam Pipe Coverings, by L. B. McMillan, was read by Webb Lail; Circulation in Horizontal Water Tube Boilers, by Paul A. Bancel, was read by J. M. May; Performance and Design of High Vacuum Surface Condensers, by Geo. H. Gibson and Paul A. Bancel, was read by H. P. Parrigin; Proportioning Chimneys on a Gas Basis, by A. L. Menzin, was read by M. S. Sullivan; Higher Steam Pressures, by Robert Cramer, was read by E. R. Pursley. At the conclusion of each article the speaker answered questions on points that were not clear to the members.

At a meeting of the Branch on February 15, L. O. Armstrong of the Bureau of Commercial Economics gave a lecture on Canada.

UNIVERSITY OF MICHIGAN

A meeting of the Student Branch of the University of Michigan was held on January 24, at which the following officers for the coming year were chosen: A. E. Hecker, chairman; T. Toby, vice-chairman; W. F. Gerhardt, secretary; F. M. Sawin, treasurer. These four officers together with one other member elected by them form the Executive Committee.

Twelve members of the Branch were present and discussed plans for increasing the membership and influence of the Branch. A decision was made to provide a "sophomore" session, the general opinion being that the Branch should have more underclassmen, who would thus be available longer for work along the lines they prefer.

UNIVERSITY OF MINNESOTA

On January 22, the University of Minnesota Student Branch held an open meeting in the Auditorium of the Main Engineering Building, at which K. Llewellyn, of the National Tube Company, lectured on the Process of Manufacturing Butt Weld and Lap Weld Steel Pipe. The talk was illustrated with motion pictures, and Mr. Llewellyn took up each process in the manufacture of pipe, from the mining of the ore to the finished product.

UNIVERSITY OF NEBRASKA

At a meeting of the Student Branch of the University of Nebraska in January, Richard Ferguson, manager of the Yankee Hill Brick Company, of Lincoln, Neb., gave a very instructive lecture on Some Engineering Features in Brick Making. The address was so arranged that the development of the science of brick making from the very simplest to the most complicated processes was shown.

Mr. Ferguson first took up the chemistry of brick material, explaining how to select a good clay deposit for the location of a brick factory. He then showed views of the different kinds of brick machines for the dry and wet processes and pointed out the difficulties encountered in the various types of machines. The processes of manufacture, cutting, repressing and drying were explained in detail. The address as a whole showed how closely the work of the mechanical, civil, and chemical engineers is related in brick manufacture. At the close of the lecture Mr. Ferguson gave a general invitation to the University students to inspect the Yankee Hill brickyard at any time.

At a meeting of the Branch on February 8, at which 29 members and guests were present, Prof. B. G. Elliot, Professor of Mechanical Engineering at the University of Nebraska, who spent three years in the University of Wisconsin extension department, spoke on Engineering Extension. He said that the dean of the extension department of the University of Wisconsin was an engineer, and pointed out the attitude of the people toward the university, saying that, in general, the people were prejudiced against the university and university people. In Wisconsin, however, this feeling has been removed as a result of the extension department, and the change in attitude of the people is shown by the fact that they sent letters and telegrams of protest to the legislature when the support of the extension department was about to be cut off. The advantages offered have changed the whole life of some of the students. This department has also undertaken work in the penitentiary.

VIRGINIA POLYTECHNIC INSTITUTE

The regular meeting of the Virginia Polytechnic Institute Student Branch was held on January 22. A very interesting paper on Superheaters was presented by W. R. Ellis and R. M. Hutchinson, who discussed the subject from both a mechanical and economical standpoint. During the course of the paper the practicability of superheater installation was clearly shown.

At a second meeting, held on January 29, the Branch was addressed by I. N. Moseley, who spoke on Low Water Alarms. The subject had been worked up jointly by Mr. Moseley and R. R. Connelly, and most of the up-to-date alarms were discussed in detail. Sketches were made of the various types now in use, among which were the float type, the balance type,

and the Nathan type, all of which are used on stationary boilers, and the fusible plug and sentinel types, which are used on locomotive boilers.

WORCESTER POLYTECHNIC INSTITUTE

A very interesting and successful meeting of the Student Branch of the Worcester Polytechnic Institute was held on February 4, at which 155 members and guests were present. Major L. T. Hillman of the United States Army spoke on Modern Ordnance, its Construction and Use. In his opening remarks, he spoke of the importance of the subject of "Preparedness" to engineers and brought out the fact that the engineer is a most important factor in modern warfare. The subject of ordnance was taken up under the four general topics: Small arms, cavalry and field artillery, machine guns, coast defense. Mention was made of the familiar small arms, including the rifle, granades, revolver, etc., after which a very interesting set of lantern slides was shown and explained. Several pictures presenting the principal types of field pieces were thrown upon the screen and particular mention was made of the extreme effectiveness of the rapid fire machine guns. It was explained that the fire of these forms of portable guns is confined to comparatively low elevations, while the howitzers, mortars and aeroplane guns cover the higher elevations. Of particular interest was the description of the shrapnel and ordinary bomb shells. After treating the subject of portable guns, Major Hillman spoke at some length of the coast defense ordnance, both mortars and guns, and the views of the mortar batteries and coast fortifications equipped with the larger disappearing rifles illustrated his points admirably. Photographs of the latest 14 and 16 inch rifles of the United States were shown, and mention was made of some of the difficulties and problems which arise in designing such guns and their mountings.. An interesting discussion followed Major Hillman's talk.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices now appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.

49 Engineering Salesman, in machinery department of Pennsylvania concern. Man should be not less than 35 years of age; good draftsman but primarily a salesman. Good salary for a man with these qualifications. Location Pennsylvania.

50 Draftsman, experienced in heavy machinery work and if possible chemical apparatus. Salary $25.00. Location New Jersey.

51 Tool Room Foreman wanted by a large manufacturing company. Must be good executive and first-class mechanic. Good permanent position for the right man. In reply give full information regarding experience, age and salary wanted. Location Middle West.

53 Draftsman with some experience in structural work. Salary $100.00 a month, with good prospects of advancement. Location Ohio.

54 Assistant Foreman for a radiator factory. Location Ohio.

55 Assistant Foreman for gray iron foundry melting approximately 25 tons per day, particular requirement, experience with all types of moulding machines. Location Ohio.

59 Cost Man for new foundry; intelligent, up-to-date and familiar with foundry materials and equipment, and experienced in foundry costs and bookkeeping. Location Connecticut.

63 Assistant Purchasing Engineer for the inspection of incoming materials, for Massachusetts manufacturer of small electrical apparatus in quantities; applicants thoroughly familiar with electrical, insulating and composition casting materials; with practical knowledge of metal working and similar machinery; state details under heading, age, nationality, education, practical experience, salary, when at liberty.

64 Draftsman experienced in design of steel pulleys. Must be accurate, rapid and industrious. Salary about $25 per week. State age, experience, previous employers and references. Location Massachusetts.

66 Superintendent for large European concern, engaged in the manufacture of rubber shoes, technical and surgical articles, covering for rollers, tubes of all kinds, balls, toys and similar articles made of rubber.

67 Foreman experienced in the manufacture of rubber articles for European concern as listed in position 66.

68 Development Work. Man who has had a technical and practical mechanical engineering education, with knowledge of electrical engineering, machine shop work, drafting, etc., is desired to assist in the further development of plans for constructing an improved rock tunneling machine. Location New York.

71 Sales Engineer for Metropolitan and New England district. Will be brought into contact with manufacturing and construction work for chemical and industrial plants. Salary depends on man.

72 Factory Superintendent for large watch making concern. Location New England.

75 Salesman with experience in marketing high grade hot rolled electric and open hearth steel specialties; one having sufficient knowledge and information to post operations in securing proper tonnage for mill. To receive attention, state age, experience and salary expected. Name confidential.

76 Professor of Experimental Engineering wanted at the opening of the University in September. Essential qualifications are, first, the right sort of man; second, training and experience fitting him for the work in question. Location Pennsylvania.

77 Draftsman on detail machine design. One thoroughly familiar with this line of work. Salary $20 to $22.

78 Drafting and Testing Engineer. A concern doing general foundry and light machine work is desirous of securing services of a young mechanical engineer for general drafting and testing work; preferable one or two years experience in shop practice; work for the first few months will be devoted mainly to drafting out the general arrangement of the foundry, shops and apparatus. Testing to consist principally of power and heat transmission and the economical operation of mechanical devices in the shops. Give references and salary expected. Location Middle West.

83 Young Mechanical Engineer, willing to start at a salary of about $25 a week, who has had experience or is interested in the operation of an isolated power plant of about 1000 b.h.p. to consist mostly of testing, estimating, superintend-

ing new construction and keeping records. Position permanent. Location Hoboken.

87 Machine Shop Foreman, well qualified to take charge of machine department making tools and special machinery. Location New Jersey.

88 Production Engineer; preferably Englishman, age 28-34, actual shop experience, machine tools, light and heavy, shop practice, for work consisting of reporting, analyzing work in shop with idea of suggestive improvements in output, etc., in munitions manufacture. Headquarters in Eastern Pennsylvania. Salary dependant upon man.

89 General Superintendent of factory employing 150 men engaged in manufacture of small parts for universal joints for automobiles. Man capable of laying out factory, organization, production, etc. Location Indiana.

91 Draftsman experienced in the design of reinforced concrete factory buildings. In applying give age, experience, salary expected, etc. Location Waterbury, Conn.

93 Mechanical Draftsman, capable of laying out and designing a varied line of machinery to familiarize himself with the particular line of manufacture in view of assuming charge of drafting room of about twenty men. Must be of the best ability and capable of handling men. Location New England.

96 Assistant to Machine Designer; young technical graduate who could take general oversight of power plant and buildings. Opportunity for advancement would be either in the designing and building of machinery or in manufacturing, for whichever line the man showed aptitude. Salary according to experience and demonstrated ability.

98 Draftsman who has had experience in the design of heavy machinery, rolling mills, etc. Location, Connecticut.

100 Grey Iron Foundry Foreman or Superintendent, for large modern factory located in New England and engaged in producing medium and light weight castings. Applicant must have had extensive experience in the mechanics of founding, mixture of metals and the systematic handling of men and give complete references.

101 Iron and Steel Engineer, acquainted with modern methods, to take charge of the planning of extensions and improvements of a steel works in Norway.

102 Designer; an engineer, technical graduate preferred, who has had experience in the design of open feed water heaters, softeners, etc. Good position to right person. Write fully giving details of past experience and references.

104 Foreman of shop for manufacturing chemists. Location New Jersey.

105 Chemist for firm of manufacturing chemists. Location New Jersey.

107 Production Engineers; young engineers, preferably technical graduates who have had good shop experience and are familiar with the methods of progressive manufacturers. Men are desired who have had experience in machine shops, foundries, paper mills, tanneries, structural shops, or any large and highly organized industry, and who feel that they have acquired a thorough knowledge of system and modern methods, opportunities for advancement are exceptional. In reply, state age, education, experience and salary.

108 Mechanical Draftsman, experienced in conveying machinery, design and detail. Splendid position for right man. All communications will be treated strictly confidential, but to receive consideration should contain particulars of experience, references, age and salary expected to begin; only desire man capable of advancement as position offers good future. Location Middle West. Apply through Society.

112 Engineer Salesman wanted by firm doing business in various parts of Spanish America, with office in Chile and handling mining, agricultural, power plant and railway machinery. Must be a native of United States and graduate mechanical engineer with degree from U. S. college or university. Man not under 30 nor over 45. Ability to write specifications for pumps, steam power plant equipment and locomotives; successful experience as salesman; culture, good address and appearance essential. Unless one is assured of his especial fitness for this position, it is useless to apply. Must speak and write Spanish.

113 Draftsman with at least five years experience along mechanical lines in connection with machine design, pipe work, etc. Salary $125 per month. Location New Jersey. State record of positions held and dates.

114 Young Engineer, capable of learning business thoroughly in shop, with view of systematizing and improving shop conditions. To right man position will eventually lead to Superintendent. Modest salary to start. Communications regarded confidentially, but should contain particulars of experience, age and salary expected to start. Middle West location.

MEN AVAILABLE

The published notices of "men available" are made up only from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

C-85 Engineer, technical graduate, ten years experience in building and power plant layout, inspection and testing, desires change in position.

C-86 Energetic Engineer, with rolling mill and steam power plant experience on both operating and repairs, desires to locate permanently with company offering good chance for advancement.

C-87 Mechanical Engineer, age 30, married, technical graduate, seven years designing, experimental, field and production experience, desires a responsible position in the Central States.

C-88 Cornell Graduate, M.E. and M.M.E. with thirteen years experience in various forms of engineering, desires position shortly after March 1. Experienced in estimating, designing, preparing plans and specifications and in ordering materials. Has held positions of development engineer, assistant to chief engineer, superintendent of construction, etc. Eastern location preferred.

C-89 Production Engineer, member experienced in the application of modern methods of management to manufacturing and sales departments.

C-90 Safety Engineer, technical graduate, age 27, wide experience in factory inspection, guarding of machinery and compensation rating. At present employed.

C-91 Combustion Engineer, at present employed by a large industrial concern in Middle West and successfully obtaining large savings, wants to communicate with prominent concerns burning large amounts of fuel. Prefer one with headquarters in New York City.

C-92 Sales Engineer, Manager or Manufacturers' Representative. Worcester Polytechnic Institute Graduate, M.E., age 36, practical experience managing sales of pumping machinery, air compressors, internal combustion engines, pressure tanks, overhead tanks and towers and design of pumping combinations. At present executive in contracting concern, but desires change.

C-93 Sales Engineer, married, with executive acquaintance among leading architects and contractors throughout East and Middle West. Experience in design and construction of equipment relating to elevators and street railways and at present holding responsible position with prominent New York manufacturing concern.

C-94 Engineer and Executive, mechanical engineer with extensive experience, iron foundry, machine shop, design and

operation of large power plants, central station work and as consulting engineer, is open for engagement.

C-95 Factory Engineer or Factory Planning Engineer, working out problems in mechanical handling of materials and the design, installation, maintenance and operation of machinery, including the power plant and all electrical, mechanical, compressed air and hydraulic equipment; over 20 years successful experience in machine shop of medium and heavy machinery and in handling men of the various trades; fully informed in latest manufacturing methods; 41 years of age, married, available on short notice.

C-96 Investment and Services, mechanical engineer, broad, practical experience, with capital, desires to become actively interested in established business where his experience and training will be of value; principals only.

C-97 Mechanical Engineer, at present employed as chief draftsman, desires change. Twenty years experience, general engineering, successful designer of automatic machinery, printing presses, paper handling machinery, sheet metal goods, quantity manufacture of precision parts, best of references.

C-98 Sales Engineer or Manager with technical education and thoroughly sound practical experience, would be pleased to communicate with a high grade manufacturer, desiring such a man.

C-99 Experimental Engineer, technical graduate, age 33, will consider either a teaching or commercial position. Four years practical experience as designer and as experimental and efficiency engineer; five years experience in teaching mechanical engineering subjects, including a large amount of experimental work; at present professor of mechanical engineering in a small university. Present salary $3000.00 per year.

C-100 Works Manager, now employed, wishes to make a change. Twenty years experience in manufacturing firearms, typewriters, automobiles, power house equipment, etc. Best of references.

C-101 Manufacturers' Representative, graduate of Massachusetts Institute of Technology, wishes to represent as sales engineer in New England, with headquarters in Boston, manufacturing concerns specializing in either mechanical or electrical materials connected with building operations. Extensive experience in the selling of building material and acquaintance with architects, engineers and contractors.

C-102 Specialist in Steam Engineering and Power Plant Equipment, conversant with practical efficiency engineering methods, will consider one or two year contract in investigating, organization or executive capacity. Ability guaranteed. Available July 1, 1916. M.E. graduate, Tau Beta Pi, Jun. Mem. Am.Soc.M.E., Assoc. Mem. A.I.E.E. Married. Experience and references upon application.

C-103 Works Engineer, or Assistant to Superintendent. Associate member, mechanical engineer, graduate M.I.T., age 29, married. Shop, design and testing experience on power plant machinery; also five years experience in investigation, design and erection of power plants, involving wide experience in power plant economy, piping, electrification of manufacturing establishments, machinery layouts and building construction. At present employed but desires to make a change in order to avoid traveling.

C-104 Advertising Manager. Graduate mechanical engineer, age 31, thoroughly experienced in modern publicity work as applied to products of a mechanical nature. Replies are only desired from high grade firms wanting clean cut, dignified methods and willing to pay a suitable salary for capable services.

C-105 Executive. Technical college graduate, honor man, several years business experience, five years in present position as equipment engineer, designing tools and product, and in supervision of tool manufacturing and production jobs. Experience in drawing and swaging operations and in manufacture of field gun cases. Desires permanent position.

C-106 Export Engineer, graduate M.E., age 38, speaking seven modern languages. Fifteen years successful engineering experience. Eight years in leading positions as chief engineer and works manager of the largest machine factories, ship yards and steel works of Russia. Specialized in Germany. Familiar with the American, European and Asiatic markets, through actual visits and special study. High competence in theory and practice of modern machine manufacture, shipbuilding, and steel. Initiative business ability. Wishes connection with a reliable American firm desiring to establish an export business.

C-107 Shop Executive, A.B. Yale, M.E. Columbia, four years apprenticeship in railroad shops, seven years drafting room experience, eighteen months in charge of construction work, desires a change from present position as draftsman to one where shop experience will be of value to employer.

C-108 Executive or Purchasing Engineer, Cornell M.E., age 32, broad engineering experience; at present holding managing executive position. Good judge of human nature and able to handle men to advantage. Conversant with organization, management and efficiency problems, desires change.

C-109 Executive Engineer, graduate Stevens Institute, age 44, nine years experience in motive power departments of railways; ten years with locomotive builders, employing 2000 men, rising from mechanical engineer to vice president; desires executive or engineering position. At present employed. Experience in building and equipping new shops, extensive acquaintance among railroad officers; can furnish capital if desired.

C-110 Sales Engineer, Chief Engineer, Manager or Superintendent, experienced mechanical and civil engineer, at present employed but will be open to make new connection April 1st, 1916. Location immaterial, prefer New York or vicinity.

C-111 Sales Engineer, age 33, at present employed, with successful record as district manager in Chicago, well acquainted with architects, engineers and large manufacturing concerns, desires to handle another line in connection with present work. Experience covers refrigerating machinery, pumps, air compressors and power house equipment of various kinds.

C-112 Superintendent. Graduate Stevens Institute, age 38, married. Experience in shop and drafting room, steam and electric machinery and air compressors; designing and building electrical apparatus for naval vessels; nine years as assistant superintendent and superintendent of inspection department of two large casualty companies, desires change.

C-113 Mechanical Engineer and Purchasing Agent, M.I.T. graduate, age 29, married. Five years' experience as master mechanic in textile plants. At present employed.

C-114 Assistant Mechanical Engineer, Cornell M.E. graduate; age 25; considerable drafting room experience and at present employed as assistant mechanical engineer with a large coal mining company, desires to make a change. For the last two years experience chiefly confined to power plants and testing power plant equipment. Location, New York preferred.

C-115 Opportunity for advancement with manufacturing concern, large central station power company or consulting engineer, wanted by member; age 35, technical training in mechanical, electrical and building construction course at Lowell Institute, experience in drafting room and design of steam boilers and steel plant work in Massachusetts. Boston location preferred.

C-116 Student Member, Bucknell University, free to go anywhere giving chance for advancement, prefers mathematical work, record good, references when needed. Will graduate in June.

C-117 Assistant to Executive Officer: technical graduate, M.E., having had experience in sales, cost and executive work; at present employed; desires better opportunity for advancement. New York or vicinity preferred.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE AM. SOC. M. E.

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

ENGINEERING AS A CAREER. A series of papers by eminent engineers. Edited by F. H. Newell and C. E. Drayer. *New York, D. Van Nostrand Co., 1916.* Gift of Publishers. Price, $1.00.

This series of essays is designed to give information to young men on the prospect of success in adopting the engineering profession for their life work. It includes short essays on Mechanical, Railway, Hydraulic, Metallurgical, Electrical Chemical, Marine, Sanitary, Municipal and Bridge Engineering. They are written by men who have gained success in these branches; and in many instances interesting personal reminiscences are given. The book should be of especial value to professional advisers of youth, and to parents who have the opportunity to learn the aptitude of their sons. W. P. C.

HANDBOOK OF CARBURETION, Arthur B. Browne. *New York, J. Wiley & Sons, 1916.* Gift of publisher. Price $2.00.

A comprehensive treatment of the fundamental principles governing the carburetion of air. It includes the methods of testing carburetors, and has a chapter on the Chemistry of Carburetion. W. P. C.

INDUSTRIAL USES OF FUEL OIL, F. B. Dunn. *San Francisco, Technical Publishing Co., 1916.* Gift of Journal of Electricity, Power & Gas. Price $3.00.

This is a practical book for practical men, covering matter not included in any other book. It covers stationary, locomotive and marine oil fired boilers and the use as fuel in the clay, lime, cement, glass sugar and rubber industries, in metallurgical and shop furnaces, in the steel industry, and the domestic use. The treatment is very complete. W. P. C.

MECHANICAL ENGINEERS' POCKET BOOK, William Kent. ed. 9. *New York, John Wiley & Sons, 1916.* Gift of Publisher. Price $5.00.

It is six years since the previous edition was published, and the changes and advances in engineering practice have made necessary great revision. The book is indispensable. W. P. C.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Yearbook 1916. Gift.

AMERICAN SOCIETY OF SWEDISH ENGINEERS. List of Members, 1916. Brooklyn, 1916. Gift of Society.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS. Proceedings vol. 7, 1914. *Chicago, 1914.* Gift of Association.

BOSTON. TRANSIT COMMISSION. 21st Annual Report. *Boston, 1915.* Gift of Boston Transit Commission.

CARNEGIE INSTITUTION OF WASHINGTON. Year Book No. 14, 1915. *Washington, 1915.* Gift of Carnegie Institution.

ELECTRIC POWER CLUB. Constitution and By-Laws, August 1, 1915. Gift of Club.

KANSAS FUELS: COAL, OIL, GAS. University of Kansas. Engineering Bulletin no. 6. *Lawrence, 1915.* Gift of University of Kansas.

MATCHING THE COAL TO THE PLANT. *New York, 1916.* Gift of Fuel Engineering Company.

NATIONAL ACADEMY OF SCIENCES. Report 1914. *Washington, 1915.* Gift of C. W. Rice.

NEW YORK CITY. BOARD OF WATER SUPPLY. Information for bidders, forms of proposal, contract, bonds and certificates, specifications and drawings for furnishing and placing copper lining in a portion of the City Tunnel of Catskill Aqueduct between shafts 18 and 19 (Contract 170). *New York, 1916.* Gift of Board of Water Supply.

OVERHEAD CARRYING DEVICES. New Jersey Foundry and Machine Co. Catalog 88. *New York, 1916.* Gift of Henry B. Newhall, Jr.

PAN AMERICAN SCIENTIFIC CONGRESS (SECOND). Daily Bulletin. vol. 1, nos. 1-11. *Washington, 1915-16.*

——— List of Latin American Delegates. Gift of C. W. Rice.

PREFACE TO THE FRENCH EDITION OF "THE PRINCIPLES OF SCIENTIFIC MANAGEMENT, Frederick W. Taylor. By Henri Le Chatelier, translated by Eleanor Bushnell Cooke. Gift of Frederick W. Taylor Co-operators.

PRINCETON UNIVERSITY CATALOGUE 1915-16. *Princeton, 1915.* Gift of University.

RAILWAY DEVELOPMENT ASSOCIATION, Address by Howard Elliott. Nov. 10, 1915. Gift of Bureau of Railway Economics.

REGULATION OF PUBLIC UTILITIES, Chas. A. Prouty. *December, 1915.* Gift of Bureau of Railway Economics.

ROUES ET TURBINES A VAPEUR, K. Sosnowski. Second Edition. *Paris, Ch. Beranger, 1904.* Gift of author.

A most complete treatment of the steam turbine up to the date of publication. Of course there has since been a great development in these prime movers. W. P. C.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION. Proceedings. vol. XXIII. *Pittsburgh, 1915.* Gift of Society.

SWEDEN HISTORICAL AND STATISTICAL HANDBOOK. ed. 2. 2 vols. *Stockholm, 1914.* Gift of Swedish Government.

SWEDISH ENGINEERS' SOCIETY OF CHICAGO. Year Book, 1914. Membership Book, 1915. *Chicago, 1915.* Gift of Society.

WATER SUPPLIES OF KANSAS. Part I. Ground Water Supplies. University of Kansas. Engineering Bulletin no. 5. *Lawrence, 1915.* Gift of University of Kansas.

EXCHANGES

AMERICAN CERAMIC SOCIETY. Transactions. vol. XVII. *Columbus, 1915.*

AMERICAN SOCIETY OF CIVIL ENGINEERS. Transactions. vol. LXXIX. *New York, 1915.*

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. Transactions. vol. XXI, 1915. *New York, 1915.*

SOCIETY OF AUTOMOBILE ENGINEERS. Transactions. vol. 10, pt. 2, 1915. *New York, 1915.*

UNITED STATES NAVAL OBSERVATORY. Publications. Second Series, vol. IX, part II. *Washington, 1915.*

TRADE CATALOGUES

ALLIS-CHALMERS MANUFACTURING CO. *Milwaukee, Wis.* Centrifugal Pumps and Centrifugal Pumping Units. (No. 1632 A.) Bulletin no. 1636. Hydraulic machinery. *Oct. 1915.*

BECKER MILLING MACHINE CO. *Hyde Park, Boston, Mass.* Becker Vertical and Horizontal Millers. 56 pp.

FLANNERY BOLT CO. *Pittsburgh, Pa.* Staybolts. *Jan. 1916.*

HAINES, JONES & CADBURY *Co. Philadelphia, Pa.* R Catalogue. Hajoca Plumbing. *1913.*

LEEDS & NORTHRUP CO. *Philadelphia, Pa.* Bulletin 242. Portable Lamp and Scale Galvanometer.

LESCHEN, A., & SONS ROPE CO. *St. Louis, Mo.* Leschen's Hercules. *Feb. 1916.*

NEWTON MACHINE TOOL WORKS. *Philadelphia, Pa.* Catalogue 50. Rotary Planing Machines.

NORMA COMPANY OF AMERICA. *New York, N. Y.* Catalog no. 105. "Norma" precision bearings. *1916.*

PROGRESSIVE MANUFACTURING CO. *Torrington, Conn.* Machine Screws, Special Screws, Rivet Specialties. 18 pp.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO. *East Pittsburgh, Pa.* Descriptive leaflet 3860. Westinghouse Continuous Duty Slip Ring Induction Motor.

WHEELER CONDENSER & ENGINEERING CO. *Carteret, N. J.* Bulletin 108-A. Centrifugal Pumps. *1915.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

AMERICAN EPHEMERIS AND NAUTICAL ALMANAC, 1918. *Washington, 1915.*

AMERICAN JOURNAL OF SCIENCE. Index to vols. 31-40. *New Haven, 1916.*

AMERICAN SEWERAGE PRACTICE, Leonard Metcalf and H. P. Eddy. vol. III—Disposal of Sewage. *New York, 1915.*

ANTHRACITE MINING LAWS OF PENNSYLVANIA, 1915. *Harrisburg, 1915.* Gift of Penn State Library.

ARCHIV FUR EISENBAHNWESEN. Gesamt Inhaltsverzeichnis. Jahrgänge I-XXXVI, 1878-1913. *Berlin, 1914.*

ARGENTINE BIOLOGICAL THEORY OF IMMUNITY, Julio Mendez. Presented to the Second Pan-American Scientific Congress by Dr. Ricardo Sarmiento-Lasplur. Gift of Dr. Geo. F. Kunz.

AUTOGENOUS WELDING AND CUTTING, Theodore Kautny, translated by the author and J. F. Whiteford. *New York, 1915.*

BEITRÄGE ZUR GESCHICHTE DER TECHNIK UND INDUSTRIE. Band 6, 1914-15. *Berlin, 1915.*

BETON KALENDER TASCHENBUCH FUR DEN BETON UND EISENBETONBAU, XI Jahrgang, 1916. 2 vols. *Berlin, 1915.*

BIBLIOGRAPHIE DER DEUTSCHEN ZEITSCHRIFTENLITERATUR. Band 35, B; 36; 36, A. *Leipzig, Felix Dietrich, 1915.*

——— Autoren Register Band 34-35. *Leipzig, 1915.*

Bibliographie der fremdsprachioen Zeitschriftenliteratur. Band 12, 13, 1914. *Leipzig, Felix Dietrich, 1915.*

Bituminous Mine Law, Pennsylvania, 1911. *Harrisburg, 1911.*

Canadian Mining Institute. Transactions. vol. 18. *Montreal, 1915.*

Chronocyclegraph Motion Devices for Measurino Achievement, Frank B. Gilbreth and L. M. Gilbreth. Paper presented at 2d Pan-American Congress, at Washington, D. C., Jan. 3, 1916. Gift of authors.

Combustion and Smokeless Furnaces, Jos. W. Hays. *Chicago, 1915.*

Commercial Organizations of the United States Miscellaneous. Series No. 28. *Washington, 1915.*

Compound Locomotive Engines. Worsdell and Von Borries' System. *London, 1887.* Gift of G. L. Fowler.

Continuous Current Electrical Engineering, W. T. Maccall. *London, 1915.*

Corrosion of Iron, L. C. Wilson. *New York, 1915.*

Design of Drill Jigs, A. N. Haddow. *Manchester, 1915.*

Eagle Almanac, 1916. *Brooklyn, 1916.*

Economics of Contracting, Daniel J. Hauer. Vol. I. *Chicago, 1911.*

Die Fabrikation der Oellacke und Siccative. E. Stock. *Wien, 1915.*

Forscherarbeiten auf dem Gebiete des Eisenbetons. Pt. 25. *Berlin, 1915.*

Gasoline Mine Locomotives in Relation to Safety and Health. U. S. Bureau of Mines. Bulletin 74. *Washington, 1915.*

Geology and Underground Waters of the Northern Llano Estacado. University of Texas. Bulletin No. 57. *Austin, 1915.*

Handbuch der Elektrizitat und des Magnetismus, L. Graetz. Band III, pt. 2; Band IV, pt. 2. *Leipzig, 1915.*

Handbuch der Mineralchemie, C. Doelter. Bd. II, no. 8. *Dresden, 1915.*

Hazards in Handling Gasoline. Bureau of Mines, Technical Paper 127. *Washington, 1915.*

Heat Transmission Through Boiler Tubes. U. S. Bureau of Mines. Technical Paper 114. *Washington, 1915.*

History and Development of the Galvanizing Industry, 1914. *Chicago, 1914.* Gift of Arthur Worischek.

Illustrierte Technische Worterbucher, Alfred Schlomann. Vol. 12—Wassertechnik lufttechnik, Kaltetechnik. *Munchen, 1915.*

India Rubber Journal, Diary and Yearbook, 1916. *London, 1916.*

Industrial Arts Index, 1915. *White Plains, 1915.*

Industrial Nitrogen Compounds and Explosives, G. Martin and W. Barbour. *London, 1915.*

Institution of Civil Engineers. Minutes of Proceedings. vol. 200. *London, 1915.*

International Catalogue of Scientific Literature, Report on the United States Regional Bureau for the Fiscal Year endino June 30, 1915. *Washington, 1915.* Gift of Smithsonian Institute.

Jahrbuch der Wissenschaftlichen Gesellschaft fur Luftfahrt. Band III, 1914-15, pt. 2. *Berlin, 1915.*

Jern Kontorets Annaler. Register 1901-1905. *Stockholm, 1912.*

Die Kaltemaschinen und ihre Anagen, George Göttsche. ed. 5. *Hamburg, 1912-15.*

Kompendium der Rontgenaufnahme und Rontgendurchleuchtung, F. Dessauer & B. Wiesner. ed. 2. 2 vols. *Leipzig, 1915.*

Lehrbuch der Eisenhuttenkunde, Bernhard Osann. Band I—Roheisenerzeugung. *Leipzig, 1915.*

Limits of Inflammability of Mixtures of Methane and Air. Bureau of Mines, Technical Paper 119. *Washington, 1915.*

List of American Doctoral Dissertations Printed in 1914. Prepared by Alida M. Stephens. *Washington, 1915.* Gift of W. P. Cutter.

Maintenance of Way and Structures, Wm. C. Willard. *New York, 1915.*

Military Aeroplanes, G. C. Loening. *San Diego, 1915.*

Mine-Ventilation Stoppings, with Special Reference to Coal Mines in Illinois. U. S. Bureau of Mines. Bulletin 99. *Washington, 1915.*

Modern Tool Making Methods. Compiled and edited by F. D. Jones. *New York, 1915.*

Municipal Chemistry. Edited by Charles Baskerville. *New York, 1911.*

New York State Public Service Commission, First District. Proceedings vol. X, 1915. *New York, 1915.*

Origin of the Zinc and Lead Deposits of the Joplin Region, Missouri, Kansas and Oklahoma. U. S. Geological Survey. Bulletin No. 606. *Washington, 1915.*

Plain Directions for Obtaining Photographic Pictures, also Practical Hints of th' Daguerreotype. *Philadelphia, 187*. Gift of Arthur Worischek.

Principles of Locomotive Operation and Train Control, A. J. Wood. *New York, 1915.*

El Problema de la Educacion Primaria en la America Latina. Memoria presentada por Guillermo A. Sherwell. Second Pan-American Scientific Congress. *Washington, 1915.* Gift of Dr. Geo. F. Kunz.

Prospects des Harzwaldes, H. Erben. *Nurnberg, 1729.*

Public Utilities Reports, 1915—F. *New York, 1915.*

Pumpen und Kompressoren, H. Haeder. Band II, ed. 3. *Wiesbaden, 1915.*

Quarry Accidents in the United States During the Calendar Year 1914. Bureau of Mines, Technical Paper 128. *Washington, 1915.*

Die Rammwirkuno im Erdreich, Karl Zimmermann. Forscherarbeiten auf dem gebiete des Eisenbetons, pt. 25. *Berlin, 1915.*

Emil Rathenau, der Mann und Sein Werk. Artur Fürst. *Berlin, 1915.*

Reinforced Concrete Construction—Bridges and Culverts, vol. III. Geo. A. Hool. *New York, 1916.*

Rubber Machinery, Henry C. Pearson. *New York, 1915.*

Science of Works Management, John Batey. *London, 1914.*

Scientific Management and Labor, R. F. Hoxie *New York, 1915.*

Scientific Memoirs of Thomas Henry Huxley. vols. I-IV. *London, 1898-1902.* Gift of Cary T. Hutchinson.

Second Pan-American Scientific Congress. Programme of Section I, II, III, V, VI, VIII, IX. *Washington, 1915-16.* Gift of Dr. Geo. F. Kunz.

Shot Firing in Coal Mines by Electricity Controlled from Outside. U. S. Bureau of Mines, Technical Paper 108. *Washington, 1915.*

Smull's Legislative Hand Book and Manual of the State of Pennsylvania, 1915. *Harrisburg, 1915.*

Specification and Design of Dynamo-Electric Machinery, Miles Walker. *London-New York, 1915.*

Sprechsaal-kalender fur die Keramischen, Glas und verwandten Industries. VIII Jahrgang, 1916. *Coburg, 1916.*

Staffordshire Iron and Steel Institute. Proceedings. vol. XXX. *Stourbridge, 1915.*

Steam Power, W. E. Dalby. *New York, 1915.*

Stevens Institute of Technology. Annual Catalogue. 1916-17. *Castle Point, Hoboken, 1916.*

Surface Water Supply of the United States, 1913. Part I—North Atlantic Coast Basins. U. S. Geological Survey. Water Supply Paper 3514. *Washington, 1915.*

Die Technologie des Kautschuks, Rudolf Ditmar. *Wien, 1915.*

Telephone and Telephone Exchanges, Their Invention and Development, J. E. Kingsbury. *London, 1915.*

Tools, Chucks and Fixtures, A. A. Dowd. *New York, 1915.*

La Transmission Electrique de la Force entre Kriegstetten et Soleure execute par la Societee des Ateliers de Construction D'Oerlikon. Rapport by H. F. Weber. *Zurich, 1888.* Gift of Carl Hering.

Ueber den Einfluss von Gasen auf Hochprozentigen Nickelstahl, Wilhelm Forehlich. *Berlin, 1914.*

U. S. Geological Survey. 36th Annual Report of the Director. 1915. *Washington, 1915.*

Vassar College. 51st Annual Catalogue, 1915-16. *Poughkeepsie, 1915.* Gift of Vassar College.

Verzeichnis der bis ende 1912 an den technischen Hochschulen des Deutschen Reiches erschienenen Schriften, Paul Trommsdorff, *Berlin, 1914.*

Water Power Engineering, Daniel W. Mead. ed. 2. *New York, 1916.*

Water Purification Plants and Their Operation, M. F. Stein. *New York, 1915.*

Water Resources of Hawaii, 1913. U. S. Geological Survey. Water Supply Paper 373. *Washington, 1915.*

The Watthour Meter, W. M. Shepard and A. G. Jones. *San Francisco, 1910.*

GIFT OF JOSEPH STRUTHERS

Cowles Electric Smelting and Aluminum Company and Alanson T. Osborn, appellants, vs. Francis P. Lowrey, Executor of the last will and testament of Grosvenor P. Lowrey, deceased, Appellee. Appeal from the United States Circuit Court for the Northern District of Ohio. 1896.

Electric Smelting and Aluminum Company, Complainant, vs. The Pittsburg Reduction Company, Defendant. Decision of U. S. Circuit Court of Appeals, n.d.

Handbook of Japan and Japanese Exhibits at World's Fair, St. Louis, 1904, by H. Hoshi.

Kosaka Mine, Fujita & Co., description of.

Lecture upon Alumino Thermics, by Hans Goldschmidt. Nov. 13, 1903.

Manila Rope, transmission and hoisting, by C. W. Hunt. 1905.

Mining and Mechanical Enterprises of the Mitsui Firm. 1903.

Montana. Inspector of Coal Mines. 4th Annual Report. 1905.

GIFT OF AERONAUTICAL SOCIETY

The Aeronautical Society has turned over to the Library all of its Library; as soon as this collection can be listed it will be printed in detail in a future issue of this journal.

GIFT OF BUREAU OF RAILWAY ECONOMICS

Address to Boston Art Club, by Howard Elliott, Chairman of the Board. Nov. 27, 1915.

Government and the Railroads, Otto H. Kahn. Reprinted from The World's Work, Feb., 1916.

Interstate Commerce Commission and the Railroads. By S. O. Dunn. Reprinted from The Annals of the American Academy of Political and Social Science, Philadelphia, Jan., 1916.

For the Railroads. Various opinions.

Public Ownership and the Wage Earner, H. T. Newcomb, Washington, 1906.

Railway Service—Is it a National Problem or a Local Issue? An address by Frank Trumbull. Oct. 30, 1915.

Reasonable Maximum Rates, H. T. Newcomb. Reprinted from Rialway World, Dec. 27, 1907.

TRADE CATALOGUES

Alexandea Milburn Co., *Baltimore, Md.* The Wells light and heating burner.

Boston Gear Works, *Norfolk Downs (Quincy) Mass.* Catalog E 9. Boston Gears. *1916.*

Farrell Foundry & Machine Company, *Ansonia, Conn.* Bulletin—Coil Clutches; Data Sheet for Coil Friction Clutches. Bulletins: General Rubber Machinery; Rolling Mill Machinery; Rubber Mill Machinery; Shears; Sugar Cane Crushing Machinery.

Intercontintental Telephone & Telegraph Co., *New York, N. Y.* "Musso System" (Estratti di relazioni e attestati sul "Sistema Musso.") Il Telefono Sistema Musso.

Supplee Biddle Hardware Co., *Philadelphia, Pa.,* Monel metal. *Dec., 1915.*

The Sweetland Filter Press Company, *New York, N. Y.* Catalog no. 10. Sweetland Self-Dumping Filter, Clam Shell Type. Bulletin H. Sweetland Laboratory Filter for the use of Chemists and Engineers.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

OFFICERS AND COUNCIL 1916

President

D. S. Jacobus

Secretary

Calvin W. Rice

Vice-Presidents

Terms expire December 1916

George W. Dickie
Henry Hess
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Honorary Secretary

Frederick R. Hutton

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Treasurer

William H. Wiley

Chairman of Finance Committee

Robert M. Dixon

STANDING COMMITTEES

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library (not appointed)
House, William N. Dickinson
Research (not appointed)
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATIVES

Chairmen

Classification of Technical Literature, Fred. R. Low
Conservation, George F. Swain
Constitutional Convention, Charles W. Baker
Electrical Engineering Standards, Henry G. Stott
Engineer Reserve Corps, William H. Wiley
Expert Testimony Committee, Francis H. Richards

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R. Hutton
Boiler Code Committee, John A. Stevens
Depreciation and Obsolescence, Alex. C. Humphreys
Filter Standardization, George W. Fuller
Flanges for Hydraulic Work, Henry G. Stott
Increase of Membership, Irving E. Moultrop
Standards for Graphic Presentation, Willard C. Brinton
Local Sections, Elliott H. Whitlock
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Sub-Committee on Fuel Oil, Raymond H. Danforth
Sub-Committee on Investigation of the Clinkering of Coal, Lionel S. Marks
Sub-Committee on Lubrication, Albert Kingsbury
Sub-Committee on Machine Tools, Leon P. Alford
Sub-Committee on Safety Valves, Edward F. Miller
Sub-Committee on Steam Meters, R. J. S. Pigott
Spring Meeting, William B. Gregory
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

LOCAL SECTIONS

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, H. N. Dawes, W. G. Snow
Buffalo, David Bell, C. A. Booth
Chicago, H. M. Montgomery, Robert E. Thayer
Cincinnati, J. B. Stanwood, John T. Faig
Los Angeles, W. W. Smith, Ford W. Harris
Milwaukee, Louis E. Strothman, Fred H. Dorner
Minnesota, Charles W. Tubby, Quincy A. Hall
New Haven, H. B. Sargent, E. H. Lockwood
New York, H. R. Cobleigh, John P. Neff
Philadelphia, Emmett B. Carter, Wm. R. Jones
St. Louis, Edward Flad, Geo. R. Wadleigh
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the February 1916 issue of The Journal.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

Arranged in the Order of their Appearance in the Survey.

Aeroplane Engines in Italy.
Aeroplane, Mechanics of Flight.
Aeroplane, Stabilization.
Dust, Transport of.
Semi-Steel.
Crystal Twinning by Strain.
Tesse Rotary Cylinder Motor.
Aluminum Alloy Pistons.
Drills, Cutting Speed.
Drills, Lubrication.
Threading, Methods of.
Vertical Pressure through Sand.
Balancing of Rotating Machine Parts.
Lavaczeck Process of Balancing.
Boiler Corrosion.
Water Softening by Lime and Soda.
Steam Turbine Condensate as Feed-water.
Draft Gages on Oil-Fired Boilers.
Equations for Ammonia.
Engineering Charts.

THE solution of one engineering problem usually leads to the creation of another one, which in its turn is solved sooner or later by the ingenuity of "mechanical men," as engineers are still sometimes called by laymen. A good case in this connection is that of the balancing of rotating masses. The high speed electric generator and motor, the steam turbine, turbo-blower, centrifugal pump, etc., have made the question of proper balancing of rotating machine parts far more important than it has ever been before, and its proper solution leads sometimes to results of considerable importance. In the present issue an abstract of an article on the proper balancing of rotating machine parts is given, describing among other things the Lavaczeck system of balancing, which is claimed to permit of obtaining a theoretically perfect balancing and appears to be of great sensitiveness.

THIS MONTH'S ABSTRACTS

In the section Aeronautics, are described aeroplane engines built in Italy. In this connection attention is called to an article in *Flight* (Vol. 8, No. 2, page 40, Jan. 13, 1916, and following) describing a 160 h.p. Mercedes engine found on a captured German aeroplane. The question of the material employed in the construction of the engine has not yet been fully established, but as to the design, several figures are shown illustrating the engine. The bottom half of the Mercedes base chamber is shown as seen from above. Centrally at top is seen the air intake to the carbureter which leads from two apertures in the wall of the casing to the other side. Very long steel bolts support the bearings. A detailed sketch of the partition walls housing the half bearings of the crank shaft in the top half of the base chamber is likewise shown. In the connecting rod of the engine the perforated floating sleeve rides between the small end and the gudgeon pin. On the whole it appears that the parts are of quite robust proportions and generous weight, and it is by careful and scientific disposition of the metal that the remarkable result obtained has been made possible in the case of the crank chamber. The shell itself is extremely thin, but is made very rigid by the manner in which it is braced. In the lower half there is a double bottom running nearly the whole length of the space enclosed by forming the oil sump. A series of exterior longitudinal fins below the casing not only give stiffness but also serve as radiators for cooling the oil. By the way, another duplication of duties is seen in the manner in which the air to the carbureter is also made to cool the oil and in doing so to become itself warmed as an aid to good carburetion. To this end the sump does not occupy the full length of the casing but really forms two compartments in the double bottom, one in front and one in the rear, connected together by a large diameter tube. Around this tube and between the adjacent end walls of the two compartments all the air to the carbureter has to pass, there being apertures cut in the side of the crank case that lead to the carbureter situated on the other side of the engine. This is an arrangement, however, the advisability of which is doubtful. The transverse end passages form a ready receptacle for the accumulation of gasoline drippings and also for oil leaks. Should a back fire occur in the carbureter, the vapor in the passage is liable to become ignited and to set fire to the oil and not unlikely to the machine itself.

Of further interest to aeronautical engineers may be a somewhat general article in *L'Aerophile* (Vol. 23, No. 23-24, page 266, Dec. 1-15, 1915) on the various shapes of floats for seaplanes. The article brings out the important fact that while an ordinary boat with its single floating element has to maintain stability in all the three respects, that is, longitudinal, lateral, and of motion, the avion is in itself, from a static point of view, extremely stable laterally. It has also a good stability of motion, while the longitudinal stability is maintained by the little tail float as well as by the volume of the main float being ahead of the center of gravity. In addition to that, as soon as the aeroplane has acquired a certain amount of velocity, the longitudinal stability of the air part of the machine stabilizes the entire system. Hence, the question of stability becomes really secondary from the point of view of design of the machine.

In the same section is briefly abstracted a paper on the aeroplane, being a general discussion of the aeroplane with special regard to mechanics of flight and stabilization.

The transport of material in the form of dust, with particular application to handling arsenical soot, is discussed in an article abstracted from the Journal of the Society of Chemical Industry.

In the section Engineering Materials is an interesting discussion of the subject of semi-steel, taken from a paper read

before the Lancashire Branch of the British Foundrymen's Association. The paper discusses various troubles in the production of semi-steel and methods of obviating them. Judging by the data of the paper, semi-steel does not possess much promise of further development.

The paper on crystal twinning by direct strain presents data of an investigation of apparently a very difficult subject.

The Tessé rotary cylinder motor is described in the section Internal Combustion Engines. Its essential feature is the method of locating the connecting rods and conecting them to the disc.

A discussion of the subject of aluminum alloy piston, with special reference to the Cothias type, is given from a paper before the Society of Automobile Engineers.

The same Society, by the way, in the January, 1916, issue of the *Bulletin*, publishes a report of its Metropolitan Section Research Committee on automobile engine governors, mainly with reference to their use on motor trucks. The various classes of types of governors for the internal combustion engine are tentatively listed as follows:

1—Hit-or-miss, inlet valve closed or exhaust open, so causing engine to miss one or more power strokes.
2—Inlet valve control, time of opening or closing inlet valve varied.
3—Ignition control, ignition spark omitted.
4—Quality of fuel, lean or recharged.
5—Quantity of fuel, throttling charge.

The only type for consideration in automobile practice is said to be the quantity of fuel type which controls the fuel supply after the fashion of the steam engines that throttle the steam on its way to the engine. In the automobile, the throttling is usually accomplished by a damper or other balance valve placed in the intake pipe. The governor operation may depend on the speed of either the engine or the vehicle. In the engine speed type, the maximum speed of the engine is fixed and its racing prevented. In the vehicle speed type, the full horse power output of the engine can be obtained for low gear work when it is desirable or expedient that the engine be forced to do its utmost. In one device on the market these two control methods have been combined.

The report describes four classes of governors, Centrifugal, Hydraulic, Inherent Design, and Gas Velocity in Intake. Some data on governor drive and other details are presented.

In the section Machine Shop will be found an abstract of an article giving a formula for the cutting speed of twist drills, derived from experimental work on other cutting tools. In the article itself an alinement chart is also given to express the relations of the formula.

In the same section is given an abstract of an article by P. W. Abbott representing a study in the various elements entering into the production of good threads, external and internal. Among other things the writer insists that the choice of lubricant is of secondary value and the importance often attached to it is due to the use of taps and dies which do not cut but push or force the metal off and out of their way. If the tools are actually cutting, all that is needed is something to keep the work and tools cool.

In the section on Mechanics are described experiments made to determine the distribution of vertical pressure transmitted through sand. In another abstract is discussed the problem of balancing of machine parts referred to briefly above. Another paper, this time in Lumière Electrique, on the same subject, has been received too late for publishing an abstract of it in this issue.

The subject of boiler corrosion is discussed in two papers. That by John C. B. Kershaw takes up the subject generally, with special reference to methods of accumulation of dissolved salts in feed water. The other article, by M. R. Schulz, takes the subject up from the point of view of utilization of water of condensation from steam turbines for boiler feeding and conditions under which oil and impurities may be present in boilers fed in this way. A point which both writers emphasize is that water which could be safely used for boilers operating at pressures and temperatures in general use some 10 or 15 years ago may become corrosive in their action at the high steam pressures and temperatures now in use. Equations for ammonia based on new experimental material are presented by Fred G. Keyes.

Attention is called to a list of charts at the end of the Engineering Survey. The use of charts for facilitating various calculations is rapidly increasing and an endeavor will be made to list such as are of interest to mechanical engineers.

Aeronautics

Aeroplane Engines in Italy, W. F. Bradley

Data on the progress of construction of aeroplane engines in Italy, and some data on the development of automobile machinery.

An interesting tendency is shown by the change from the pump to the thermosyphon method of cooling. It is admitted that it is a difficult task to produce a thermosyphon cooled motor which will be satisfactory both on the hot plains of Italy and in the Alpine passes, but it is claimed that with careful design and such good foundry work as they can produce in Italy, the pump can be abolished.

At the Chiribirri factory the writer was shown a 40 h.p. aviation motor with aluminum cylinders and cast iron liners built in 1912 and flown in that year. The paper shows also a fixed six cylinder aviation motor built by the same concern. Fiat is at presented interested in the six cylinder vertical water cooled type with inclined overhead valves and a single overhead cam shaft. The cylinders are of steel, separate, with a sheet steel water jacket common to the cylinders in pairs. Lancia is building twin sixes with horizontal valves. The Diatto Co. has taken up the Bugatti aviation motor which has six separate steel cylinders welded together and surrounded by a copper water jacket. There are four vertical valves per cylinder with a patented mechanism by which a single cam operates direct on a pair of valves. As in France, it is expected that the aviation motor will tend to bring the twin six motor into greater prominence and assist in its adoption for car work. (Italy Developing Aeroplane Engines, *The Automobile,* vol. 34, no. 4, p. 182, January 27, 1916, 3 pp., 3 figs. *d.*)

The Aeroplane, L. Goldmerstein

A general discussion of the aeroplane with special regard to mechanics of flight and stabilization.

The author pays particular attention to disturbances in stability due to air gusts and variation in the direction and strength of the wind. All of the stabilizing systems are based on the principle that when a machine gets out of equilibrium, some of its component parts such as ailerons, fins or tiller, will in some way be moved to such an angle as to cause the machine to return to its original position. The operation of all stabilizers is based on the assumption that the machine is fly-

ing or moving through the air at a certain speed. But when Wilbur Wright went up in the air about 300 ft., stopped his engine and then tried to operate it, he found that with the engine still the controls were absolutely useless, so that (as his brother expressed it) he "fell down 200 ft. in a time too short to be comfortable." All stabilizing devices are effective only when the machine maintains a certain speed.

Another point which the author takes up is the relation between stability and transient stresses on the machine. The aeroplane is subjected all the time to puffs of the wind and as the gusts are applied for extremely short periods there will be a blow on the plane practically every time the wind changes. That is one of the reasons why monoplanes have been practically discarded, as their wings are apt to collapse. For example the German Taube which is a modified Ettrich monoplane has been almost entirely discarded and biplanes substituted for it. The Taube was wonderfully stable and its stability was its undoing, for instead of giving way under gusts of wind, it opposed them, and such excessive transient stresses were produced that the machine collapsed. (*S. A. E. Bulletin*, vol. 9, no. 3, p. 166, December 1915, 12 pp., 4 figs., *t.*)

Conveying

The Transport of Material in the Form of Dust, T. C. Cloud

Discussion of the removal and transport of very fine material, such as, for example, dust from the flues of a set of Lancashire Boilers, or of impalpable powders produced in large quantities.

In a case with which the author had to deal, furnaces were producing a gas highly charged with arsenious oxide. This was to a large extent deposited in a complicated system of condensing chambers and flues followed by filtration through bags in a bag house. The points at which it was necessary to remove the arsenious oxide from the bag house flues, etc., were numerous, and it was also necessary to deliver all the material to the packing room where it could be packed in casks for marketing. After some experimentation a vacuum plant, of which the following is a description, was designed:

The vacuum pump at normal speed of 160 r.p.m. has a displacement of 20,000 cu. ft. per hr. and will produce a vacuum of 18 in. of mercury if all valves to the various branch mains are closed. In the packing house the pipe main enters a cyclone separator in which the bulk of the arsenious oxide is deposited. Following this is another small separator. Finally the air is drawn through a shallow layer of water and then passes to the vacuum pump. The cyclone separator has a small storage capacity, and the arsenical soot is automatically removed from this apparatus and discharged into the casks placed below. The smaller separator is furnished with baffle plates and a collecting receptacle from which the deposit is only discharged at long intervals when the vacuum is off. The water separator is arranged so that a small continuous supply of water can be passed through it, or it may be charged and discharged intermittently.

In the piping about the works all bends and entering branches are of large radius, and for moving the material upwards all vertical members are avoided and inclined pipes substituted. At numerous points capped branches are arranged, to which, on the removal of the cap, suitable flexible hose, either metallic or reinforced rubber, can be attached. A suitable nozzle is fixed on the end of the hose, and on inserting this into the accumulated deposit the latter is immediately sucked up and conveyed to the separating plant.

This plant having an air pump capacity of 20,000 cu. ft. per hr. deals with 1½ to 2 tons of collected arsenious oxide per hr., and the farthest point at which a branch is situated is about 200 yd. from the separator. The pump in this instance is electrically driven, working at the rate of 12 to 14 h.p. It has been found that all annoyance caused by the handling of this material is removed and respirators are superfluous. (*Journal of the Society of Chemical Industry*, vol. 35, no. 1, p. 7, January 15, 1916, 2 pp. *d.*)

Engineering Materials

Semi-Steel, J. E. Hurst

The article represents a paper read before the Lancashire Branch of the British Foundrymen's Association. It appears that the most important difficulty in the production of semi-steel is that of maintaining a uniform content of carbon in the melting. At first sight the mechanism of the melting of steel in the cupola is apparently simple. Steel heated in contact with carbon or coke especially in an atmosphere containing carbon monoxide absorbs carbon as the carbon content of the steel increases or the melting point of the steel decreases, until finally the melting point of the steel in the cupola is gradually reduced to a figure within the temperature range of the cupola.

There are, however, several points which complicate this simple looking process. In the first place the effect of temperature on the absorption of carbon is very often misunderstood. It must be remembered that the higher the temperature the more rapid the absorption of carbon by steel. Moreover this absorption of carbon is not an instantaneous action but requires a certain amount of time, the length of time required being in its turn largely dependent on the temperature which establishes the relation between time and temperature. From a practical point of view it is important to bear in mind that the cupola method of melting offers no practical means of controlling such variables as time and temperature, with the result that the chemical composition and particularly the carbon content, on which the whole of the properties largely depend, cannot be uniform.

In a blow the first charge comes in contact with the hot coke long before the subsequent charges, hence as far as the carbon content is concerned it is not necessarily of the same composition. Further, the character of the steel scrap, the manner in which it is charged and in which it sinks down in the sack, all tend to influence the carbon content in various ways. Even after the steel has passed the melting zone, the absorption of carbon is not finished, for the metal drops down amongst the bed coke and there continues to absorb carbon.

The following experiment has been made in this connection. A charge consisting of hematite and cold blast pig, together with 20 per cent of steel scrap in the form of turnings and borings was charged into the furnace, and the blast turned on. Five minutes afterwards a small clay laboratory crucible was introduced into the cupola at the end of a steel rod inserted through a tuyere hole. The drops of molten metal caught by the crucible were withdrawn and a further sample taken. The analysis of the two samples together with that of the final metal are given in Table 1. The two samples taken were quenched in water, with the result that the carbon was all in the combined form. The steel borings portion of the charge was put in first and consisted of steel of about 0.25 per cent C.

The difficulty of obtaining perfectly homogeneous cast iron has led to the introduction of mixtures of pig iron and known percentages of steel, which are recommended for the production of castings. This method has been largely used in Germany and finds a parallel in the British manufacture of pig

plate, but even with the method it should be remembered that any mixture of cast iron, the carbon content of which is not the eutectic percentage for the given composition, will, on being melted in contact with carbon as in the cupola, absorb carbon to a greater or lesser extent according to the particular conditions of the cupola. The only remedy for this defect of semi-steel is to adopt some plan similar to the mixer in steel manufacture, or better still to melt in furnaces so designed that the metal is not in contact with carbon.

The author points out the essential difference between semi-steel made by the addition of steel in the cupola and that made by the addition of steel to molten iron in the ladle. However, even in semi-steel of the latter type it is necessary that the metal be well stirred.

Regarding the casting of semi-steel mixtures there seems to exist a large amount of uncertainty and contradiction, some of which may be due among other causes to the influence of the casting temperature. As far as the writer's experience goes, semi-steel can be cast exactly as any other cast iron with the same chemical composition, but stirring is practically the only way of insuring homogeneity of semi-steel mixtures. Small minute pin holes are a serious trouble which occurs

TABLE 1 ANALYSIS OF TWO SAMPLES OF SEMI-STEEL

	Sample 1	Sample 2	Final Metal
	Per cent	Per cent	Per cent
CC	2.50	2.94	0.86
Gr	....	....	3.07
Total C	....	....	3.93
Si	1.21	1.59	1.63
Mn	not estimated	not estimated	0.48
S	not estimated	not estimated	0.085
P	0.73	0.74	0.66

very frequently in semi-steel; the author has personally experienced this trouble, especially in high percentage steel mixtures (30 per cent and 40 per cent), and furthermore the trouble was accentuated in those castings in the mixture of which solid steel scrap was used. The author is of the opinion that the Fe_2O_3 oxide cannot exist in the cast iron in the presence of high silicon, and that pin holes are caused not so much by direct oxidation as by excessive gas absorption and local defects. The use of ferro-manganese as a deoxidizer is unnecessary, but aluminum in small quantities is undoubtedly beneficial.

Hard spots constitute another serious trouble in connection with semi-steel, but they are also common in castings without steel, especially low silicon iron. The mechanical strength of semi-steel is claimed to be from 20 to 30 per cent above that of ordinary cast iron; tests made by the author do not, however, show very high increase in tensile strength.

In all the author comes to the conclusion that the mechanical properties of semi-steel vary, and that the steel itself may conditionally be partly responsible for this change in the mechanical strength; but the conditions are of such a complex and uncontrollable nature, that cupola melted semi-steel must be considered a failure when considered from the standpoint of those who urge the wonderful results of this product. However, semi-steel possesses excellent wearing properties. What the author believes is that the only effect of steel in the mixtures is to reduce the silicon and phosphorous, thus making a cheap substitute for the somewhat costly hematite and cold blast irons. The true object of semi-steel mixtures is undoubtedly attained in the mixtures of steel and cast iron made in the ladle, the practical objection to this method being that the temperature of the metal is greatly lowered, and therefore high percentage steel mixtures are not possible by this method. Two methods are suggested to overcome this difficulty. One is to melt the cast iron in a reverbatory or a regenerative furnace, and then add the steel scrap to the molten cast iron. The other method recommends placing the steel scrap, preferably in the form of punchings or turnings previously heated to a red heat, in the bottom of the ladle. Into this ladle is tapped the heated cast iron from the cupola and in the metal is immersed a can of thermit. The reaction which ensues provides sufficient heat to rapidly melt the steel scrap and maintain the temperature of the whole metal. None of these methods, however, possess the peculiar advantages of the cupola method of melting, which are cheapness, economy, speed, and adaptability. (Lancashire Branch of the British Foundrymen's Association, through *The Foundry Trade Journal*, vol. 17, no. 168, p. 657, December 1915, 5 pp., 3 figs. *ep.*)

Crystal Twinning by Direct Strain, C. A. Edwards

Data of an investigation made to determine whether structural changes in metals can be produced without subjecting the mass to an annealing operation. The conclusion is drawn

Fig. 1 Multiple Twinning in Tin Showing Change of Direction in Certain Twins Passing Through Others —Unetched and Magnified 150 Diameters

that acicular markings, or markings having sharp points like needles, formed on tin and zinc are actually twin crystals and not mere surface appearances.

The difficulty of the investigation lay in the fact that the lightest rubbing on the finest emery has the effect of completely changing the structure of tin and zinc for a considerable depth below the surface. If, however, the upper layer of broken up crystals or amorphous material is dissolved off by immersing the specimen in strong acid, and the surface again polished on chamois leather, the structure can then be developed by ordinary etching. By working in this way it was possible to obtain the evidence required to demonstrate that twin crystals are produced when tin and zinc are strained.

Microphotographs taken in the course of the investigation show the abrupt change in direction of the so-called slip bands as they pass through the markings under discussion, and are further proof that the latter are twin crystals. Fig. 1 is still more significant, because it shows a similar change in direction of certain twin crystals as they pass through twins which cannot be explained in any other way.

Regarding the mechanism of the formation of twin crystals

in metals by direct mechanical change, the author attributes the increased hardness of the metal to the increased kinetic energy at the disturbed surfaces, and asks whether crystal twinning involves external movement of a kind which will produce the amorphous layers. He believes that rotation, which occurs in twinning as affected by the fact that the twinning planes are not perfectly smooth but consist of numerous rectangular projections, must cause a crushing or breaking up of the crystalline material on those surfaces.

The facts which have been observed in connection with the twinning of zinc and tin indicate that the rotation does not proceed *en masse* in a simple manner. The units which go to form twin lamellae cannot retain after twinning the same relative position to each other as they did before the twinning rotation took place in the individual units or small groups of such units; and since a movement of this kind must cause a further grinding between the units or groups of units inside the twin lamellae, the amount of amorphous matter or distortion of the space-lattice produced during mechanical crystal twinning must be a maximum. (*British Institute of Metals*, through *The Iron Trade Review*, vol. 58, no. 6, p. 341, Feb. 10, 1916, 5 pp., 13 figs.)

Internal Combustion Engines

Tessé Rotary Cylinder Motor

In radial rotary cylinder motors the coupling of the connecting-rods of the pistons is usually defective because only the foot of the principal or primary connecting-rod describes a circle. The feet of the other connecting-rods being pivoted or jointed on journals or trunnions in rigid connection with the first, describe dissimilar curves and with a non-uniform movement. This causes detrimental inertia stresses due to variations of velocity of the feet of the secondary connecting-rods. The obliquity of the secondary connecting-rods being much greater than that of the principal connecting-rod, the reactions of the pistons on their cylinders are greater. The functions of the various cylinders do not occur during the same angular periods. Also as the principal connecting-rod is reinforced a balance of the system of connecting-rods coupled to the crank is not possible. In the case of connecting-rods coupled to the crank by means of curved slippers or ends, the large number of connecting-rods usually employed in motors of this kind renders it compulsory to reduce the width of the slipper of each connecting-rod foot to such dimensions that the least defect of adjustment or lubrication causes heavy wear or even gripping of the shoes.

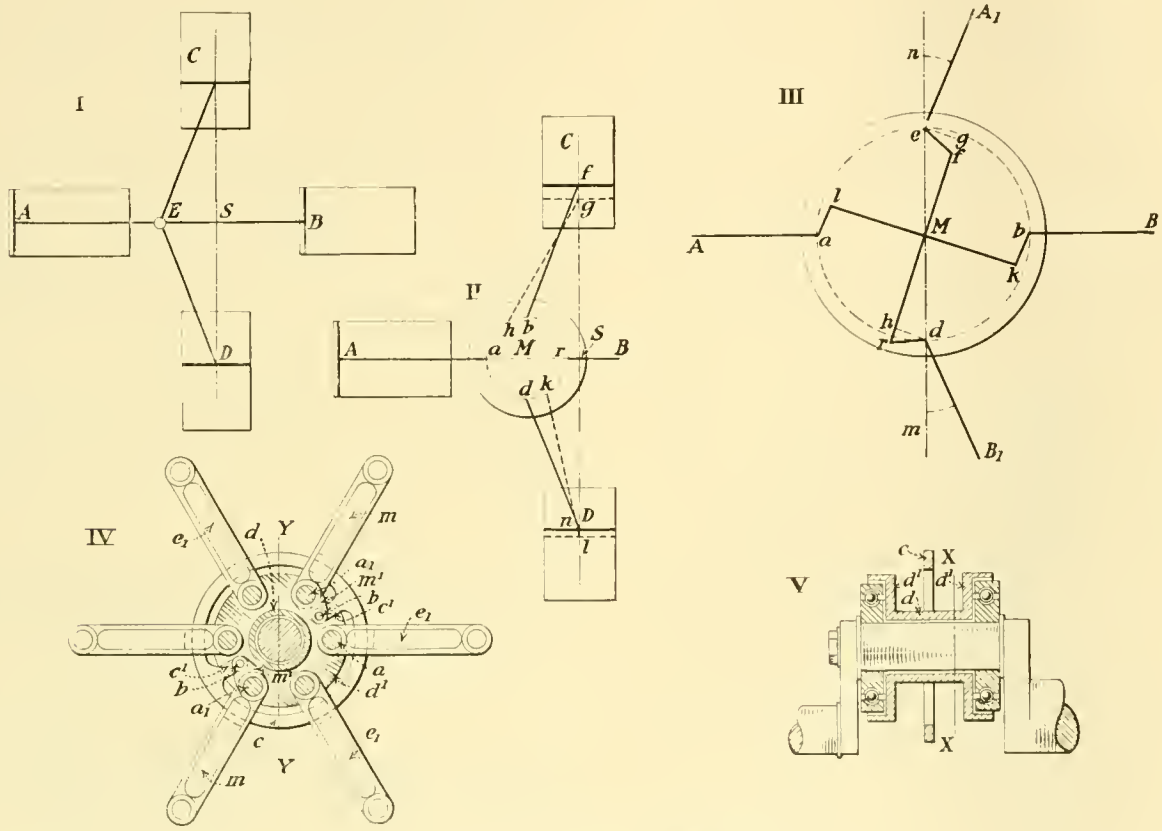


Fig. 2 Tessé Rotary Motor

Fig. 2, I shows an engine of the Tessé system with four cylinders rotating about the fixed centre S, the ends of the connecting-rods being attached to the fixed crank E. Because of the eccentric position of E with respect to the circle of rotation of the cylinders, the pistons A, B, C, D will move in their cylinders exactly as they would supposing the cylinders fixed and E rotating as a movable crank around S. For uniform motion the pistons would execute in the cylinders simple harmonic vibrations varied slightly by the obliquity of the connecting-rods.

With a large number of cylinders it is inconvenient to connect all the rods to the single crank-pin E, but if the crank-pins are distributed around a disc as shown in Fig. II the fixing is much simpler and the motion of the pistons much the same as before, provided that the disc rotates about its own centre M at the same rate and in the same direction as the cylinders. If the disc, however, is simply free to rotate about its fixed centre M, then the connecting-rods and pistons are not completely constrained; that is, for any given position of cylinder C the connecting-rod may be in any posi-

tion, $b\ f$ or $g\ h$ (Fig. II), the corresponding positions of the connecting-rods of cylinder D being $d\ n$ or $k\ l$.

It is necessary, therefore, to arrange links connecting the cylinders with the disc so that the latter is driven around at a uniform rate with the rotating cylinders. In the Tessé rotary cylinder motor this is achieved by making bell-crank levers of two connecting-rods driving the disc. These are shown as $B\ b\ k$ and $A\ a\ l$ (Fig. III) hinged to the disc at the points b and a on opposite ends of a diameter of the disc. The ends $k\ l$ of these bell-crank levers are connected by a coupler $l\ k$. The positions of the connecting-rods and coupler after the cylinders have turned through an angle of 90 deg. are shown at $A_1\ e\ f$ and $B_1\ d\ r$ respectively. In this position it will be seen that the connecting-rod $B_1\ d$ is no longer collinear with a diameter of the disc, but has turned through an angle $B_1\ d\ m$ relatively to it. The arm $r\ d$ has also turned through an equal angle $h\ d\ r$ relatively to the disc, and this angle is practically equal to the angle $g\ e\ f$ through which the coupler has pulled the arm $e\ f$ of the other connecting-rod $A_1\ e$. It is plain, then, that the angle $A_1\ e\ n$ through which the connecting-rod $A_1\ e$ has turned relatively to the disc is equal practically to the angle $B_1\ d\ m$.

Fig. IV, is a section of the connecting-rod system on X-X Fig. V, and Fig. V is a section on Y-Y, Fig. IV, with the connecting-rods omitted; $m\ m^1$, $m\ m^1$ represent the principal or master connecting-rods, which are formed as bell-crank levers, and $e_1\ e_1\ e_1$ represent secondary connecting-rods for the other cylinders. In the example shown two principal connecting-rods are employed to drive the disc d^1, but any even number may be employed. All the connecting-rods, principal and secondary, are analogously jointed or pivoted at $a_1\ a_1\ a_1$ on a central hub member d, which is itself mounted through the medium of ball bearings on the crank-pin. The pivot pins a are mounted in and lie between the inside faces d^1 of the crank hub d and the pivoted ends of the connecting-rods e and $m\ m^1$ are forked, the limbs passing on each side of the ring or connecting member c and being pivoted on the pins a. The two principal connecting-rods are mechanically connected together by a ring c (the coupler), to which their short arms $m^1\ m^1$ are pivotally attached by pins or trunnions $b\ b$ passed through these forked short arms, and through inwardly projecting arms $c^1\ c^1$ of the ring c, but not into the faces d^1 of the crank hub. (*The Practical Engineer*, vol. 53, no. 1506, p. 4, Jan. 6, 1916, 2 pp., 5 figs. *d.*)

The Aluminum Alloy Piston, James E. Diamond

The author discusses the problem of the aluminum alloy piston and considers certain phases of piston design.

The coefficient of friction of an aluminum alloy suitable for pistons is about 50 per cent of that of cast iron. Because of the greater heat conductivity of the aluminum alloy piston, under favorable lubricating conditions very little, if any, carbon is deposited. In case an aluminum piston seizes it is damaged only in rare cases and the cylinder is practically never injured.

Permanent mold pistons are considered superior to sand cast, being 25 per cent harder and having a tensile strength ranging between 25,000 and 30,000 lb. per sq. in. Further, they can be ground quite well with kerosene which is a suitable grinding medium.

The design of aluminum alloy pistons can follow closely that of iron pistons but it is advisable to rib the head to better carry heat away from it, eliminating the possibility of a gradual deterioration of the metal through being subjected to a high temperature for a long time. Wherever possible, it is wise to increase the length of the piston, possibly as much as 25 per cent.

The author believes that the prejudice against the "hour glass" type of piston is gradually disappearing, and it was mainly this that stood in the way of commercial introduction of the Cothias process of piston manufacture. (*S. A. E. Bulletin*, vol. 9, no. 3, p. 177, December 1915, 5 pp. *p.*)

Machine Shop

Effect of Feed and Diameter on Cutting Speed of Drills, A. Lewis Jenkins

The article gives a formula for the cutting speed of twist drills derived from experimental work on other cutting tools. This formula gives the speed of cutting in terms of the drill diameter and feed, in addition to which a certain constant is used. An alinement chart is also given to express the relations of the formula.

The cutting speed is a function of two variables, the feed and the diameter. When the feed is constant the cutting speed, increases, according to the formula of Taylor, with the diameter. It has been generally observed that for a given drill working in a material the cutting speed may be increased when the feed is decreased, and vice versa. The feed is directly proportional to the thickness of the chip as already shown by Taylor.

The author from data furnished by the experiments of Taylor, Nicholson, Lindner, Herbert and others, expresses the relation between feed and cutting speed for drills working on cast iron, steel and brass, with a fair degree of accuracy by the equation

$$V = \frac{constant}{t^{0.24}} \quad \ldots\ldots [1]$$

where t is the feed in inches per revolution, and it was further found that the relation used when the cutting speed is constant for all diameters is represented by the formula

$$t = \frac{d^{1/3}}{K} \quad \ldots\ldots [2]$$

where K is a constant depending upon the material drilled, the shape and construction of the drill, and whether it is made of high-speed or carbon steel. The author gives the following table of values of factor K in the above formula:

Kind of Drill	Cast Iron	Hard Steel	Medium Steel	Soft Steel	Brass
High-speed	80	115	125	140	105
Carbon	64	92	100	112	84

The following equation is obtained by combining equation [1] with another equation derived from the Taylor equation for the cutting speed of a drill

$$V = constant \times \frac{d^{0.92}}{t^{0.24}}$$

from which the revolutions per minute are expressed by the equation

$$N = \frac{C}{d^{0.92} t^{0.24}}$$

where C is a constant depending on the work, the drill and the feed.

A chart is given for graphically solving this equation. This chart also shows the feed in inches per minute when the revolutions per minute and feed in inches per revolution are known. The author remarks, however, that for a given class of work it is necessary to do more or less experimenting in order to find the best feeds and speeds to use and after these have been determined, it is not always possible to get them from the machine. (*American Machinist*, vol. 44, no. 4, p. 152, January 27, 1916, 3 pp., 1 fig., ep.)

On Methods of Threading, P. W. Abbott

The article presents a study in the various elements entering into the production of good threads internal and external.

The author insists that just as accurate work can be done in machining threads as on plain cylindrical work, at no greater cost than poorly cut threads and without the necessity of any hand work. The taps and dies must, however, be correct and the author does not believe that accurate work can be done with the commercial taps and dies sold by the tap and die manufacturers at the present time.

He recommends the following specification: The threads in dies shall be burnished smooth after hardening to remove the hardening scale and to correct the lead. After this the dies shall be ground on outside diameter and on both sides true with pitch diameter. That means that they shall be ground from the thread itself. The die should be 0.005 in. over-size on pitch diameter and should cut a thread whose lead will not vary over 0.002 in. either way, in 1 in. Taps should be straightened after hardening to be within 0.002 in. on the pitch diameter and to show correct for lead within 0.002 in. either way, in 1 in.

The author recommends the use on threaded or tapped work of roughing and finishing cuts when necessary. Accurate threads cannot be tapped in one cut either by hand or machine, but they can be tapped with the use of roughing and finishing taps, the roughing tap being 0.010 in. smaller than the finishing tap. On large work of say 12 pitch, two dies should be used, a rougher and a finisher.

The choice of lubricant is of secondary value and the importance often attached to it is due to the use of taps and dies which do not cut but push or force the metal off and out of their way. If the tools are actually cutting, all that is needed is something to keep the work and tools cool, and the correct method is to direct oil under pressure through the threading spindle and out of the front or cutting side of the die, preventing chips from getting into the die and holder to clog and damage the die and threads.

As to lead, the author believes that the only thing that affects lead is the tools doing the thread cutting and to know what kind of lead one gets, means must be provided for measuring it. The saw-tooth gages will show whether the lead is good or bad, but not *how* good or *how* bad. Hence there should be in every department cutting external threads, a lead-testing fixture (usually reading the lead in thousandths).

Threading on multiple spindle automatics should not be done at an excessive speed, and it is very necessary that the proper size of tap drill or boring be used for each size of hole to be tapped.

The quality of stock materially affects results since if it varies in hardness the threads will vary also, due to the spring of the dies. Therefore stock should be purchased to exact analysis and Brinell hardness within reasonable limits for both the bar stock and forgings.

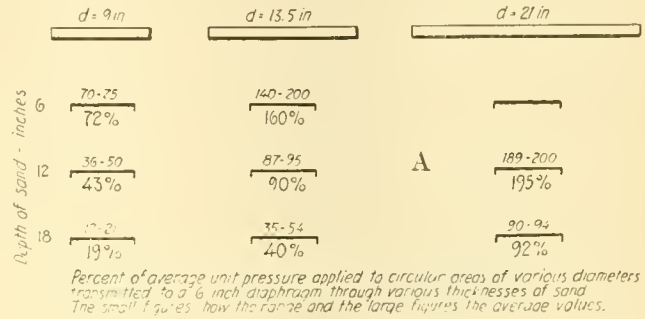
The author discusses also the desirable limits of actual work and the alinement of tools. (*What's the Matter with Our Methods of Threading?* P. W. Abbott, *American Machinist*, vol. 44, no. 4, p. 173, January 27, 1916, 3 pp. *p*).

Mechanics

Experiments on Distribution of Vertical Pressure through Sand, Prof. Melvin E. Enger

Description of experiments made to determine the distribution of vertical pressure transmitted through sand. These experiments were carried on at the University of Illinois, and thesis work by several students and more elaborate experiments along the same lines have been planned at the same University by the Joint Committee on Stresses in Railroad Tracks.

Experiments were made with depths of sand of 6, 12 and 18 in., the sand being thoroughly compacted before taking readings. In order to determine the effect of the size of the area loaded upon the way the pressure is transmitted through the sand, the load was applied to plates 9 in., 13½ in. and 21 in. in diameter, and measured with a 6 in. diaphragm of packing rubber. In these experiments the center of the diaphragm was directly below the center of the plate to which the load was applied, and as shown by Fig. 3A, the size of the loaded area has an important effect upon the proportion of the ap-



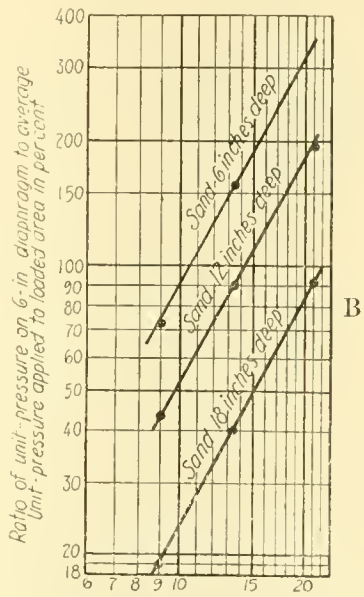


Fig. 3 Distribution of Vertical Pressure Through Sand

A, Results of Tests Concerning Effect of Size of the Area Loaded upon the Way the Pressure is Transmitted through the Sand; B, Curves Showing Relation between Diameter of Loaded Area and Load Transmitted to 6-in. Diaphragm

plied average unit pressure transmitted through sand of a given depth to the diaphragm. In these tests the 21 in. plate carried loads up to 18000 lb., the 13.5 in. plate up to 9000 lb. and the 9 in. plate up to 2500 lb.

Fig. B gives curves showing the relation between diameter of loaded area and load transmitted to 6 in. diaphragm. In it parallel straight lines pass through the points plotted for each given depth of sand. From the slope of the lines it is found that the proportion of the applied average unit load which is transmitted through sand of a given depth to a diaphragm directly below varies as the 1.86 power of the diameter of the loaded area.

In the experimental work the diaphragm has been found to be a less satisfactory method for measuring the transmitted pressures than the method of weighing the load on the plug.

The reason is that the diaphragm becomes distorted when load is applied, the center being depressed and the outside portion raised by the water pressure; and the distortion increases with the repetition of the load. So much trouble was experienced with the bursting of the diaphragm that it could not be used for off center loads or thin layers of sand.

For the relation between the intensity of pressure directly below the center of the loaded area to the applied average unit load, the following equation was found:

$$p = 91 \frac{d^{1.93}}{h^{1.98}}$$

in which p is the ratio expressed as per cent which the intensity of the transmitted pressure at a point h, 8 in. directly below the center of the loaded area bears to the average applied unit load, and d is the diameter of the plate in inches. This equation represents roughly the results of the experiments, and it is not probable that it has a general application.

Curves are given showing the intensity of the transmitted pressure at different distances from the center line of the applied load in terms of the applied average unit load, as determined by experiments in which the transmitted pressure was measured by the 4 in. plug. Another set of curves gives the results of experiments showing lines of equal vertical pressure in the sand below the plate. The region below the center of the load is one of high pressure, and the diagram shows the manner of the distribution of the vertical pressure at different depths and different distances from the axis of the load. Among other things, it is seen that the pressure in horizontal planes is far from uniform. (*Railway Review*, vol. 58, no. 4, p. 129, Jan. 22, 1916, 4 pp., 12 figs. *e.*)

Balancing of Rotating Machine Parts, E. Heidebroek

The problem of the proper balancing of rotating parts of machinery became all the more important with the increases in the speeds at which machine parts are operated.

In the simplest way this problem is presented in the case of disc shaped bodies of limited extension axially, since, when the center of gravity of the rotating body is located not on the axis of rotation but at a certain distance from it, it is usually possible to place an additional mass at such a distance on the opposite side of the axis of rotation as to effect a static balancing. To do this methods of determining the so-called static balance may be used, of which there are several. It must be, however, borne in mind that at least some of the processes of determining this static balancing are affected by the rolling resistance between the body and its supports which the article discusses in full.

In order to increase the sensitiveness of the process of determination of static balancing, the axis of the balanced body is placed on movable lineal supports, for example, on wheel rims having knife edge tires. Such wheels are supported so as to be easily rotatable, and since the rolling resistance on the periphery acts on the lineal support tangentially, it has, in reference to the center of the disc, a comparatively long lever arm and will make the disc rotate even if it is very small in itself. Fig. 4A shows the Lebert apparatus for the determination of static balance. This apparatus is so sensitive that it will show an eccentricity of the center of gravity as low as 0.07 mm.

A similar purpose may be served by the so-called pendulum apparatus of which several are shown in the article. In this the body is suspended free to exert pendular motions so that the center of gravity of the entire aggregate must finally take a place exactly under the point of suspension. So far no very precise tests of these apparatus are available and the author doubts their usefulness since they may be affected by a number of sources of error and in any case cannot be more precise than an ordinary pendular balance.

In the case of bodies rotating at comparatively high speeds as in steam turbines, turbo-pumps, blowers, and dynamos, static balance is entirely insufficient. In a disc the center of gravity of which is only 0.5 mm away from the axis of rotation, the centrifugal force which may be considered as acting on the center of gravity of the mass, creates a load on the shaft which equals the weight of the disc already at a speed of about 1500 r.p.m. Hence, the bending stresses of the shaft due to centrifugal force may under certain circumstances quite materially exceed that exerted under a stationary load. Periodically alternating bending stresses arise which may set up in the shaft undesirable oscillatory phenomena.

The distribution of mass forces becomes still more complicated when the body under consideration is not a disc but a drum-like structure, that is, with a considerable extension axially. In this case, it is impossible to obtain uniform running by means of purely static balancing only, since such purely static balancing does not take care of centrifugal forces which may be at any angle whatsoever to one another. Further, if such centrifugal forces be compounded they will always give a couple and a single force with the further complication that in nearly every case both the couple and the single force will lie in the plane of the axis of rotation, but the single force will not lie in the same plane as the couple. Fig. B gives an illustration of what would happen.

A couple Pl and a single force R are both of constant magnitudes as long as the speed of rotation remains the same. There is further a load G_0 due to gravity acting vertically downwards and a couple G_0x the magnitude of which periodically varies from zero to a positive and then a negative maximum. The axis of this last couple coincides with the axis of rotation, and the couple may, therefore, under certain conditions, produce periodic variations in the speed of rotation of the shaft. Even if this possibility be neglected, there still remains the problem which has to be taken care of in balancing and which is determined by the fact that the couple Pl as well as the free force R have to be eliminated entirely or reduced as much as possible, since both of them moving at the speed of rotation of the shaft, may impart to the shaft more or less powerful oscillatory impulses or vibration.

This consideration of the distribution of forces which affect every rotating body shows that static balancing alone can never be sufficient. The static balancing takes place in a state of rest when only forces of gravity are present and it helps only to establish the proper position of the resultant center of gravity but does not in the least eliminate the resultant couple and free force created by the action of the centrifugal forces. Here and there one can still find in technical literature intimations that by static means an amount of balancing sufficient for practical purposes may be obtained. This is entirely wrong since in rapidly rotating machine parts the couple and free force connected therewith and described above are of particular importance, as under certain conditions they may attain dangerous proportions. This may happen if they come into resonance with the natural period of vibration of the system affected, but even apart from the question of resonance these forces may produce injurious vibrations. The couple created by the centrifugal forces tends to jar the shaft in its bearings hither and thither which produces an overload and excessive wear of bearings.

A material improvement in the methods of determining the conditions of balancing of bodies is represented by the process suggested and patented some years ago by Dr. Lavaczeck. The essence of the apparatus consists in the utilization of the resonance action itself for the determination of the lack of balance. Instead of setting the shaft in bearings having freedom of pendular motion, Lavaczeck provides, as shown in Fig. C, two bearings, one of which has freedom of horizontal rotation, while the other is held by springs and has freedom of pendular action. Hence the entire system located in a horizontal plane acts simply as a physical pendulum in which the oscillation phenomena can be fairly easily established by calculation.

It is quite easy to bring the entire system into a state of resonance even at a slow speed of rotation by taking into consideration the stiffness of the spring, the distance between the bearings, the oscillating masses, etc. The drive is applied by a motor through a flexible shaft or belt, the motor being placed in the rear of the rotatable bearing. In order to increase as much as possible the sensitiveness of the apparatus, all bear-

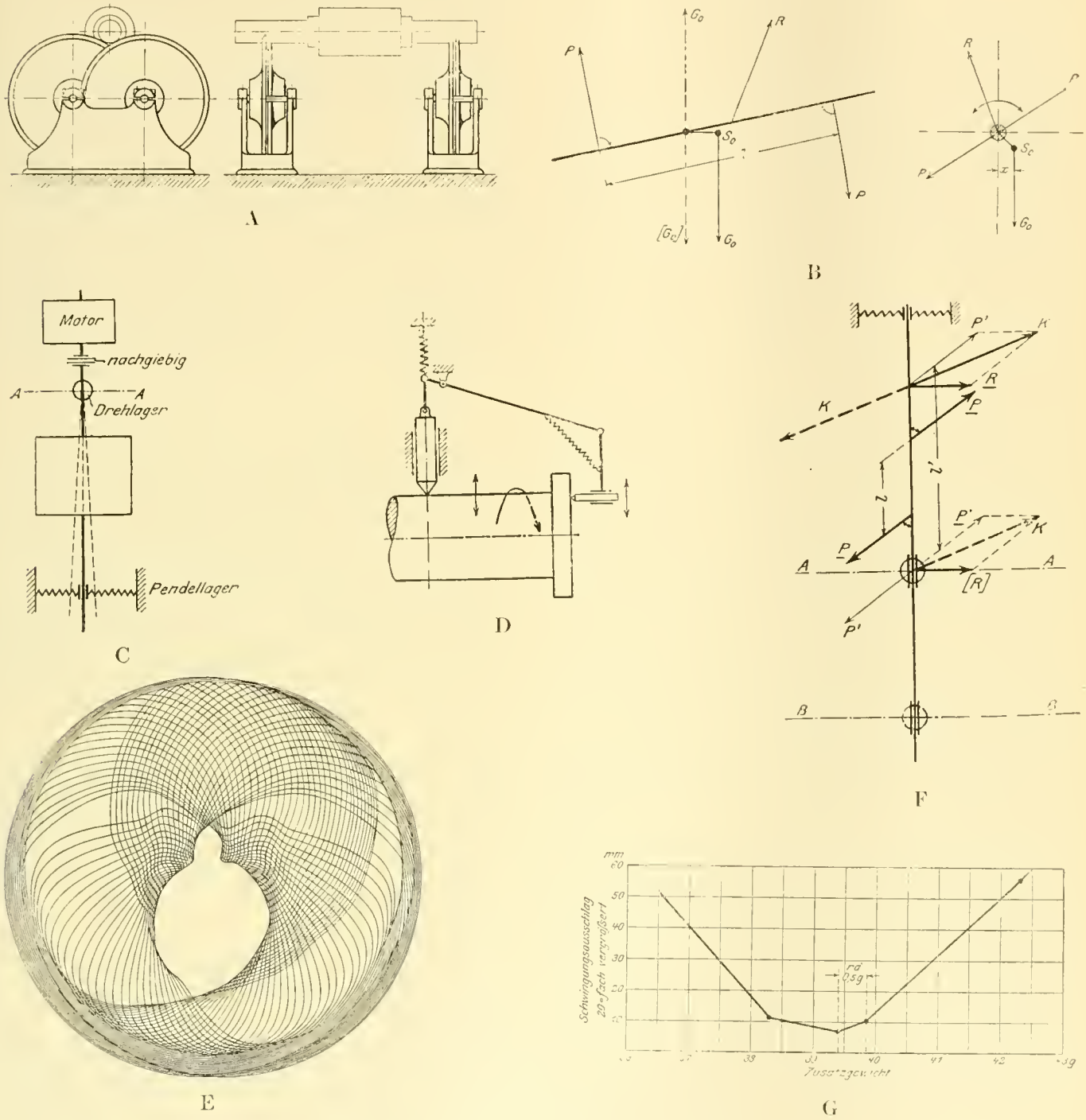


Fig. 4 Balancing of Rotating Machine Parts

A, Roller Apparatus for Static Balancing; B, General Diagram of Unbalanced Forces; C, Diagram of the Lavaczek Balancing Apparatus (*nachgiebig*, flexible; *Drehlager*, rotatable bearing; *Pendellager*, oscillating bearing); D, Recording Indicator of the "Zone of Unbalance"; E, Diagram Plotted with the Shaft Running in Both Directions, on the Front Side of the Shaft; F, Elimination of the Couple and Single Force by the Lavaczek Method; G, Sensitiveness of the Apparatus when the Weight of the Rotating Mass is about 100 kg (220 lb.): ordinates: amplitude of oscillations, magnified twenty times; abscissae: balance weights, in grams.

ings and journals are of ball bearing type and hence practically free from friction. In tests made it has been found that the damping of oscillations no matter how produced in the system itself, is extremely slight, in fact the apparatus has been found so sensitive that unbalancing weights as low as fractions of one gram show their presence quite noticeably by definite indications in the development of the state of resonance.

Of particular interest is Lavaczeck's process for the determination of the "plane of unbalance." The head of the oscillating shaft (Fig. D) carries a circular sheet of paper tightly held, on which slides a recording stylus operated from the oscillating shaft by a special indicating device. This is done by placing on the shaft a small piston actuated by a slight spring pressure. If now the shaft makes an oscillation, the piston transfers it, magnified, to the stylus which simultaneously records it on the piece of paper. Because of the simultaneous rotation of the recording disc slight oscillations appear as cavitations of the circular motion of the stylus with respect to the shaft. The greater the oscillations the sharper are the curvatures and if the maximum oscillation is allowed to reach the middle part of the sheet of paper, it is recorded as a clear angular peak.

If, therefore, the indicator be allowed to run over the paper for a certain period of time during resonance, the peaks recorded will show the "plane of unbalance" which (as is shown elsewhere in the article) must have a phase variation of about 90 deg. with respect to the maximum amplitude of oscillation. For safety's sake the shaft may be allowed to make one revolution forward and one revolution backward. If then a radial plane be passed through the peaks of the diagram thus obtained and the angle between the two be bisected, the bisectrix of the angle will directly indicate the "plane of unbalance" on the head of the shaft. Tests made in this connection have shown that the above described process permits of determining in a few minutes the location of the "plane of unbalance" with the precision of a few degrees. Fig. E shows such a diagram taken with the shaft running in both directions.

The Lavaczeck process permits also of eliminating both the couple Pl and the free single force R; compare diagram Fig. F. The couple Pl can be assumed to be replaced by another couple acting in the same plane $P'l'$ of which the force P' passes through the point of application of the free force R which the other force of the couple P' passes through the center of rotation of the shaft. The forces $P'R$ give together a resultant K which exerts a moment with respect to the center of rotation of the shaft and tends to set up oscillations in the shaft. The plane of this resultant can be easily found in the usual manner.

In order to equalize these oscillations all that has to be done is to produce in this plane another couple by the addition of weights such as to make the shaft run oscillation-free. This additional couple can be again assumed to be represented by a couple of the magnitude Kl' of which one of the forces passes through the center of rotation of the shaft while the other force opposes and eliminates the original force K. One can now imagine the force K, having its point of application in the center of rotation of the shaft, to be resolved into its original components P' and R. It is clear then that the two forces P' having their point of application in the center of rotation of the shaft mutually eliminate each other and only the force R remains at the center of rotation.

The result of this system of balancing is therefore the entire elimination of the couple and the transference of the single force to the center of rotation of the shaft. What remains now is to eliminate this single force. To do this one may either turn the shaft itself in its bearings so that the force R falls into the pendular bearing, or the center of rotation may be displaced from A to B so that the still available free force R should have a lever arm with respect to the center of rotation and would produce oscillations in the shaft. Then this single force can be balanced and its plane determined in the manner described above.

It appears therefore that this process permits of obtaining a theoretically perfect balancing. Comprehensive tests have been made on a machine with steel discs weighing about 50 kg. (110 lb.), each of which would balance singly and together. These discs had a diameter of about 600 mm (23.6 in.), a reinforced rim, and bore of about 60 mm (2.36 in.). Although they were very carefully machined, previous to balancing they produced quite violent oscillations, while after balancing it became quite possible to reduce to resonance the practically undamped oscillations of the pendular bearing of fractions of 1 mm, or to obtain a motion practically free from vibrations.

Fig. G shows how sensitive this process is. It indicates amplitudes of oscillations measured with various additional weights and shows that oscillating masses of 100 kg. (220 lb.) were affected in their motions by additions of weight of 0.5 grams (77.1 grains) while the total amplitude has a minimum of only 7/20 mm (0.0102 in.), which is all the more remarkable as such an amplitude is obtained at resonance. This play moreover is obtained with a fairly large bore of bearing and disappears entirely with the slightest damping. Since the additional weight is placed at a distance about 300 mm (11.81 in.) from the axis, a variation of weight of 0.5 grams (77.1 grains) with a total weight of 100 kg. (220 lb.) represents a displacement of the center of gravity of the mass of only 0.001 mm (0.000039 in.). Speed at resonance during the tests lay between 400 and 600 r.p.m. and by selecting a weaker spring this speed can be still further reduced, so that the handling of the apparatus requires neither exceptional care nor very large power consumption, such as is indispensable with the higher speeds.

The article describes and illustrates the actual construction of the Lavaczeck apparatus. It is of interest because, as the author states, a good balancing device of the dynamic type ought to be in use now-a-days in every mechanical shop side by side with other machine tools. (*Zeits. des Vereines deutscher Ingenieure*, vol. 60, nos. 1, 2, pp. 11 and 32, January 1 and 8, 1916, 8 pp., 25 figs. *ed.*)

Steam Engineering

Boiler Corrosion, John C. B. Kershaw

Discussion of the effects of dissolved salts in feed water upon boiler life and management.

The author emphasizes the point that salts which may be quite harmless in their action upon iron and steel at pressures and temperatures in general use for boilers operating 10 or 15 years ago, may undergo rapid chemical decomposition and become corrosive in their action at steam pressures of 180 to 225 lb., equivalent to temperatures of 372 to 392 deg. fahr. He states, therefore, that under modern conditions of boiler temperature and pressure, sodium chloride and possibly sodium sulphate in the presence of an alkali, do attack and corrode boiler plates and fittings.

Among other things the author gives several practical examples personally known to him of corrosion due to the presence of dissolved salts in feed water. In one case an excessively high content of dissolved salt matter was found in a boiler where the feed water contained comparatively little

chlorides and ordinary care was taken as regards blowing-off. Soda ash was indicated as the origin of the impurity and the test of a sample showed 49.5 per cent of sodium chloride and only 46.3 per cent of carbonate. This is proof of the need that exists for all engineers who use alkaline salts for softening purposes, of having them tested from time to time in order to see whether they contain cheap and dangerous adulterants like common salt.

In another case of corrosion, it was found that an excessively high content of dissolved salts was due to their accumulation in the boiler and to failure to blow off the boiler at sufficiently frequent intervals.

The author believes that the retention of the old two-and-a-half-thirty-seconds salinometer limit for sodium chloride or other dissolved salts given in English engineering pocket-books, is responsible for much of the trouble with land boilers and only the purest water should be allowed as feed water. The author expresses this in the formula: "To keep all soluble salts outside the boiler and to use for feed-water purposes water entirely free from dissolved gaseous and salt impurities." (*Cassier's Engineering Monthly*, vol. 48, no. 5, p. 271, November 1915, 6 pp. *p.*)

Some Points on Water Softening by Lime and Soda Process, Frederick A. Anderson

Discussion of the problem of determining, when lime and soda processes are applied for the treatment of water, what quantities of reagents are required and whether the results are satisfactory. The article describes some valuable methods, not yet to be found in every text book, for the determination of free carbon dioxide, alkalinity, total lime and total magnesia. The author expresses alkalinity in "degrees,", one degree being the equivalent of one grain of calcium carbonate per gallon. (*Journal of the Society of Chemical Industry*, vol. 34, no. 23, p. 1180, December 15, 1915, 2 pp. *dp.*)

Water of Condensation from Steam Turbines for Boiler Feeding, M. R. Schulz

Further discussion on the question of maintenance of clean feed water in boilers, now with reference to the feeding of boilers by water of condensation from steam turbines. For an abstract of the preceding article see *The Journal*, July 1914, p. D149.

It is the general impression that the water of condensation from steam turbines is quite clean in itself and can cause no scale deposits in the boiler or corrosion of metal parts. The author strongly disagrees with this view.

He makes a distinction between rust and corrosion, defining *rust* as a uniform oxidation of the entire surface of a metal article (iron or steel), and *corrosion* as an intensive chemical process essentially local in its action. In the case of boilers fed by water of condensation from steam turbines one has to deal with a mixture of water of condensation proper and additional feed water more or less clean initially or cleaned in proper apparatus. While water of condensation from steam turbines greedily absorbs oxygen and air, oxygen alone will not produce any corrosion of iron, and it is the air that does it mainly.

The best way to eliminate air from water is to heat the latter to 80 or 90 deg. cent. (176 or 194 deg. fahr.) which would, however, entirely eliminate the function of cast iron preheaters. Recently an apparatus has been placed on the market in which air is eliminated from the feed water by driving the latter through a bed of iron shavings. The principle is in itself correct, but it seems that the apparatus has not yet been fully perfected, as its action ceases as soon as the filler material is consumed, besides which it has the further disadvantage that a part of the iron oxide produced by the chemical reactions to which the usefulness of the process is due, is carried over into the preheater and even into the boiler, and produces a dangerous foaming.

Another statement to which the author seriously objects is that water of condensation from steam turbines contains no oil. In the first place, through carelessness of attendants, especially on the low pressure side, a vacuum may be created causing oil to be sucked in from the bearings. Further, a certain amount of oil may penetrate into the feed water from the intermediary units such as feed water pumps, condenser pumps, etc., and the author states that he has found greater or less amounts of oil in the water of condensation in practically all the electric power stations which he has investigated. In fact, it is easy to notice such oil by observing the opalescent layer on the surface of the water of condensation in the collector tank, and the larger the surface of such a tank the easier the oil can be seen.

In this connection it must be borne in mind that the oil which flows on top in the tank is by no means all the oil that is contained in the water, since a large amount of it is suspended throughout the water in a state of emulsion.

Settling tanks are of little use in this connection unless they are extremely large, so large indeed, that the water may come freely to a state of rest. The so-called coke or gravel filters, even when built in several compartments, take up only that oil which comes into immediate contact with the filter material, while the rest of the oil flows freely over. The author believes, therefore, that there are only two reliable methods of oil separation and they are the electrolytic process and oil separation by chemical reactions, *e. g.*, the lime-soda process.

He firmly believes that in most cases where corrosion occurs, it is due in the first instance to the presence of oil in the feed water. There is, however, one other important source of corrosion, and that is the presence of impurities in the additional feed water. In some cases where complaints of corrosion were investigated, it was found that the cleaning apparatus for the additional feedwater was too small to take proper care of it. In this connection the author emphasizes an opinion expressed elsewhere both by him and other engineers, that it is not the air itself but the carbon dioxide that is the most dangerous agent of corrosion, and from this point of view he raises serious objections to the use of the so-called Permutit process. If day after day, 10 per cent of water treated by Permutit be added to the water of condensation from steam turbines, the percentage of carbon dioxide in the form of sodium carbonate will gradually increase in the boiler water. Now, sodium carbonate decomposes under the combined action of pressure and high temperature, and the interesting part of it is that corrosion coming from this source will affect steam piping, superheaters, etc., but not boilers (at least not to any large degree) since boilers are fed below the water level.

As regards using distilled water for feed-water purposes the author states that distilled water is essentially clean water but by no means "chemically pure," since there are several impurities such as carbon dioxide and ammonia which are not eliminated from the water either by the initial vaporization or by subsequent condensation. They not only stay in water but undergo a process of enrichment so that they produce practically the same phenomena of corrosion as when undistilled impure water is used. (*Ueber Verwendung von Dampftur-*

binenkondensat zum Speisen von Dampfkesseln, M. R. Schulz, Zeits. für Dampfkessel und Maschinenbetrieb, vol. 38, no. 51, p. 417, December 17, 1915, 3 pp., *p.*)

Draft Gages on Oil Burning Boilers, F. H. Rosencrants

Description of the right and wrong ways of connecting draft gages to oil burning boilers and the good and bad results which follow.

Some connections tolerated on coal burning installations because usually the front dampers are kept wide open and the fuel bed forms the major portion of the resistance to the gas passage, would be entirely inadequate for oil burning boilers, as there is an unlimited number of damper combinations that will admit the same amount of air to the furnace and several combinations will give a different draft reading. Hence the draft readings obtained when both front and back dampers are used for regulating the air supply are worthless. The writer recommends that either all regulating be done with the back damper, the front one always open the same amount, or that the gage be connected as in Fig. 5 A or B, as in either case the resistance offered to the flow of gases between the two points of connection of the gage is constant, and the draft will vary with the rate of gas flow. The fact that the draft resistance of oil burning boilers and other furnaces is small makes the air infiltration small, but the consequent small draft makes its indication difficult with existing gages with sufficient accuracy to be of value. It is important that the gage be checked frequently to be sure that it reads zero for zero draft, for which purpose it is advisable to install three way valves as shown in Fig. A. To increase draft readings it may sometimes help to change the combustion chamber connection down to the ashpit and thereby add the resistance of the furnace to the draft reading. Usually this will be a mistake because the aspirator action of the burner makes the furnace resistance negative and reduces the draft below that which will be shown when the gage is connected as indicated in Figs. A and B. The draft readings may be slightly increased by projecting the connection at the rear pass into the setting and putting an ell on the end of the pipe, turning its open end in the direction of the gas travel. (*Power,* vol. 43, no. 5, p. 147, February 1, 1916, 2 pp., 3 figs. *d.*)

Equations for Ammonia Based on New Experimental Material, Fred. G. Keyes

Presentation of data from a series of exhaustive experiments on the thermal properties of ammonia, together with some equations and a discussion of previous work in this connection. The paper is based on work done at the Research Laboratory of Physical Chemistry of the Massachusetts Institute of Technology, and covers the determination of the vapor pressure of the liquid to the critical point, the specific volume of the liquid to pressures of 1000 atmos. and to 200 deg. cent., the specific volumes of the vapor in the superheated region, and the specific heat capacity of the liquid; results are given mainly in tables.

In computing the results of experimental work of this nature many corrections must be applied before the final experimental values can be accepted. Allowance must be made for the temperature expansion of the steel ammonia container and the mercury used to confine the ammonia. The dilation of the experimental system itself, due to pressure, must be considered; likewise the various mercury and oil levels existing in the experimental system enter into the reduction of each pressure observation. The calibration data of the thermometers are in themselves a small investigation. In spite of all the pains taken, the data obtained are seldom as good as within 1/10 per cent of the true values.

It is expected that in the near future ammonia tables based on the new experimental data will be issued. The complete equation giving the pressure in atmospheres is as follows:

$$\log_{10} p = -\frac{1969.65}{T} + 13.31704 - 3.2385 \times 10^{-2}\, T + 5.4131 \times 10^{-5}\, T^2 - 3.2715 \times 10^{-8}\, T^3$$

It has been known that Regnault's high pressure or closed manometer readings were too low, and Mosher's investigation gave higher readings. Table 2 gives the pressures in atmospheres assigned by Regnault and those resulting from the new work for each 10 deg. cent. from — 30 to + 100 deg. Table 3 gives the new values of the saturation specific volume of liquid ammonia at each 20 deg. cent. from — 50 to + 120 deg., together with older values.

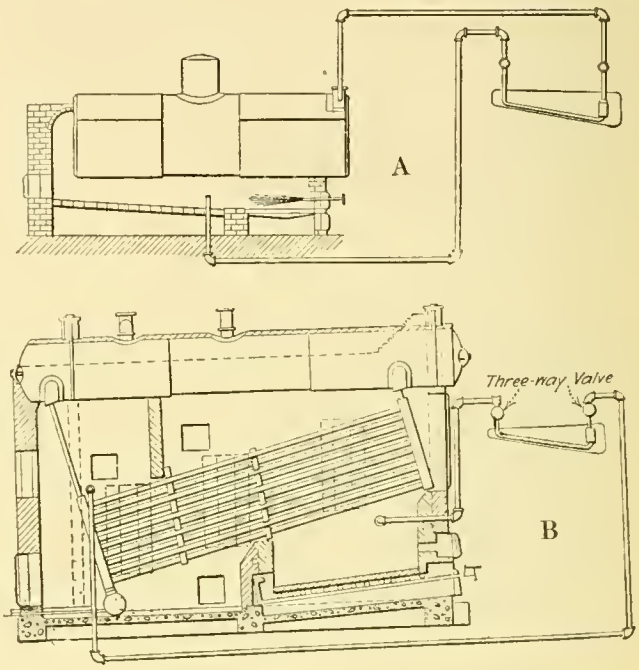


Fig. 5 Proper Connections of Draft Gages on Oil-Burning Boilers

A, For Horizontal Tubular Boilers; B, For Water-Tube Boilers

For the heat of evaporation of liquid ammonia, the following equation connecting heat of evaporation and temperature was obtained:

$$\log_{10} L = 1.56817 - 2.822 \times 10^{-5}\,(T_{-c} - T) + 0.43387 \log_{10}(T_{-c} - T)$$

where T_{-c} is the critical temperature. Table 4 gives the values of L, together with those values in the tables of Regnault, Jacobus, and Kraus.

For measuring heat capacities of liquid ammonia, the following method was used: A steel bomb containing liquid ammonia under the pressure of its saturated vapor is brought to a constant temperature in a thermostat above the calorimeter. It is then dropped into a calorimeter containing a definite weight of water, and the temperature change of the calorimeter is observed. Another steel bomb, identical with the first but containing water under the pressure of its saturated vapor, is placed in the thermostat and dropped into the calorimeter. The weight of water in the water bomb is adjusted by repeated experiments until it gives practically the same temperature change as the ammonia bomb. This

method is dependent for operation on a large temperature difference between the thermostat and the calorimeter, but the errors are the same, or nearly so, for both the ammonia and the water experiments, and are consequently compensated.

The equation taken to represent the saturation liquid specific heat capacity is somewhat arbitrary. It seems probable that because of the term dv/dT the heat capacity becomes infinite at the critical temperature. For this reason the empirical equation chosen to represent the heat capacity was

$$C_{s2} = 1.13747 - \frac{5.7575}{(T_c - T)} + \frac{898.53}{(T_c - T)}$$

and this equation passes through two measurements made in the course of this investigation. The equation for the integral heat referred to zero deg. cent. is

$$\int_{273.1}^{T} C_{s2}\, dT = 1.13747T + 13.257 \log_{10}(T_c - T) + \frac{898.53}{T_c - T} - 345.556$$

A table gives a list of values for the specific heat of liquid ammonia herein obtained.

In the discussion which followed the author stated that he is by no means convinced that all the so-called throttling phenomena are in reality Joule-Thomson experiments. Joule made a large number of observations which imitated very closely the so-called throttling. He found that only under very particular conditions could he obtain numbers which coincided with the meaning expressed by the equation:

$$\left(\frac{dT}{dp}\right) = T\frac{\left(\frac{\delta U}{\delta T}\right)_p - U}{C_p}$$

The truth of the matter probably is that the reduction in the temperature produced by the expansion of a liquid through an orifice is, so to speak, a mixture of this latter equation and

$$\left(\frac{dT}{dp}\right) = T\frac{\left(\frac{\delta U}{\delta T}\right)_p}{C_p}$$

but further investigation is necessary to determine whether in the so-called expansion valve a Joule-Thomson phenomenon really takes place. (*A.S.R.E. Journal*, vol. 2 no. 4, p. 20, January 1916, 19 pp., 5 figs. *etA.*)

TABLE 2 VAPOR PRESSURES OF LIQUID AMMONIA IN ATMOSPHERES

Temp. °C.	Regnault	New Values
−30	1.140	1.177
−20	1.831	1.885
−10	2.821	2.892
0	4.189	4.278
10	6.018	6.127
20	8.402	8.535
30	11.45	11.60
40	15.26	15.44
50	19.95	20.16
60	25.62	25.90
70	32.47	32.78
80	40.59	40.95
90	50.16	50.56
100	61.36	61.83

TABLE 3 SPECIFIC VOLUME OF LIQUID AMMONIA AT SATURATION POINT IN CC. PER GRAM

Temp. °C.	Lange	Dieterici	Mosher	Brownlee and Keyes
−50	1.4375	.....	1.4351	1.4222
−30	1.4895	.....	1.4851	1.4742
−10	1.5480	.....	1.5415	1.5330
0	1.5795	1.5656	1.5728	1.5656
20	1.6503	1.6342	1.6430	1.6387
40	1.7383	1.7227	1.7268	1.7255
60	1.8487	1.8250	1.8307	1.8328
80	1.9982	1.9595	1.9675	1.9757
100	.....	2.1525	2.1684	2.1859
120	.....	.....	2.5538	2.5965

TABLE 4 COMPARISON OF LATENT HEATS. CAL. PER KG.

Temp. °C.	Calculated by Equation (3)	Observed	Percentage Difference	
−33.4	336.7	321.3	−4.58	Estreicher & Schuerr.
−33.2	336.5	336.6	+ .03	Franklin & Kraus measured.
−33.2	336.5	336.8	+ .08	Franklin & Kraus from ebullioscopic constant.
−23.71	328.1	316.1	−3.6	Regnault—Jacobus—Denton.
−19.55	324.5	335.1	+3.2	Regnault—Jacobus—Denton.
− 9.72	316.0	317.0	+ .3	Regnault—Jacobus—Denton.
7.80	298.4	293.0	−1.8	Regnault—Jacobus.

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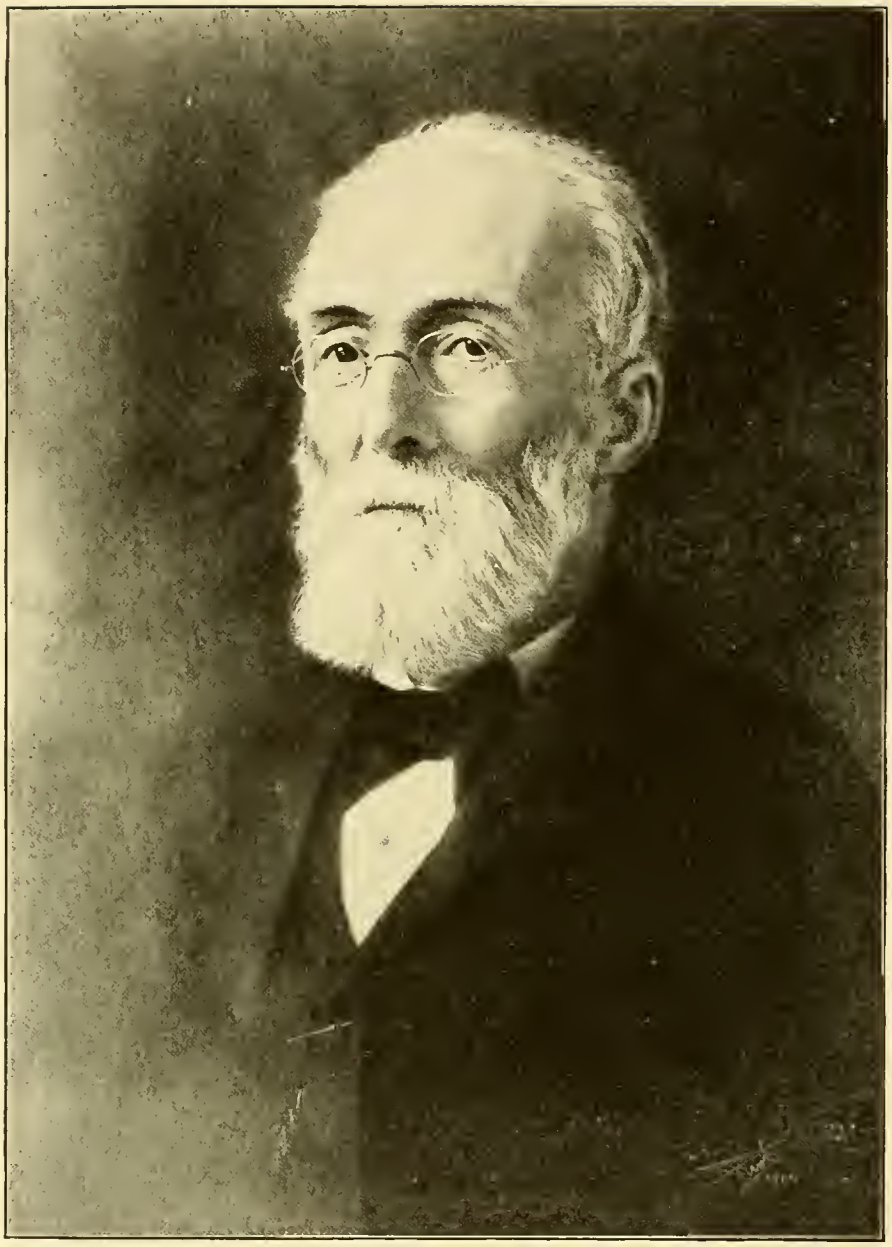

ERASMUS DARWIN LEAVITT ONE OF THE ORIGINAL MEMBERS OF THE SOCIETY. VICE-PRESIDENT. 1881-82. PRESIDENT, 1883. HONORARY MEMBER, 1915. DIED MARCH 11, 1916

ANNUAL MEETING PAPERS

THE final session of the 36th Annual Meeting of the Society held in New York, December 7-10, 1915, was devoted to papers on Industrial Safety. There were four papers contributed by the Sub-Committee on the Protection of Industrial Workers, as follows: Standardization of Safety Principles, by Carl M. Hansen; Modern Movement for Safety from Standpoint of Manufacturer, by Melville W. Mix; The Attitude of the Employer Towards Accident Prevention and Workmen's Compensation, by W. H. Cameron; Industrial Safety and Principles of Management, by W. P. Barba. The first three of these papers are published in abstract form in this issue; Mr. Barba's paper appeared in the December 1915 issue of The Journal.

STANDARDIZATION OF SAFETY PRINCIPLES

BY CARL M. HANSEN, NEW YORK

Member of the Society

WITH the dawn of the twentieth century, it was seen that we had achieved an efficiency in our industries surpassing that in all other countries. The machine tools of the United States, for instance, were recognized as superior to any manufactured elsewhere. Through the clogging of our courts with litigation involving injuries to operators of these machines, however, we began to ask ourselves if in our zeal for productive efficiency of machines, we had not overlooked one vital factor. Were these machines reasonably safe for those workers who had to give them constant or intermittent attention?

With an annual toll of upward of fifty thousand workers killed and approximately two million others more or less serious, but non-fatal accidents, we realized that we were rapidly on the road to creating a nation of cripples, and that in order to measure true efficiency in our industries it would be necessary to take into account the economic loss occasioned by all these work accidents. In taking stock to that end we found that an amount of between five and six hundred million dollars had to be added to our cost of production in order to collate an exhibit of our true efficiency.

Some of our larger corporations, particularly the United States Steel Corporation, The International Harvester Company and several others, at the same time, and even earlier began to study the subject and someone—who it was has never yet been finally decided—coined the happy expression "Safety First." It was recognized that compensation for injuries was a just and equitable plan, generally in the interest of society at large, but that if we could prevent the injuries from happening we should eliminate not alone a tremendous amount of human suffering and hardship, but we should make one of our greatest forward steps in economic efficiency. The whole movement was characterized by duplication of action and resulting inefficiency, until at last in the fall of 1912 the National Safety Council was formed in the City of Milwaukee for the purpose of bringing to some extent harmony out of the existing conflict of opinions. This organization, now embracing a membership of many of the most progressive corporations and individuals in every state of the Union, has done splendid work. It has been a powerful factor in arousing public opinion to the subject and in bringing it to the stage where the engineering profession must take due cognizance of it and do their share in bringing about universal safety.

It is through standardization that engineers must play their most important role and in the standardization of safety principles there are the five requirements, to put the matter tersely, that these principles must be high, comprehensive, practical, simple and positive.

By high standards is meant those which afford all possible safety to life, limb and property from accident and fire hazards; that a building or a piece of equipment is safe enough only when it is as safe as it can possibly be made or only when it is as safe as any other building or piece of equipment designed to perform the same function.

By comprehensive standards, is meant those which embody

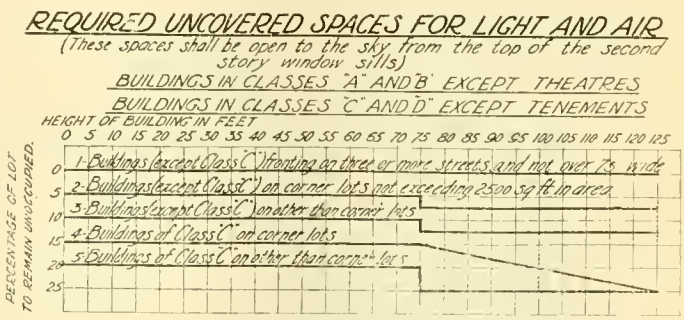

FIG. 1 SAFE AREAS OF BUILDINGS ON CITY LOTS

not alone the equipment in a building, but the building itself as well, and not only a plant in New York, but rather any plant regardless of location.

By practical, is meant those which do not destroy or distort either the convenience or efficiency of the equipment to which they are applied.

By simple, is meant that they be so prepared that they will be readily understood and applied by the ordinary mechanic, that the safest way will always be the easiest way.

By positive standards is understood to be meant that they will eliminate the hazard for which they were designed; that is, that they will do something, or cause something to be done, or absolutely prevent something from being done, rather than simply serving as a suggestion—that, in other words, they can be depended upon for unfailing action with as little consideration as possible for the universally uncertain human factors, such as knowledge, memory and involuntary acts, etc.

In the following an attempt will be made to illustrate these principles in actual application. Commencing with a typical factory building, the supposition is that the site has been selected and that the problem is to design and equip the building for maximum safety without interfering with efficiency or convenience.

Presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 1915. Pamphlet copies without discussion may be obtained: price 10 cents to members, 20 cents to non-members.

An isolated factory presents few difficulties, but the city factory offers problems in planning, due to the proximity of other buildings, which must be regulated by standards. It has been determined that a certain percentage of the lot must remain uncovered in order to provide sufficient air and light. What that area of unoccupied space should be, given the size of the lot, is indicated in Fig. 1. This illustration shows the percentage of area which can safely be occupied with any class of building on any type of a city lot.

Having determined the outline of the plan, the next step is to determine means of rapid and safe egress which at the same time will not interfere with the efficiency of the manufacturing processes and are based on total occupancy of building. Figs. 2, 3 and 4 show suggested arrangements of such a plan by means of stairs enclosed in fire resisting walls and smoke proof towers.

As will be noted, the power plant and the vertical transmission shafts are separated from the rest of the building to prevent the spread of fire, and elevator shafts are inclosed in fire resisting walls and equipped with automatic fire doors.

The windows exposed to fire hazard from other buildings are glazed with wire glass set in metal sash. All lintels are far enough below the ceiling so that the heated gases will be contained to operate automatic extinguishers and so that flames breaking out through the windows are diverted from the other wall openings.

Even allowing for this and for the minimum width of piers, ample lighting facilities are obtained. Space is provided for toilets and wash rooms having outside light and ventilation and with a sufficient number of wash basins and other toilet facilities to accommodate the employees.

The construction should be fire resisting to a high degree, as illustrated in Fig. 5, but in case this should prove too expensive, owing to location or other circumstances, a good type of slow-burning construction may safely be adopted. Whether it be fireproof or slow-burning mill construction, fire fighting equipment should be provided, such as automatic sprinklers, wall and yard hose, portable extinguishers, etc.

It is admitted that no specific standard can be laid down which will embody specifications covering any or all of the

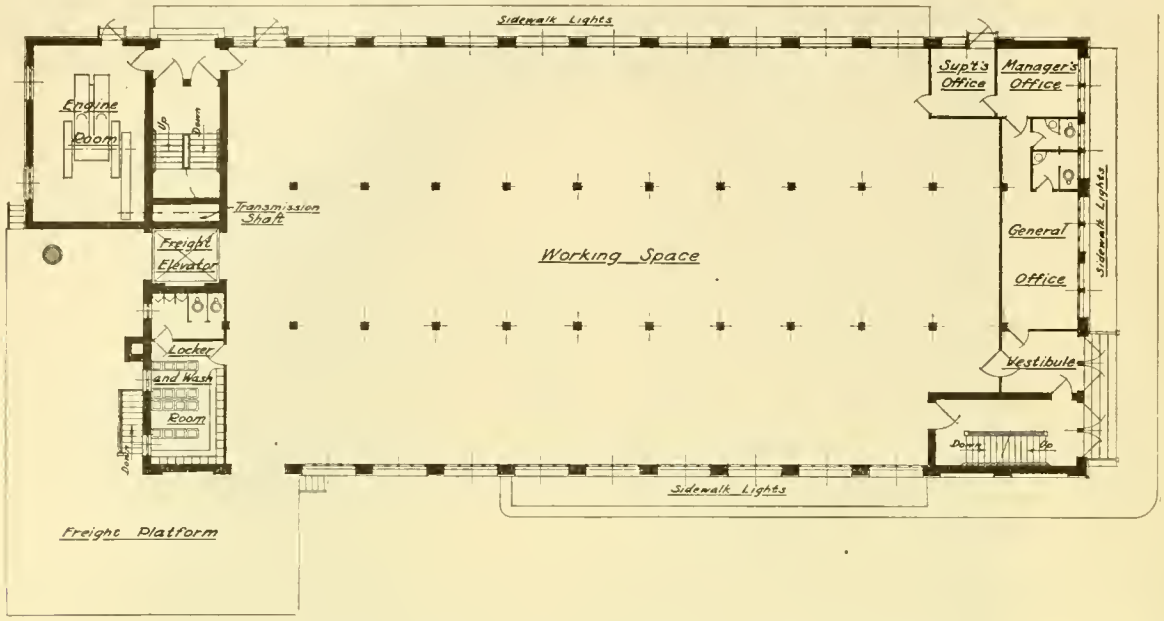

FIG. 2 FACTORY BUILDING MILL CONSTRUCTION. FIRST FLOOR PLAN

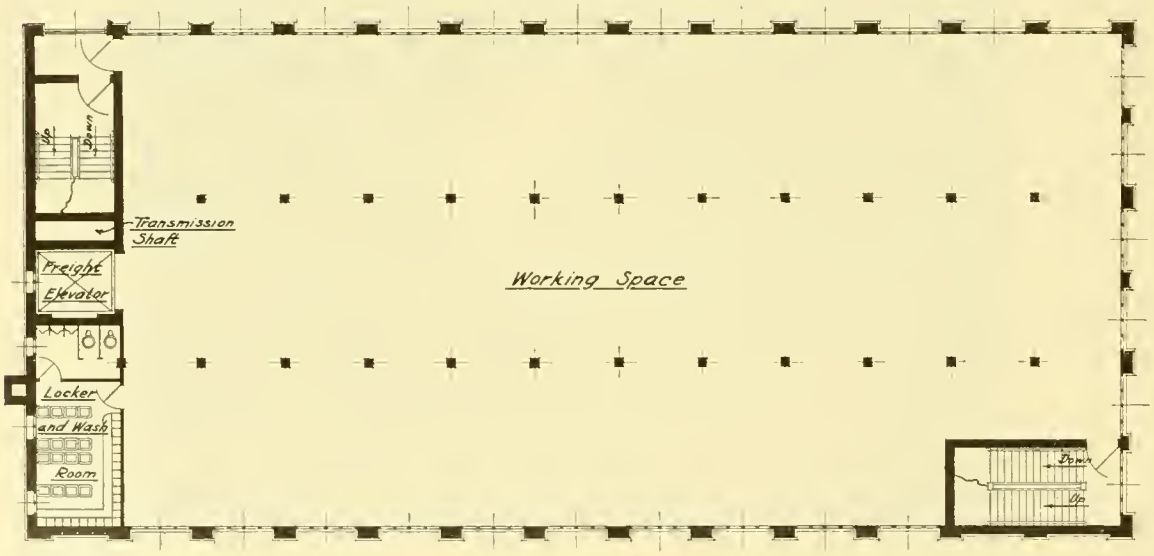

FIG. 3 FACTORY BUILDING MILL CONSTRUCTION. TYPICAL FLOOR PLAN

foregoing. All that the author is endeavoring to show in these illustrations is the principle which must be applied to the particular problem confronting the architect or engineer in designing a building and he desires to emphasize the fundamental fact that these principles are essential.

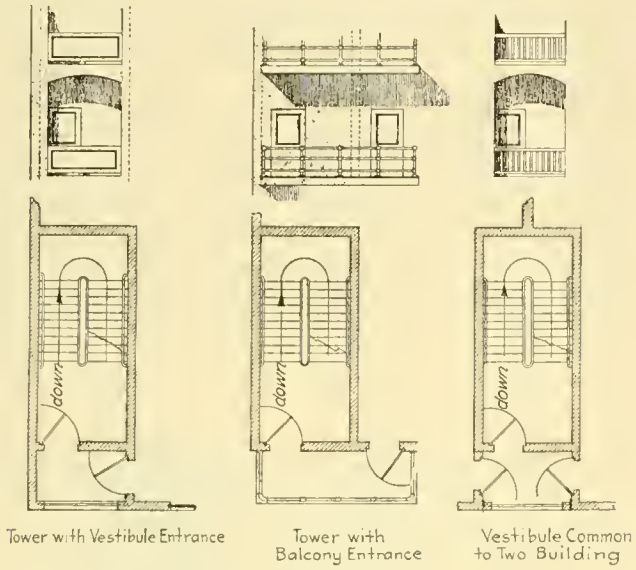

Fig. 4 Smoke Proof Towers

ing products of the controlling political parties, is it not too much to assume that scientific results will be obtained?

As practical men, however, it would be impossible to condemn all buildings now in existence which do not embody the ideal safety principle. Our plan must therefore include existing buildings as well.

Taking the building, for example, where adequate means of egress has not been provided, it may be necessary to overcome this deficiency by means of outside exit stairways of a type as shown in Fig. 6, but under no circumstances should the so-called "fire escapes" as commonly known be countenanced, that is, exits with such objectionable features as grid-iron balconies connected by open stairs, or ladders or exits so located that they adjoin windows.

The horizontal exit obtained by means of bridges connecting adjoining buildings, or in the case of large floor areas the breaking up of the area with fire resisting partitions and automatic fire doors, are very effective means for promoting safety from the fire hazard in many existing buildings and it is quite incomprehensible why those plans are not more extensively used. This method places safety zones immediately next to the danger zones.

It is naturally impossible in a paper of this nature to go largely into details. There are many more questions which properly should be considered in connection with buildings

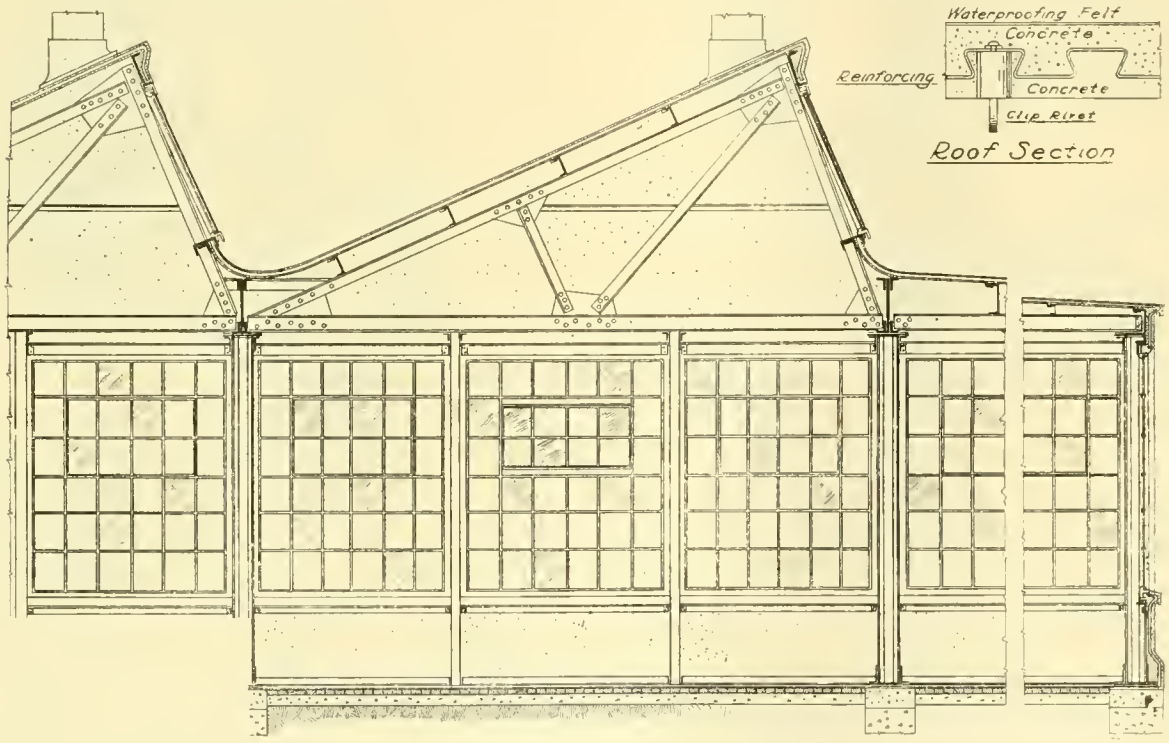

Fig. 5 Saw Tooth Factory Construction

It may be maintained that all these factors are having careful attention at this moment and are being embodied in modern structures. It is admitted that such is the case in individual instances, but as a general rule—No! Facts are against such a contention. Very few factory and even few office buildings which have been designed and built in this country in the last few years are truly safe for the occupants. It is not asserted that they fail to comply with existing codes, law and regulations, but as long as each individual city has its own building code, often based upon the particular market of its locality and dominated by the build-

but it is hoped the foregoing will illustrate the points involved.

We next come to the selection and installation of machinery and equipment generally. Where machine tools are to be used, only those should be specified which have all possible safeguards embodied in original design: that is, as an integral part of the machine itself. A safeguard on a machine should not be an extra attachment or an after-thought; it should be as much an original part of that machine as are the gears or the pulleys. A manufacturer of machine tools should consider it an insult to have a purchaser of his prod-

not add parts or equipment to it after it has been installed.

Gears are necessary on certain classes of machines for the transmission of power, but no engineer will admit that these gears have to run openly in order to perform their function. Knowing that as long as they run openly they present a hazard, and knowing further that it is an unnecessary hazard and that it will not reduce the efficiency of the machine to eliminate it, it must appeal as a logical proposition that such elimination should be effected in original design rather than after the machine has been installed. This applies equally to all other points creating an accident hazard.

In order to meet the principle of safety a guard for a machine should be so constructed as to prevent the removal or misuse of its essential parts. Wherever possible, it should be so designed in relation to the machine to which it is applied that the machine cannot be operated unless the safeguard is in position. This may seem to present insuperable difficulties in the design of certain types of machines. It has been the author's experience, however, that where concentrated study has been given to that particular principle in machine design, it has been met in every instance. Fig. 7 indicates the principle applied in the door-lock on a laundry extractor. This principle is again illustrated in Fig. 8.

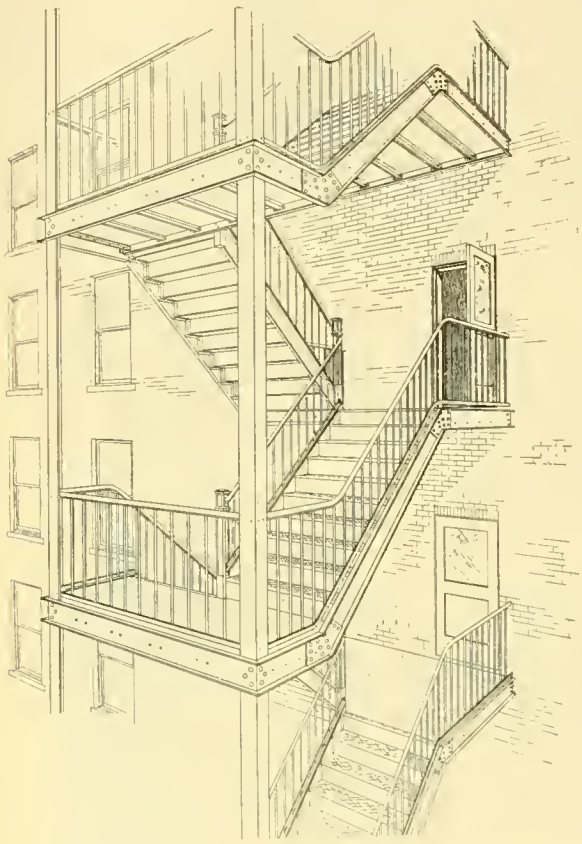

Fig. 6 Approved Type of Outside Exit Stairway
Stairs Perpendicular to Wall

A further study of the question of safeguarding has brought out the fact that the application of a safety principle often increases the efficiency, as, for instance, in the case of stamping presses equipped with slide and gravity feeds, as shown in Fig. 9. It is a fact well established in stamping press operations that that method of feed naturally increases the output on the machines and often produces that result. It must be noted, however, that the automatic feed as such does not in itself form a complete guarding of that press. Some further protection must be provided, making it impossible for the attendant to put his or her hands in the actual danger zone during the downward stroke of the ram.

If from a construction standpoint the building is properly provided with all safety features, and the machinery and equipment with its belts, pulleys, gears, set-screws, couplings, etc., embody all safety principles, there are still other hazards which must be carefully considered and the principle for elimination of these hazards established. The slipping hazard is one of the most important. A careful study of many accidents as reported has brought out the fact that slippery surfaces constitute one of our largest contributory causes to such accidents. That the slipping hazard is easily and can be practicably eliminated by the introduction of anti-slip surfaces on all stairs and on all floor surfaces where employees or other occupants of buildings frequent is an established fact. It is particularly necessary that such anti-slip surfaces be used around machinery.

Having proven, so the author hopes, the necessity of safety as an essential principle in the design of buildings and their equipment; having further proven the practicability of such safety principles; and having reinforced this by showing the apparent need of standardization in the premises, the question is before us of where and how shall we obtain such standards? The answer lies in another question: Where did we get our industries? Who is responsible for the hazards in these industries? We—the engineers. We have created the machines used and it is up to us to eliminate any unnecessary hazard which these machines have introduced.

The unfortunate phase of the whole subject is that up to now safety has been dealt with as a legal subject. We have left it to our courts, to our lawyers, to decide whether or not a building or a machine was safe for its occupants or operators. Now, the author maintains that safety never was and never should have been made a legal question. It is not a question of law; it is in every instance a question of fact, and who is more competent to deal with questions of fact than engineers, especially when these facts pertain to their own business?

To give a typical illustration of legal and engineering standards: The hazard of moving elevators and open shaft doors has long been recognized through occurrence of hundreds of fatal and serious non-fatal accidents. Legislators in different municipalities and states have passed statutes to the effect that it shall be deemed unlawful for an elevator operator to start his car until the doors of the shaft are closed and latched. This is a typical standard produced by legislators. But does this prevent the occurrence of elevator accidents from open doors? It does not, because it is impossible to enforce the act in time to prevent the accident. The only thing that such a statute accomplishes is to establish responsibility for the accident after it has occurred.

Let us consider briefly how an engineer would solve the same problem. He would analyze the mechanism of the elevator, the door, and the motive power. He would find the contributing causes which produced the hazard and re-design his elevator so that it would become impossible for the operator to reproduce the dangerous conditions, and would compel him to perform a certain act before he could get motive power—the act in this case consisting in closing the door in order to move his operating lever.

When engineers have developed such a principle and shown it to be a practical one, our legislators may well assist them in giving legal force to it, but this should be done without

any unnecessary phraseology. To write a law book on a question of fact which can be expressed in a line is folly.

Before closing, it is desired to express a further word in respect to building design. Our architects may well say this is an architectural problem and one which should be left to them to deal with and solve. Let it be clearly understood there is no desire upon the part of the author to dictate what is and what is not proper building design. Let it further be understood that there is no intention to advocate that our architects should sacrifice art, utility or any other desirable feature of building construction in the interest of safety. But it is maintained—and this with a fair degree of conviction—that the architect of the future must combine safety, convenience, efficiency and art in order properly to serve the interests of society, with always—as in the case of the engineer—"Safety First."

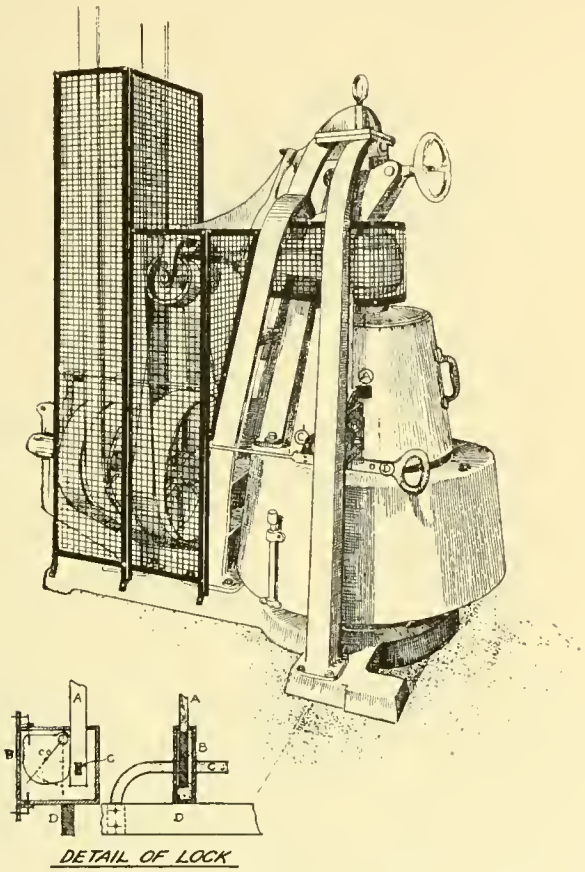

Fig. 7 Door-Lock on Over-Driven Extractor

Let it be further understood on the part of the author's brother engineers that no attempt is made or will be made on the part of the organization which he represents, namely, the Workmen's Compensation Service Bureau, to enter into specification details in any standards which that organization may be responsible for. In fact, the term "standard" as used under the auspices of that organization refers solely to standardization of principles, leaving it then to the engineers of the various industries to apply these principles in their particular field, a task for which they are far better qualified than anyone else.

The Workmen's Compensation Service Bureau, however, has a vital economic interest in the premises. It is an organization composed of the leading liability insurance companies on this continent. It deals with the matter in a concrete sense in so far as its constituent company members insure the liability occasioned by any hazard present in buildings and equipment. To value these hazards properly and to eliminate them, as well as to avoid discrimination, specific standardization is essential. We have undertaken it in the interest of our own business, but the interest is equally as great on the part of the industries insured because the rates for insurance are in direct ratio to the presence or absence of any hazard.

In conclusion, the author believes it a self-evident fact that the engineers as creators of our industries owe it as a duty to these industries and the nation of which they form so important a part to exert their utmost efforts in the conservation of life and property which are so essential to the economy of the individual plant and so essential to the nation as a whole. The subject should be treated with the consideration which some of us at least feel it justly deserves. Our methods for reducing waste, whether it be material or

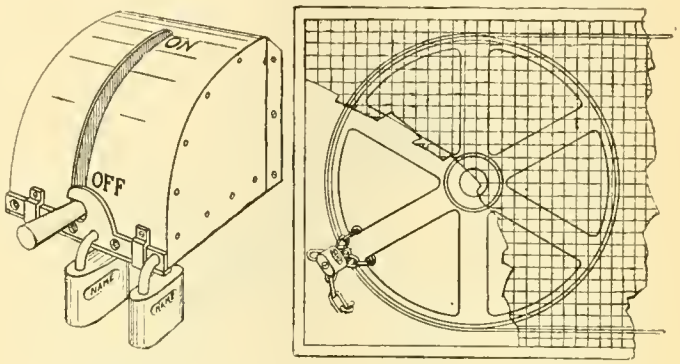

Fig. 8 Two Examples of Padlocks as Safeguards

vital, must be improved through preventive methods and none is better fitted to lead such a movement than the engineers. It is not proposed that a new branch of engineering shall be established for this problem. The real object must be to make each branch of the engineering profession in the true sense of the word "Safety Engineering."

DISCUSSION

Frederick R. Hutton. In the historic development of any productive industry, the first consideration had to be to make something that would do the work,—that was the condition from the seventies to the nineties. Then came the period of improving the efficiency with which the result was attained. In the early part of the twentieth century, the third stage was reached; that is the evolution takes the forms of, *first,* getting the result; *second,* getting it economically and efficiently, and *third,* getting it with safety to the men concerned.

Mr. Hansen has not mentioned what I know he very clearly sees, and that is that the most effective way for designing engineers to attain the desired results is by means of what is called the interlocking principle. In a laundry machine, for example, it should be impossible to shift the belt to start, until you have closed the machine and locked it, and got your hand out. It should be impossible to start the elevator until the door has been closed; correspondingly, it should be impossible to open the door until the elevator has been stopped.

Mr. Hansen has not referred to one unfailing method of securing safety, and that is that it should require the use of both hands to start a machine. If the operator must pull a

lever with the right hand and then pull a lever with his left, to either start or stop the machine, he has no hand free which be can get in the way of maiming forces.

Complementing the author's statement of basic principles, and his definition of "practical" safety devices, I would say that these devices must be such that they do not diminish production.

In closing, may I express my pleasure that the Society should have devoted a session at this meeting to the discussion of this most important subject. I have been interested in the subject of Safety since about 1895, when nobody thought much about safety engineering. I did not myself until it was brought to my attention that the practice in Europe was far ahead of our own. We are catching up, and it is to the credit of the engineer that this result should come

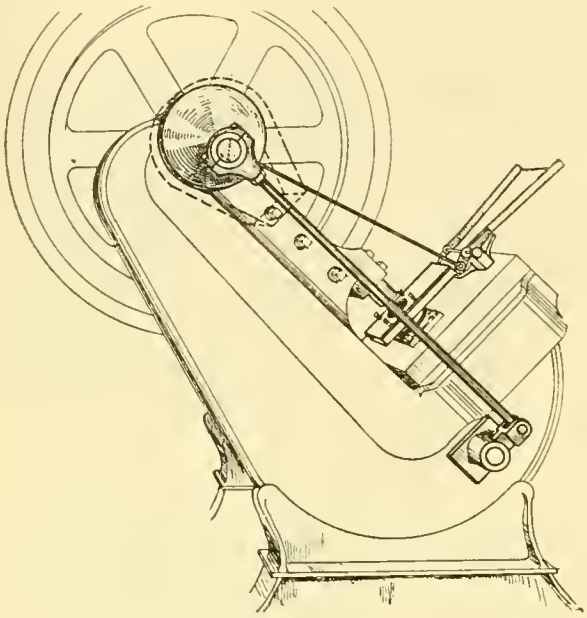

Fig. 9a Stamping Press Gravity Feed Cam-Actuated Ejector

about, and to organizations such as those of which Mr. Hansen is representative.

Frank E. Law contributed a written discussion, stating: I doubt whether safety standards should be absolute, should be hard and fast. It seems to me that there are often several ways of accomplishing a desirable end, and one way should not be adopted to the exclusion of others. All that should be necessary is that the particular way adopted will achieve the desired end. If some latitude is allowed in the choice of means, we can often secure the coöperation of a workman through his pride of authorship. A workman is much more likely to use willingly and effectively a guard devised by himself than one imposed upon him by authority. I think, therefore, that Mr. Hansen is proceeding along the right lines when he announces "that no attempt is made or will be made on the part of the organization which he represents, namely, the Workmen's Compensation Service Bureau, to enter into specification details in any standards which that organization may be responsible for. In fact, the term 'standard' as used under the auspices of that organization refers solely to standardization of principles, leaving it then to the engineers of the various industries to apply these principles in their particular field. . . ."

I would urge upon engineers the propriety and desirability of checking all designs of structures and machinery prepared in their offices from the safety standpoint, and when purchasing machinery to include safety requirements in the specifications.

I would express doubt as to the advisability, in legislating with regard to safety measures required of employers, of setting forth in detail the guards to be provided, but would instead recommend a statement of the principles, imposing upon the Commissioner of Labor the duty of issuing regulations covering the details.

It constitutes a distinct reproach to the engineer that he has done so little in the field of safety engineering. At the same time it is only fair to bear in mind that he has often been hampered by his employers and by the limitations imposed by competition and expense.

It is interesting to note, however, to what a considerable

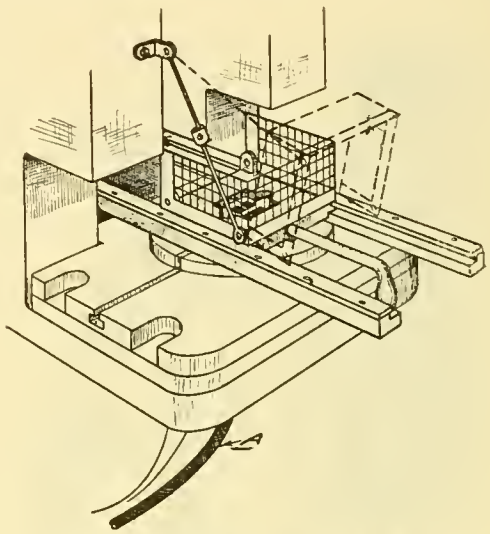

Fig. 9b Stamping Press Slide Feed Air Ejector
A = Air Ejector Hose

degree the work of the Society has had to do with things that lie within the realm of safety engineering. The design and construction of structures and machines to secure maximum strength, the choice of proper materials, is safety engineering. A large part of the work of the Boiler Code Committee had to do with the proper design and construction of boilers from the safety standpoint and the choice of proper steel for the shell, furnaces, stays, rivets, and other component parts. But there is much more that the members of the Society can do, and the field of subjects for papers dealing with safety problems is practically unlimited.

Safety engineering, unfortunately, like every other effort for betterment, often runs afoul the matter of expense. The expense of perfect design, materials, construction, conditions, is prohibitive. We have constantly to bear in mind, therefore, the distinction between what is desirable and what is feasible, having regard to the matter of expense. The problem of the engineer is to secure the maximum of safety at the minimum of cost. It is easy to wreck a promising safety programme on the rock of expense.

The insurance companies have done and are doing a great deal to help solve the problem of the prevention of accidents. They have published literature on the subject, have made and are making safety inspections, and have established service bureaus and inspection boards to make merit or schedule rating inspections for the purpose of determining discounts

and additions to the rates, as safety measures are or are not adopted by employers. The companies earnestly hope that they will have the full and complete coöperation of engineers everywhere in the great work of promoting industrial safety. Mistakes will be made at the outset, for we are doing pioneer work, but we hope these will be as few as possible, and we hope also that we shall have the benefit of constructive, not destructive, criticism of our friends and fellow-workers, the engineers.

John H. Barr (written). The author states that only those tools should be specified which have all possible safeguards embodied in original design. It may be difficult at the present day to get always the machine required with all danger points guarded in accordance with modern ideals, but the statement that safeguards *should* be included by the maker and as a part of the original design is absolutely sound. Not only on aesthetic considerations, but in the interests of effectiveness and true economy should this be done. Until builders generally adopt the practice of supplying "built in" safeguards (and for some years afterwards while old machines are still in action) the poultry netting, picket fence and ashcan types of makeshifts will persist in offending the eye. It is not necessary to dwell on the unsightliness of these contraptions, much as we may rejoice to see them where no protection previously existed. In many cases they are not as effective as would be well-considered designs made in the shops of the builders.

It is, however, the consideration of real economy which may be expected to make consistent well designed safeguards the rule rather than the exception. In the first place, the introduction of the "merit rating system" will be an incentive to purchasers to call for all necessary safeguards with the original purchase. The history of factory fire insurance proves that owners will respond to higher requirements when convinced that there "is money in it." When purchasing agents show a preference to the bidder whose product has these features properly incorporated, the seller will begin to take notice.

I believe the progressive builder is disposed to anticipate such demands and that he would voluntarily go much further in the matter than he has yet done if there were adequate assurance that *any* design he can offer will meet the statutory requirements, the insurance standards and the idiosyncracies of inspectors wherever his product is sold. At present, unfortunately, he has no such assurance. The chaotic condition of today must be remedied before the situation can become really satisfactory.

Such work as that done by the National Machine Tool Builders Association, the Abrasive Wheel Manufacturers and the Machine Shop Practice Committee of this Society on the Safety Code for the Use and Care of Abrasive Wheels will have great influence on legislation in the various states and will tend strongly toward uniformity of requirements.

In a letter to the sub-committee of this Society on Protection of Industrial Workers, Dr. S. W. Stratton, director of the U. S. Bureau of Standards, said:

> We are in entire sympathy with your feeling that the great obstacle to the adoption of more complete standardization from the safety standpoint by manufacturers, is the diversity of requirements and the conflict with existing regulations in different sections of the country and even by different jurisdictions in the same territory.

This statement sums up the matter quite conclusively.

Adequate, yet reasonable and practicable codes, generally acceptable to all interests, must be worked out for each class of mechanical equipment. If this work is well done, it is not unreasonable to expect that eventually it may be generally adopted. While other organizations may be better adapted to promote the important work of safety propaganda and while the prosecution of various phases may be properly left to different agencies, it is believed that this Society is peculiarly called upon to take a leading part in formulating several of these standard codes and in exerting its influence toward securing their adoption throughout the United States.

John W. Irwin[1] (written). The effort to standardize safeguards would be more immediately effective if there could be devised some way to show manufacturers the waste resulting from lack of standards. There are so many men who have their own ways of doing things, and who are unwilling to look about them and see what has already been done by others. Many know the end to be attained and have a general idea of how to reach it, but have neither the knowledge nor the equipment of the organizations which specialize on the subject.

The matter of mechanical safeguards and their standardization is an engineering question in the sense brought out in the paper, but the profession can render a further service for industrial safety. Engineers can develop methods of guarding, but they can also be teachers and leaders. They can disseminate information about what has already been done. They can utilize countless opportunities of pointing out the waste of experimental, haphazard safeguarding.

The waste from ignorance in guarding is not to be compared with the cost of industrial accidents, but it is sufficiently large to warrant the attention both of engineers and safety men generally. This waste may be reduced, and gradually eliminated, by concerted action on the part of all who come in contact with people who are trying to find their own ways of doing things that have already been successfully accomplished.

The desirability of standards is quite sufficiently obvious. The thing that is now needed is a widespread knowledge that a long step in standardization has already been taken. I refer to the Universal Safety Standards as already developed by the author and his associates.

Our company takes the attitude that mechanical safeguards constitute the beginning of accident prevention; and the education of the workmen towards the elimination of accidents resulting from ignorance and carelessness is of equal, if not of more importance.

We have found that safety work as a whole must comprise the application of mechanical guards, the elimination of such general hazards as may exist in a plant, and then a systematic, progressive, never-ending campaign to develop the minds of the men in the direction of safety—of carefulness through force of habit.

The men must be reached by varying methods. Frequently, general welfare work, plant sanitation, social features and the like, are effective in proving good faith on the part of employer, and bringing the men to believe that the influences for safety are for their own good.

An educational plan cannot be operated until the matter of mechanical guards has been covered. You, as an employer, cannot consistently ask and require that your employees exercise caution, and cultivate the spirit of universal safety, until you have proved your good intentions by doing what you can to make accidents impossible. In a recent issue of a prominent magazine an illustration showed a workman operating a machine bearing a placard: "Think Safety"—a flywheel re-

[1] Vice-Pres. and Secretary, Universal Safety Standards Co.

volved within a foot of the operator's head, and it was not guarded; there were no belt guards visible, and exposed gears were easily discernible in the picture. This merely shows that there are multitudes of little things, and big things too, yet to be learned, both by the average plant operator and by the one supposed to know better.

No better "Safety Method" can be conceived than an ideal combination of high engineering skill, 100-point common sense, and the experience of the successful teacher. The devising of efficient guards, removal of building hazards, and the like, are engineering subjects purely. What we urge upon all engineers is to go further than that, and lend influence, example, and earnest coöperation in extending the work beyond the point of engineering as such, thus advancing the ideal condition where there is no machine unguarded, no unprotected building hazard, and where every workman knows what to do to protect himself and his fellows—and invariably does it.

W. M. KIDDER contributed a written discussion, stating that opposition to measures intended to prevent accidents arises from self-interest both of workers and of those in authority over them.

The owner, the stockholder, fears in the compulsory adoption of accident preventive appliances and measures a new drain upon the earnings of his business. Nevertheless, he may become a powerful ally of this latest move toward industrial efficiency when he realizes the practical economy of accident prevention in the long run.

To every serious accident there are many minor ones and each represents an interruption of industry—idle machines while fellow workers aid the injured one, damage to product, damage to machinery, and often a gang or a department thrown out of balance by the absence of an essential worker. These things do not merely add to the difficulties of the foreman in charge and of his superintendent; they cost the stockholder money. Just so far as he realizes this will he desire accident prevention, because it increases his profits by decreasing their impairment.

If the possible potent aid of the stockholder is utilized by engineers and a broad view is taken of the commercial aspect of the standardization of safety principles, the added impetus of this powerful influence will lighten the task of the engineer and leave him the more free to deal with the technical side of the matter, which holds quite enough problems to engage his best energies.

DAVID S. BEYER[1] (written). The author, in stating that the real goal must be to make each branch of the engineering profession Safety Engineering, has established a motto which might well hang over the desk of every engineer in the country. It is a primary duty of the engineer to eliminate needless expense and waste, and during the past few years it has been shown conclusively that one of the most appalling wastes in industry is that caused by preventable accidents.

The most effective time to prevent accidents is when the construction drawings are being evolved under the pencil of the engineer. Then the erasure of a line, or a few additional strokes of the pencil, may mean the saving of a human life or the elimination of hundreds of dollars of unnecessary expense in making changes later.

It might be said that there are two equal doors to the House of Safety, the first marked Mechanical Safeguards, the second Safety Education. The engineer has always held the key to the former through his control of the design and construction of new buildings and machinery. This phase of his work is usually most prominent in our minds, and I notice Mr. Hansen has confined his remarks to it. The attitude of the man who runs a machine is just as important, however, from the standpoint of accident prevention, as the condition of the machine. On account of the ever-increasing influx of engineers into all industrial lines and the fact that executive positions are being filled more and more by men of engineering training, the matter of safety education of employees should accordingly be mentioned as a vital form of standardizing safety principles.

The safety organization has become an integral part of the working organization of hundreds of our foremost industrial plants, and the knowledge of how to organize the working force for safety and how to interest the employees in accident prevention is an essential part of the engineer's equipment, if he aspires to the largest fields of usefulness.

[1] Mgr. Accident Prevention Dept., Mass. Employees Insurance Assn.

JAMES O. GIBBONS (written). One of the most interesting points brought out in this paper is that safety should be considered as an essential element of good engineering design, rather than as something to be added just because the customer or the law demands it. Of course this idea has been gaining ground for some time, but if it can be shown that the liability of a machine to cause injury calls for an actual cash charge against it as insurance of the risk, we are putting safety efficiency on the same plane as production efficiency.

As has been pointed out, the loss to the community through preventable injuries is very great. It is perhaps not quite so easy to show just what the loss to the individual employer is, because in addition to the time taken laying off for recovery, there is the moral effect produced by accidents, the effect of which on efficiency is hard to estimate.

Knowledge on this subject of safety is a great help, because however much we may wish to do the right thing for its own sake, the surest way to put safety on a sound foundation is to show that it pays as a business proposition.

GEO. M. PRICE[1] (written). I regard this movement for the standardization of safety principles by safety engineers as one in the right direction and an important advance in the safety and sanitation of industrial establishments. Your society and the Workmen's Compensation Bureau are doing what the German Trade Associations have been doing for a great many years, and the results of such standards of safety devices, etc., are bound to be a great improvement in the safeguarding of the workers' lives and limbs in factories and workshops.

May I not suggest that there is also a great need in extending the standards not only to safeguards and safety devices, but also to the sanitation and general hygienic environment in industrial establishments. May I also make the suggestion that your Society endeavor to introduce the study of safety engineering in the various technical and engineering schools so that the future managers and heads of industrial establishments should be fully prepared to put into practice all possible safety devices for protection of workers.

Another suggestion would be that the description of safety devices should be couched in a simple and, if possible, non-technical language so that the workers and mechanics may be able to understand them and put them into practice.

THE AUTHOR. I desire to express my appreciation of the interest which my paper has created, as indicated by the discussion.

[1] Director, Joint Board of Sanitary Control, New York.

MODERN MOVEMENT FOR SAFETY FROM STANDPOINT OF MANUFACTURER

BY MELVILLE W. MIX, MISHAWAKA, IND.

Member of the Society

THE successful salesman is the man who first sells himself on his proposition, who becomes so saturated with its merits, so enthusiastic in his beliefs that conviction is automatically transmitted to the buyer. Substantially the same principle holds with the modern safety movement; no manufacturer will make real progress in the movement until he takes a personal interest in it, and is able to transfer his enthusiasm and earnestness to those directly in charge of work and, through them, in turn, to the workers themselves. A form of evangelism is required that arouses the spirit of all concerned.

In these days of Workmen's Compensation and high damage awards in employer's liability suits, the manufacturer will not be slow to grasp the main idea that "saving is earning," and act accordingly. He will find that the market is full of "guards" of all kinds for all sorts of protecting purposes and places, and a large supply of propaganda calculated to encourage him to spend money in an endless way on preventive appliances. He will find an army of inspectors ready and active with unlimited recommendations and orders for every machine and for every nook and corner of his factory. He may be pursuaded to buy them all and to protect without limit, but if he is not himself converted to their efficiency and need, and if he has not the coöperation in spirit of his employees, foremen and superintendents, his financial investment in them counts for little.

In no place is there a better or more practical way to develop the "save my pal" movement than in a factory or mill. Not only must the worker look out for himself, but his every thought, when engaged in hazardous work involving operations with which others have to do, must be "how about my fellow worker?" When in a factory organization such thoughts become automatic from president to "sweep," then money spent for guards becomes a real capital investment; but without that spirit its principle effectiveness is to expand the inventory and keep up the insurance rates.

We spend thousands of dollars in fire protection in order to reduce the hazard and save in operating expenses. We drill our factory fire brigades without thought of the cost, because we are educated by actual experience to realize what such losses mean in actual money and stoppage to business. It has taken years to learn the lesson, but we have done so, and fire protection is a recognized essential part of wise business administration. We do not stop at the installation of fire prevention appliances, but we put them under constant, careful inspection: we instruct every man in their location and uses; we leave no stone unturned to insure the effectiveness of the apparatus when called upon.

But, with safety "guards," until we can see the same benefits in providing the same relative protection to the individual, until we can bring him to see how it affects him physically and financially to "keep right with the guards," we fail to realize the full benefit of the investment of money and time spent in education. As a concrete example of what may be accomplished in this direction, I give here figures (Table 1) showing the experience for the past five years of the company with which I am associated.

A wage bonus of two days' extra pay for all men in a department having a perfect score for one year was based on the general effect of a cash bonus, but more particularly on the fact that a man will do for the benefit of the gang or department what he would consider beneath his dignity to do to safeguard himself against minor accidents.

We have numerous cases on record where men have cautioned each other with the admonition that such recklessness would endanger the standing of the department. One instance where a foolish act of one man lost two days' pay for a whole department has proven a wonderful object lesson to the entire plant.

In these days of scientific management and administration, there may be a tendency to the thought that, as such things do not seem to show immediate cash credits on the balance sheet, their importance may be set back for the moment for motion studies, rewards on operations, etc., but there is no economy in tolerating a condition that may require new men to be broken in to replace those impairments which a little time spent in educating men and in arousing them to the Safety First pitch might have avoided. It is impossible to place a money value on a pair of eyes, a leg or an arm; and while the expression "the human scrap heap" displeases us, we must know that there is such a thing, and that the right word at the right time may be effective in saving a fellow worker from that untimely and unseemly misfortune.

TABLE 1 COST OF ACCIDENTS COMPARED WITH PAYROLL, AND TIME LOST COMPARED WITH TIME WORKED

Five Year Record

Year	1910	1911	1912	1913	1914
Total cost of accidents for each one hundred dollars of annual payroll, including first aid, hospital, bills and claims, if any..	$0.503	$0.228	Score board adopted $0.112	Score board in use. Actual cost $0.079	Score board in use. $0.070
Time lost due to accidents beyond the fraction of the first day. Percentage of number of men-days lost to the total number of men-days worked....	No record kept	No record kept	Fraction of 1 per cent 0.394	Fraction of 1 per cent 0.1924	Fraction of 1 per cent 0.1165

Why not be practical and do all we can whenever we can to prolong the usefulness from the physical standpoint, if from no other, or every man or woman that we employ. Experience has developed that guards are not especially effective if, with them, we do not have the coöperation of the workman. If we make things automatically safe, we are quite as apt to do the worker an injustice in weakening his own spirit of self-preservation. Workers must recognize danger—they must respect it, and be ever watchful in every phase of life as well as when at work. The family must have it drilled into them; schools must preach and teach it; the citizen must be a party to the campaign of education, as only in that way may we be assured that the practice of "Thinking First" comes before Safety First.

Out of 30,000,000 male workers in the United States, about 7,250,000 are engaged in the general manufacturing lines. The annual loss due to fatal accidents is about one to four thousand, the lowest of the eighteen principal occupational groups; yet from the standpoint of public attention, the manufacturer is held up before the public as the cause of

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nearly all of the physical suffering and loss due to occupational disaster.

This situation would not exist if the manufacturer were more personally interested and inclined to fight for his rights and a proper recognition of his standing on the score board of national employment. Out of 22,500 fatal accidents in 1913, only 1819 are attributed to the manufacturing occupations—comparatively small indeed. Yet it can be much smaller if we will only approach the subject from the personal standpoint, evangelize with our employees, and arouse in them a spirit of coöperation and thoughtful, prudent regard for themselves and their fellow workers that will be automatic, and a habit for protection and carefulness, of which they cannot break themselves even if they should wish to. That is the manufacturer's work today.

Numerous plans have been devised for arousing and maintaining this personal interest; score boards, bonuses, special favors to winners, lectures, moving pictures and many other plans are being used. To the extent that a management believes in these plans and encourages their uses, just to that extent will it be rewarded with the association of an unimpaired, efficient organization of contented, prosperous workers.

DISCUSSION

LUTHER D. BURLINGAME agreed that while we are giving attention to the matter of guarding and protecting our machinery and buildings, we should give equal, if not greater, attention to engendering the spirit of safety among our employees, and should consider the various means which can be used to develop the safety habit among the workmen.

He was not fully in accord with the author as to the statement that putting guards on machines might make the workmen lax in regard to safety matters, and therefore increase the hazards rather than otherwise. He believed we should do all the guarding possible, and protect the machines as fully as possible. Even then there will be hazards enough to keep the workman alert and make it advisable to preach safety in the organization, and preach it so hard that the spirit of the workman shall be that a part of his value lies in working in a safe way, and that the spirit of the foreman shall be that a part of his value lies in seeing that his workmen work in a safe way.

FREDERICK R. HUTTON. I would like to contribute something to the statement that "a man will do for the benefit of the gang or department what he would consider beneath his dignity to do to safeguard himself against minor accidents." There is a splendid philosophy in that sentence. The difficulty with many of us is that we are inclined to take the position that we are immune from accidents which might befall someone else less fortunate. If, therefore, we can safeguard the less gifted alongside of ourselves and make that protection our responsibility, we shall have done a great deal in securing safety.

To this end, I would like to emphasize the creation among the working people themselves of committees of safety. After a workman has served on such a committee, and has himself seen the philosophy and importance of the habit of safety, he will not only find it very much easier to protect his reckless neighbor, but he himself will not offend. He will keep himself from doing that which, as a member of the safety committee and serving to prevent accidents for a week, or for a month, he was called upon in an administrative way to prevent in someone else.

FRANK E. LAW emphasized the point that securing the coöperation of the workmen was often more important in preventing accidents than installing safety devices. He instanced the case of a large manufacturing corporation which had spent upwards of five million dollars in safety work. It had been estimated that not more than fifteen per cent of this vast sum had been *directly* effective in preventing accidents, but the money had been well spent because the expenditure resulted in securing the coöperation of the workmen. When the employer himself does all that is reasonably possible, he is pretty certain to evoke coöperative response from his employees.

JOHN H. BARR fully agreed that the importance of the educational work is frequently greater than that of merely providing guards. He said, however, that the Committee on Protection of Industrial Workers had decided its work should be confined, at least for the present, to an attempt to develop and bring about the adoption of standard Safety Codes, because so many other organizations and agencies are working very effectively on the educational side.

The influence of this Society, he believed, would help in the adoption of such standards, whereas other organizations have made a specialty of propaganda work. He said the committee is fully in sympathy with this work and desires to coöperate, but it has selected what is conceded to be the narrower field, because it seemed to be the one in which it can work with the best effect at the present time.

CARL M. HANSEN said that the standardization of the human equation is a factor he did not believe anybody was able to cope with. He thought we should confine ourselves as nearly as possible to mechanical details of safeguarding.

LEONARD WALDO said that he had noticed that in some of the great steel works the safety first idea has so permeated the administrative staff and the men that you will find notices constantly posted for semi-weekly, weekly and bi-monthly meetings on safety subjects. Prizes are offered for the best safety work; certain men are appointed to supervise safety matters around the different parts of the plant; highly organized hospitals are established, and there is a wonderful movement on the part of the intelligent control of great works towards safety among operatives.

A bad accident almost invariably occurs because the sense of danger is not present, on account of some new modification or some novelty of the process. If we codify our rules of safety, we have been of the greatest possible help to the administration of the Safety First movement.

In all our occupations new forces are coming into use every day; in regard to these new forces there is no explanation or codification of what the possible dangers are, and many people are injured.

F. D. PATTERSON[1] said that from the standpoint of manufacturing, safety paid dividends not only in dollars and cents, but also as a matter of fact in added happiness to every employee, by the prevention of industrial accidents.

He dwelt on his experience at the plants with which he is connected, showing that before active safety work was undertaken the accident curves were mounting upwards, but upon adoption of safety measures, these plants not only had their experienced men saved from injury and available for productive labor, but thereby avoided the necessity of having inexperienced workmen laboring in their place; and he em-

[1] Director, Dept. Sanitation & Accident Prevention, Harrison Bros., Philadelphia.

phasized the fact that from the accident standpoint the new employees form one of the perils of modern industry.

He considered that the work in accident prevention in industrial plants comprises two distinct features:

a Guarding of all accident hazards by mechanical guards which will reduce the number of accidents approximately 20 per cent.

b A campaign of education bringing home to every workman the facts that he is personally responsible for the accidents that occur and that he ought to constitute himself a safety committee of one to see that accidents do not occur either to himself or to his fellow employees.

THE ATTITUDE OF THE EMPLOYER TOWARDS ACCIDENT PREVENTION AND WORKMEN'S COMPENSATION

BY W. H. CAMERON,[1] CHICAGO, ILL.

Non-Member

THERE was a time when workmen were expected to assume the hazards of their work, and employers, through insurance companies, paid as little as possible for accidental injuries or death. In one State only seven deaths in the hundred were paid for. Employers were not inhuman—workmen were careless or reckless and simply suffered for their foolishness.

This condition has changed. In thirty States the democracy has said that the financial burden shall be borne by the industry. This meant social and industrial revolution. Many employers predicted that the whole movement was a transient outburst of humanitarianism and that it would die out in the course of time, just as fashions in clothes changed. There were others, however, who had an overwhelming sense of the safety movement, who realized that it spelled industrial efficiency and justice and was a symptom of progress in civilization.

The census reports do not show the number of employers for or against Workmen's Compensation Laws, or industrial safety measures, but a radical transformation in relationships to this problem has brought about many and varying attitudes towards it. This paper is an attempt to interpret these tendencies in as unbiased a manner as possible.

Interest in accident prevention is not new. For many years our Government has been a leader in providing a measure of protection for mariners through the lighthouse and life saving services, the Interstate Commerce Commission has ordered the use of certain safety appliances for railroad cars, and other agencies have contributed to the general movement.

About twelve years ago, however, America began to realize that preventable industrial accidents were a national evil of appalling magnitude. The agitation for Workmen's Compensation Laws brought forth astounding facts and figures. It was shown that both the number of accidents and the economic losses occasioned by them were increasing in ratio more rapidly than the output of our industries, but it was not until the extent of the evil became fully apparent that the safety campaign began.

For many years labor unions had demanded safeguards for machinery, and we had on our statute books various kinds of safety requirements, which, though perfunctorily observed, were not really enforced. As soon, however, as Workmen's Compensation Laws transferred the burden of industrial accidents from the workman to the industry, the "Safety First" movement began. Mention should be made, however, of some of the large corporations who had "seen the light" several years previously, and had voluntarily taken decisive steps not only to safeguard their employees, but to compensate every injured workman.

Under the stimulation of self-interest, national commissions, Governmental bureaus, employers' organizations and chambers of commerce began a serious study of the causes of accidents and a possible means of preventing them—the methods of minimizing the losses from accidents. Finally, there has resulted a full and free interchange of ideas through various engineering and industrial organizations and through the National Safety Council, which has made the work immensely more effective.

The effects of this work were another triumph for method when applied to the social and industrial question. The work had previously been done in a haphazard and unscientific way, and was, in consequence, very unsatisfactory.

It should be further stated that it was commonly assumed that the rapid increase in industrial accidents was inevitably caused by the growing use of power driven machinery. This view has been shown to be far from the truth, because the majority of industrial accidents are not caused so much by machinery as by carelessness in its use—carelessness proven to be very largely preventable through extensive and thorough educational methods. The employee "took chances" and the employer expressed his attitude on the subject by the slogan: "Get out the work." The man who received his approbation was the man who "did things" and accidents were accepted as part of the price of success. This fallacy had to be very obvious before it was exploded.

This attitude of mind was reflected in the state of the law, which held that while the employer was bound to carry on his work in a reasonably safe manner, in a reasonably safe place, with reasonably safe tools and reasonably safe workmen, reasonable safety did not require him to take undue precautions, the hazard being put on the workmen through the three archaic common law defenses, viz., the fellow servant doctrine, acceptance of risk, and contributory negligence. In other words, the employer was not bound to abolish the danger spots even if they were vital to production, and did not place him outside of the "reasonableness" test. The common law held that the employer was not under any obligation to provide guards, unless they were required by a special statute. The real cause of the acceptance and growth of accidents was the general and philosophical acceptance on the part of both employers and workmen that nearly all accidents were due to the "human equation" and an inevitable part of the business, and that it was impracticable to guard against or prevent them. There was no true appreciation of the causes of accidents, and, therefore, no logical plan put forward as a remedy.

The first step in accident prevention was to disprove this doctrine and to show that accidents were unnecessary. This could only be done by serious study of the causes of accidents, and a willingness to invest time, money and brains in remedial methods. Sentiment may make men anxious to abolish accidents, but "self interest" spurs them on to collect and classify accident statistics, to hire competent engineers to devise methods of accident prevention, and to spend a

[1] Secretary, National Safety Council.

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great deal of money in making these methods productive. That is why effective safety work coincided with the introduction of Workmen's Compensation Laws. Credit should be given, however, to the concurrent growth of a larger belief in the doctrine of fellowship; and feeling of responsibility for the welfare of their men on the part of a large number of employers has been a powerful adjunct to the force of necessity in bringing activity to a focus.

It was also feared that if machinery could be safeguarded, or changed in character, or operated at lower speed, economic operation of industry would be interfered with. This, too, has happily been proven untrue, for good safety work has been found the partner and part of efficiency; for, being simply the study of the right and orderly way to do things, it has aided shop methods and economy in a very marked degree. Safety work has, therefore, evolved as a great constructive economic force in industry, as well as a social and humanitarian one.

What then is the present attitude of employers toward effective methods for reducing industrial accidents, and paying for every personal injury suffered by workmen under Workmen's Compensation Laws.

The ultra-conservative type of employer is not yet awake to the modern methods of accomplishing results. He is often the man who has come up from the ranks, or the one who has inherited the established customs of his forefathers—the employer who feels that he only gets as much work out of a man as he can force out of him—that industry is a struggle between two men as to who will get the "best of the bargain." This type of employer has not taken kindly to the suggestion of his responsibility for safe methods of doing work in his shop. His attitude is that he owns the business—that he has the exclusive privilege of directing it, and the suggestion that his foremen or workmen be asked to tell him where the dangers of the business may lie is obnoxious to him and wrong in principle. He is afraid that if his workmen are organized into accident prevention committees this will encourage the union idea among his men. The Workmen's Compensation Law forces this type of employer to study more carefully the causes of accidents suffered by his employes, and because he has to pay the cost of the accidents he may be converted and study the results secured by other employers through more humane measures. He will first have to learn to do business by the coöperative method, and if he wants to eliminate the excessive cost of accidents he must realize that his employees should be recognized as having a part in the organized plan to eliminate accidents. He must be willing to educate his workmen in safe practices—the right way of doing things—to study their operation of the work in his shop from the standpoint of safety, and make his workmen understand that "Safety must be the first consideration."

A second group of employers may be said to occupy the "middle ground." These are the employers owning modernly constructed plants, well ventilated and illuminated and clean and orderly—and who take a moderate interest in the safeguarding of machinery, if it does not cost too much money—but who do not believe in "new-fangled notions." This employer is shocked by the horrible details of an accident, but considers himself to be a model of propriety in his own personal relationships. He would resent any insinuation that he was not vitally interested in the welfare of his employees. At the same time he is rather slow to accept new conditions—he believes in all the rights of the "boss." He is averse to publicity methods concerning accidents; he dislikes criticism or any intimation that there may be anything wrong with the operation of his plant. A large percentage of the owners of small plants may be included in this category. This applies particularly to employers whose businesses are not generally considered to be of an especially dangerous character. Employers in this group have not actively opposed Workmen's Compensation Laws but are apt to support associations who boost propaganda against radical legislation.

The attitude of the third group may be termed that of the progressive type—the pioneers in the accident prevention movement. The large employers of labor, the leaders in industrial life, and the employer who is himself working earnestly for the welfare of the race, are among those who have taken the lead in making an effort to solve the accident prevention problem. They are in favor of a fair and equitable Workmen's Compensation Law. They have equipped their plants with sanitary toilets, locker facilities, modern washrooms and recreation centers, and do everything within their means to make their work places attractive and comfortable.

This class of employers asks safety engineers to review plans for new shop buildings from the standpoint of safety and comfortable working conditions. Tacitly they confess to their employees that they may not have done their full duty towards them in the past in providing safe working conditions, and urge coöperation by encouraging the men to work with them in establishing safe working practices to eliminate as many of the hazards of the industry as may be possible. They organize their workmen into committees for the purpose of getting their suggestions in making conditions safe, and carry on a vigorous educational campaign to teach the workmen the real causes and remedies for accidents. These are the employers who reduce accidents in their plants from 25 to 85 per cent, and whose efficiency account shows savings up to many million dollars per year. These employers unanimously declare that results are securable from safety work commensurate with the time and effort put into the task. One of them has recently stated that his investment for safety has brough a tangible return of 80 per cent.

The increase in insurance rates for protection from liability under workmen's compensation has brought about a revision in the methods of establishing premium rates, and now, through the (so-called) "merit rating system," this group of employers realizes the benefits of making their plants safe.

To summarize, from the anciently accepted attitude of indifferent or ignorant acquiescence in accidents has come:

I An awakening, caused by
- *a* publicity that has compelled a realization of the inhumanity and fearful economic waste of accidents
- *b* the discovery and growing conviction that accidents are preventable

II The employer has proceeded to prevent accidents
- *a* impelled by his humanitarian impulses
- *b* spurred by compensation laws that put the burden and responsibility on the industry and employer, and sweeping away the old outgrown customs and laws

III The result has been
- *a* a great and gratifying reduction of accidents through mechanical safeguarding and education of workmen
- *b* the discovery that good safety work has been a big money saver over the old accident conditions
- *c* the discovery of the great constructive value of safety work, it proving to be a study of the proper way to accomplish manufacturing results and, therefore, a great aid to industrial efficiency and economy

d the bringing of employer and employee together on a common ground of mutual interest, thus producing a fellowship and good feeling and coöperation in industry that nothing else could have accomplished.

Aside from the attitude of the three groups of employers referred to, it should be stated in all fairness that when the history of the safety movement is written a great deal of credit will be given to the employer. It has been due to his study and interest that the cause of accident prevention has grown to immense proportions in an amazingly short time.

No better evidence could be given of the attitude of employers toward real interest in accident prevention than the development and growth of the National Safety Council. The council was organized by a group of representative employers as the result of a safety meeting held in Milwaukee in 1912. The headquarters of the council were not opened until October 1913, but within a period of two years this organization has secured a membership of over 1600 employers, representing 150 industries, included within which are 5500 representatives located in every State of the Union, except two, and in many foreign countries. These employers have voluntarily joined the council for the purpose of formulating information to promote the cause of accident prevention. Through the dissemination of the collective experience of the members of the council of various methods adopted to eliminate accidents, a great deal of light has been thrown upon these problems. The National Safety Council has organized twenty-three active local councils in various parts of the country from San Francisco to Boston. The Fourth Annual Congress was attended by over 1500 employers, or their representatives, and for attention and interest this meeting has rarely been excelled.

Some employers predict the most far-reaching effect from the safety organization plan in bringing the employer and employee together into closer relationship, by obliterating the class feeling which has kept employer and employee apart. When both sit down at a safety meeting to discuss a problem of common interest, there is apt to grow up a better understanding of the aims and purposes of each party. If the employee has imagined in the past that the employer's indifference has been the cause of accidents, he soon learns that the remedy lies principally within himself.

While it is realized that many employers are not yet in sympathy with many of the aspects of the accident prevention problem, and that the Workmen's Compensation Laws are defective in many ways, it is believed that both employer and employee will profit by the new status of the work and will gain a new and better view of their industrial obligations.

DISCUSSION

John Price Jackson. I believe that this paper is a clear review of the attitude of the employer in Pennsylvania toward safety, and the work that is being done. From the point of view of safety legislation, the situation to-day is that practically every State in the Union now has something in the nature of what may be called an Industrial Board. In many cases there are obligatory laws which are enforced by these Boards and the accompanying inspection forces, but many of these laws are often imperfect and without uniformity over the whole country. Suppose Pennsylvania, through its Board, calls for a certain kind of guarded lathes, and Illinois calls for another kind, and Indiana for a third kind, then undoubtedly waste and useless expense is involved. There are a great many kinds of machinery where a great many types of guards can be used, and therefore, where the Boards can make a great differentiation and cause unnecessary lack of uniformity by specific requirement.

If such a body as this Society, through its Committee on Protection of Industrial Workers, can put on record a reasonably sound practice for providing all of our industrial machinery with safety devices, then the Boards, instead of making haphazard rules and regulations, may be guided to make rules according to this practice.

We have another group of laws growing up—compensation laws—which have been adopted in nearly every State. Under these laws an employer who saves human loss of life and capacity as carefully as he now saves fuel loss, is actually going to save many dollars in his actual outlay, and also in his insurance rate.

There is a very material opportunity for financial saving by having available acceptable practices for the installation of safeguards and safety devices.

The subject of safety organizations and safety methods, though more a matter of management than design, is of even greater importance than that of safeguards. It should, therefore, have the careful consideration of this Society in order that the best methods may be outlined for the development of carefulness on the part of all connected with an industry.

Summarizing, my thought is that this Society of the Industries, with the help of its whole membership, should put on record conclusions and opinions which will be the directive force in the safety movement, and will keep this movement in the right direction, both as to the laws that may be passed in the several States, and as to the methods that may be used by the manufacturers themselves, and by the Industrial Boards and safety and inspection officers.

Charles Whiting Baker. In the general discussion of safety, a fact which is often ignored, is that safety is always a relative term, and that there is no such thing as absolute safety.

We cannot prevent all accidents, but what we can do is to make reasonable requirements that will raise our standards of safety. The question then arises as to where shall we draw the line. This is a matter which can only be determined by the engineer from experience and expert knowledge.

There is another serious side of this subject, and that is the question of fixing responsibility for accidents. As engineers, we should always remember to have some charity for the men who are responsible. It very often happens that the accidents which occur may have come from some cause for which any of us might have been responsible. Ignorance of some of the simple principles of physics on the part of some of the wisest is sometimes responsible for serious accidents.

Lew Russell Palmer. The engineer is playing a greater part every day in the work of accident prevention. Engineers, as a rule, stand for efficiency. There is nothing that indicates inefficiency in such a marked degree as a useless waste in human energy. Plant managements woke up several years ago to the fact that they could produce double the amount of material with the same number of men if they installed proper appliances and safeguards. Safety work is another application of the efficiency idea.

Mr. Cameron states that cooperation is the keynote of the work, and we need cooperation, both from safety organizations and State and National organizations of engineers.

STANDARDIZATION OF POWER PLANT OPERATING COSTS

BY WALTER N. POLAKOV, STAMFORD, CONN.

Member of the Society

THE aim of this paper is to outline the principle for a method by which the owners of power plants can, without the necessity of going themselves into technical details of operation, judge how close the actual performance of the plant is to the possible minimum cost at any time or under any circumstances, all variable factors beyond operating control being automatically adjusted.

THE cost of manufacture of power or any other commodity, being a result of numerous factors involved in production, is in final count the chief criterion upon which the market price, range of use, legislation, future developments, social welfare, etc., are depending. Few if any of these questions can be intelligently answered from the knowledge of actual costs, owing to the effect of an unknown factor—degree of perfection of the actual performance. The importance of an accurate knowledge of the meaning and significance of actual cost data to the financier warrants the development of a method whereby a cost report tells:

a What the power costs
b What it should cost
c Where the loss has occurred
d Why the loss has occurred

These questions answered, elimination of waste is a comparatively simple engineering problem.

Standardization and predetermination of cost of power production have never before been considered as possible undertakings, and their advantages were thought questionable. Predetermination of operating costs has not been made use of for other than estimates of probable future expenses prepared by promoters or contractors. These estimates are usually based, as is always the case in work of such nature, either on past performances modified by expectations, or on data obtained from actual performance of another plant considered as similar. The accuracy of such estimates depends at least on the following conditions:

a How reliable were the cost records used
b How near the possibilities were realized
c How close is the similarity of the equipment of plants under consideration
d What effect the location has
e What effect the nature of load has
f What effect the labor market produces
g How completely the future factors were foreseen

Since there is, however, no assurance that in the *sample plant* the operating methods are perfect, neither is it reasonable to expect that another plant is in every respect identical to the *sample plant,* and the value of such guessed operating cost is highly problematic.

Realizing, on the other hand, that such estimates are inevitably colored by the personal sympathies and prejudices of the estimator, a demand for a class of disinterested counsellors has been created. As the financial and not the thermodynamic side of the question is more vital in the eyes of the investors, the predetermination of results of power production is often entrusted to public accountants who may or may not be fully equipped to account thoroughly for the influence of such factors as chemical and physical properties of available fuels on efficiency of boilers and furnaces, effect of load and machine factors, water rate of turbines under predominating condition of load, role of power factor, wattless current, phenomenæ of electric transformation, transmission, drop of voltage in distributing lines and numberless other factors affecting the cost of current either directly or indirectly.

PREVIOUS EFFORTS TOWARD STANDARDIZATION

Urgent need of dependable measure for financial efficiency of operation prompted managers and owners to compare their operating cost data with those available from other plants. An attempt to form an opinion whether one's operation is as economical as possible by comparison with operating data from other plants whose equipment and service is more or less radically different would be absurd were it not for the want of a better method. Table 1 presents examples of such typical effort to make use of cost data comparing monthly cost reports of seven central stations. Their equipments are widely different; no two of them use the same grade of coal; the arrangement of machinery requires in some cases double the number of attendants; one is generating electric current for a trunk railroad, whereas others supply suburban and tunnel traffic or even private consumers, with consequent differences in characteristic of current, distribution of load and peaks during the day, etc. Under such circumstances, to say from those data that one is operating more efficiently than another is at least too presumptuous.

The most interesting attempt to devise means for more rational cost studies was offered by Messrs. H. G. Stott and W. S. Gorsuch (Transactions A. I. E. E. 1913, Vol. II, p. 1619). Yet the use of various factors tending to compensate for differences in fuel, load factor of load, labor cost, etc., are evidently inadequate. Prices per heat unit in shape of fuel, if adjusted, do not ascribe the differences in cost to either inherent efficiency of boilers, furnaces and stokers, or to the methods of firing and the personal element of attendance. The effect of load factor corrections is entirely offset by existing differences in the water rate of turbines and influences of auxiliary apparatus in the plants under comparison. Payroll correction factors established on the basis of mere pay-rates is erroneous, because of the size of units, floor plans, automatization of certain operations, etc., not mentioning the fact that generally low pay to attendants results in high cost per kilowatt-hour, usually on the coal item and often in maintenance. Even if these factors of correction were unquestionably correct, this method leaves the effect of supremacy of equipment efficiency unseparated from efficiency of methods of management. Finally, even if all factors are fully accounted for, the fact that one plant is equally economical to another does not tell how far each of them is from its possible degree of perfection.

The idea was voiced at the Spring Meeting of the Society in Buffalo, in June, 1915, by David Rushmore, that the oppor-

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tunity existed for standardizing cost accounting for industrial plants, and hoped that some member would lay before the Society a method and data for establishing such a standard. Proper tabulation and distribution of costs is, however, of lesser importance than a satisfactory method of analyzing the data collected. It is the writer's belief that the time is now ripe to consider these questions, at least in this one branch of manufacture, namely, generation of power.

TABLE 1 COMPARATIVE COST OF OPERATION AND MAINTENANCE OF POWER PLANTS—JUNE 1915

		A		B		C		D		E		F		G	
		Dollars, Total	Cents per kw-hr.	Dollars, Total	Cents per kw-hr.	Dollars, Total	Cents per kw-hr.	Dollars, Total	Cents per kw-hr.	Dollars, Total	Cents per kw-hr.	Dollars, Total	Cents per kw-hr.	Dollars, Total	Cents per kw-hr.
Operation	Labor														
	Boiler Room	2233.21	.036	1639.45	.056	2686.34	.025	4967.27	.0195	3076.18	.0318	3283.50	.0855	1133.95	.052
	Turbine Room	1116.52	.018	679.89	.024	1682.89	.016	3156.36	.0124	1471.10	.0153	1472.54	.0383	756.10	.035
	Electrical	1080.52	.018	522.75	.018	536.12	.005	982.22	.0039	1105.73	.0114	264.28	.0120	144.87	.007
	Superv.—Janitors and Watchmen	563.14	.009	531.99	.018	601.26	.006	1230.89	.0049	460.85	.0048	1061.43	.0276	149.80	.007
	Total Operating Labor	4993.39	.081	3374.08	.116	5506.61	.052	10336.74	.0407	6113.86	.0633	6281.75	.1634	2184.72	.101
	Material														
	Coal	20535.00	.335	7338.55	.252	29945.89	.285	73803.55	.2908	35260.67	.3648	11820.31	.3075	8587.80	.395
	Water	675.65	.011	59.56	.002	1618.32	.015	475.42	.0019	1353.96	.0141	789.18	.0205	30.69	.002
	Lubricants	84.02	.002	61.11	.002	44.88	.001	226.47	.0009	270.81	.0028	135.68	.0035	68.13	.003
	Miscellaneous Material	194.55	.003	157.30	.005	27.70	.000	2043.91	.0080	35.12	.0004	555.73	.0145	149.87	.007
	Miscellaneous Charges	20.91	.000	Cr. 1.55	.000	757.96	.007	...	...	...	...	...	...	129.87	.006
	Total Operating Material	21510.13	.351	7614.97	.261	32394.75	.308	76549.35	.3016	36920.56	.3821	13300.90	.3460	8966.36	.413
	Total Operation	26503.52	.432	10989.05	.377	37901.36	.360	86886.09	.3423	43034.42	.4454	19582.65	.5094	11150.86	.514
Maintenance	Labor														
	Building	40.95	.001	129.36	.004	190.19	.002	1312.28	.0052	140.91	.0015	77.35	.0020	2.35	.000
	Boilers	291.36	.005	319.27	.011	703.13	.007	641.67	.0025	751.72	.0078	279.49	.0073	139.45	.006
	Boiler Room Auxiliary Apparatus	173.89	.003	268.33	.009	594.54	.005	520.47	.0020	280.40	.0029	66.15	.0017	31.49	.002
	Turbines	1055.16	.017	27.49	.001	328.36	.003	55.50	.0002	361.42	.0037	286.24	.0075	1.84	.000
	Auxiliary Apparatus	142.08	.002	21.23	.001	561.59	.005	322.21	.0013	176.86	.0018	334.92	.0087	6.83	.000
	Electrical Apparatus	9.32	.000	1.50	.000	399.57	.004	119.43	.0005	353.12	.0037	85.69	.0022	1.23	.000
	Piping	85.83	.001	54.03	.002	389.61	.004	433.24	.0017	119.59	.0012	131.69	.0034	136.05	.006
	Miscellaneous	49.40	.001	55.06	.002	132.23	.001	55.69	.0002	396.04	.0041	1.92	.0001	23.78	.002
	Total Maintenance Labor	1847.99	.030	876.27	.030	3299.22	.031	3460.49	.0136	2580.06	.0267	1263.45	.0329	343.02	.016
	Material														
	Building	212.17	.004	99.98	.004	799.08	.008	3490.00	.0137	2.19	.0000	29.65	.0008	15.14	.001
	Boilers	295.16	.005	66.56	.003	895.22	.008	1389.30	.0055	702.81	.0072	169.67	.0044	457.45	.021
	Boiler Room Auxiliary Apparatus	50.22	.001	40.28	.001	836.39	.008	529.10	.0021	88.08	.0009	73.00	.0019	36.18	.002
	Turbines	78.42	.001	.25	.000	739.08	.007	27.48	.0001	18.35	.0002	78.08	.0020	5.54	.000
	Auxiliary Apparatus	41.08	.001	8.18	.000	1344.22	.013	68.04	.0002	143.86	.0015	1300.79	.0338	28.15	.001
	Electrical Apparatus	14.06	.000	.84	.000	138.89	.001	766.58	.0031	137.70	.0014	162.13	.0042	...	...
	Piping	20.69	.000	7.94	.000	220.35	.002	574.31	.0023	81.34	.0008	200.10	.0052	149.53	.007
	Miscellaneous	8.76	.000	2.13	.000	127.11	.001	82.47	.0003	209.01	.0022	...	...	60.60	.003
	Total Maintenance Material	720.56	.012	226.16	.008	5100.34	.048	6927.28	.0273	1383.34	.0143	2013.42	.0523	752.59	.035
	Total Maintenance	2568.55	.042	1102.43	.038	8399.56	.079	10387.77	.0409	3963.40	.0410	3276.87	.0852	1095.61	.051
Summary	Total Labor	6841.38	.111	4250.35	.146	8805.83	.084	13797.23	.0543	8693.92	.0900	7545.20	.1963	2527.74	.117
	Total Material	22230.69	.363	7841.13	.269	37495.09	.356	83476.63	.3289	38303.90	.3964	15314.32	.3983	9718.95	.445
	Total Lab. and Mat'l Pow. Sta. Proper	29072.07	.474	12091.48	.415	46300.92	.440	97273.86	.3832	46997.82	.4864	22859.52	.5946	12246.69	.562
	Other Items Chg. to Pow. Sta. Accts.	676.55	.011	676.55	.023	294.42	.003	2024.28	.0080	...	...	966.73	.0252	255.52	.013
	Total	29748.62	.485	12768.03	.438	46595.34	.443	99298.14	.3912	46997.82	.4864	23826.25	.6198	12502.21	.575
	Net Output in kw-hr.	6133065	...	2915417	...	10509685	...	25286650	...	9664081	...	3844419	...	2171400	...
	Total Power Generated, kw-hr.	6211195	...	2941018	...	10625545	...	25385400	...	9781610	...	4043803	...	2171400	...
	Lb. Coal per kw-hr.	2.68	...	2.72	...	2.18	...	2.062	...	2.682	...	3.78015	...	3.40	...
	Cost of Coal per 2000 lb., Dollars	2.50	...	1.85	...	2.613	...	2.803	...	2.72	...	1.61	...	2.33	...
	Load Factor—Machine, Per Cent	59.6	...	74.5	...	64.56	...	73.17	...	86.6	...	49.0	...	64.0	...
	Load Factor—15 Min. Max., Per Cent	45.3	...	23.8	...	36.37	...	90.44	...	58.1	...	35.0	...	112.0	...
	B.t.u. per net kw-hr. Output	38289	...	33513	...	30716	...	29561	...	38046	...	43627	...	49300	...

CLASSIFICATION OF EXPENSES

All expenses incurred in the course of power production fall under analysis into two main groups:

a Constant (within a certain range) for any output
b Variable in some direct proportion with the output

Expenses that are independent of volume of output are at the same time independent of each other and do not characterize the efficiency of processes performed in the power plant. Their effect on unit cost is represented by a parabolic curve decreasing with the increase of output. They are exemplified by interest on investment, depreciation, sinking fund, insurances, management, pay roll (in some cases), taxes, etc.

Expenses that vary with the output of the plant characterize, other conditions being constant, the efficiency of operation, and their elements stand together in dependent sequence. If represented graphically, they show very irregular shaped curves peculiar to each set of equipment. Unit cost has a general tendency to drop with increased output, as the efficiency of boilers, turbines, etc., tends to improve with increased load; yet as with higher degrees of overload the efficiency decreases, the unit cost rises. With further increase of load when an additional unit is started, the efficiency again begins to improve until their cumulative efficient capacity is exceeded, when the unit cost commences to increase again. Such waves are sometimes very pronounced and generally, throughout the range of the plant's capacity, the number of waves on the unit cost curve is equal to the

number of generating units installed. Fuel, water, certain supplies, and in less pronounced dependence, maintenance expenses, belong to this group of expenses, and for the purpose of classification of expense account, it is best to itemize them correspondingly to the steps in which the energy is transformed during the generating process.

The criterion of economy is formulated by the interplay of three factors, *time, product* and *cost.* When only one factor varies, its effect on economy can easily be foreseen. Thus greater product, without change of time required or cost, increases the economy. Increase of either time of production or cost of production reduces the economy. Generally, however, all the factors vary simultaneously, in which case the analysis of the equation of economy criterion $e = \frac{P}{ct}$ can be made for any influential element n, and the increase of economy of unit increase of n, if differentiated, is

$$\frac{P}{ct} = \left(\frac{P'n}{P} + \frac{C'n}{C} + \frac{t'n}{t}\right)$$

all elements essentially positive.

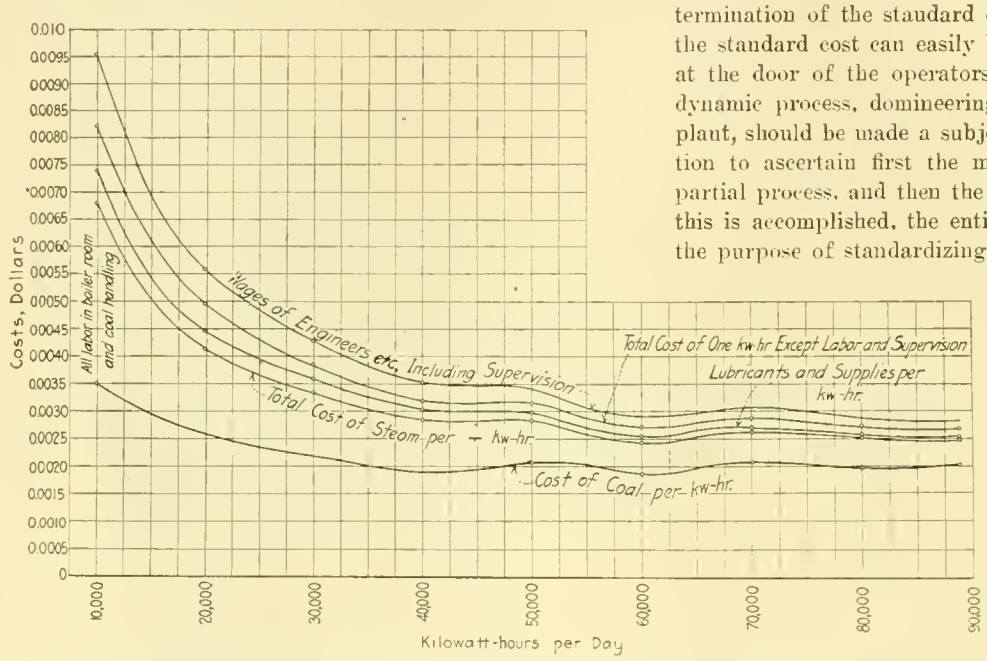

Fig 1. Curves Showing Variation in Standard Costs of Operation in a Public Utility Central Station

Such a general study can be made with respect to economy if more than one influential element is involved as simultaneous equations for each. The graphic method offers, however, an easier means of solving the problem. To determine the *economic limit* reached by continuous increase or decrease of influential elements is by no means an easy problem, but unless it is solved we are in the dark not only as to *what economy can be obtained,* but also *what changes in conditions and methods are essential.* The analysis of the effect of the variations of these elements involved in determination of *maximum limit of economy* can be compared to a determination of the height of the apex of a hill by taking altitude readings on both slopes in one direction and then repeating observations in the crosswise direction.

STANDARD COSTS

It is relatively unimportant whether the maximum limit of economy is determined empirically by rigorous observations, tests and analyses of all influential elements, or calculated from the principal data already available. *It is imperative that such study be made and the economy limit established, as this is the only criterion for judging the actual performance.* Carrying out the analysis of economy limit to its logical conclusion, the standard cost of product is arrived at, and evidently during this investigation, not only are itemized costs of individual partial processes found out, but the conditions and methods whereby standard cost can be attained are established. In other words, *unless the standard costs are established there is no measure of existing losses or exact knowledge how to eliminate them.*

Manifestly, in the course of determination of standard operating cost, such factors as inherent efficiency of equipment, its efficiency under different loads, prices of fuel and supplies, necessary and sufficient number of attendants and their compensation, etc., are already taken into consideration for a given plant. Any deviation observed between the actual operating cost and this standard cost indicates that some of the necessary conditions were not lived up to and, if standardization has been carried out in sufficient detail, it leads directly to the allocation of the loss to operating methods. On the other hand, any change in the basic data used in determination of the standard cost being known, adjustment of the standard cost can easily be made before the blame is put at the door of the operators. The efficiency of the thermodynamic process, domineering the operating cost in a power plant, should be made a subject of a most thorough investigation to ascertain first the maximum efficiency limit of each partial process, and then the result of their interplay. When this is accomplished, the entire process will be re-studied for the purpose of standardizing methods and adjusting for such a balance of efficiencies of partial processes as will secure the maximum profit or economy from the expenditure of time, energy and money involved. In this, it is sometimes found that the most economical thermal efficiency is somewhat below the maximum obtainable, as the slight additional gain in efficiency necessary to reach the maximum is not warranted by the expenditure required for its attainment. When these limiting conditions are studied and determined, a method can then be defined for each member of the working force, prescribing his duties and the conditions he must maintain to secure the *most profitable* degree of efficiency.

Upon the conclusion of these studies, the best efficiency of each unit and their combination being known for any load, the standard cost for any output in a given time unit can be conveniently represented in graphical form.

The principles of determining the standard cost of maintenance and upkeep of the plant and equipment are substantially the same; the method of study, however, is somewhat different. It involves a study of design and construction of all elements of equipment; minute records of their service and cost of maintenance may lead to a modification of design, use of cheaper renewable parts, etc. Next, the standardization of supplies, beginning in the laboratory and followed by actual service tests, helps to determine not alone the purchase price, but the lowest service cost. Finally, time studies embracing schedules for inspection, routes for maintenance

men, standardization of tools, motions, methods, etc., conclude the investigation. The criterion is, of course, not the wages of the employee, but freedom from accidents, breakdowns and the lowest attainable cost of upkeep per unit of the plant's output. It is evident that there may not be any theoretically certain standard cost of maintenance, but an empirical standard thus developed is generally but a fraction of the best actual records of the past.

CURVES OF STANDARD COSTS

Upon conclusion of this double analysis of the maximum economy obtainable, the graphs of standard cost of power production may be drawn. Curves may be conveniently arranged in the co-ordinates of cost C and product per unit of time $\frac{P}{t}$(output). It will then be noted that the time element is one of the most influential factors in power economy. Whereas in some cases, where the number of generating units is large, the coal-rate per unit of output remains fairly flat and the other items of cost reduce rapidly with increased production per unit of time, in other cases the standard cost of fuel also decreases as the time during which a certain output is produced is reduced. Figs. 1 and 2 represent curves of standard operating costs. It is evident that any number of curves may be plotted following the above method, each curve representing an itemized standard cost according to the adopted classification. Fig. 1 is thus prepared for a medium size public utility central station. It shows the variations of standard costs of coal, boiler room labor, water, supplies, overhead charges, engineers and supervision per kilowatt-hour at various monthly outputs. The cost scale does not show, however, the actual standard. This plant comprises four 600 h.p. boilers and three turbo generators, one of 2,500 kva. and two 500 kva. rating; it operates 24 hr. per day, 7 days a week.

From this diagram it appears that the cost of coal per kilowatt-hour is lowest when the output of the plant is approximately 1,900,000 kw-hr. per month. Further increase of output coincides with the increased cost for fuel required, due to the characteristic of boilers and turbines that they lose in their efficiency at higher rates of driving. Again, costs of labor, supplies, pro-rate overhead charges, etc., per kilowatt-hour, which drop more rapidly than the cost of fuel rises, offset the difference and render a greater monthly output more desirable economically. Even there, however, we meet a limit when at the rate of 2,200,000 kw-hr. per month the unit cost becomes higher than it was at the lower output of 1,900,000 kw-hr. per month.

Fig. 2 illustrates a few characteristic curves of standard cost per kilowatt-hour for various rates of output of a large central station feeding the lines of an electrified trunk railroad. The plurality of waves on the fuel cost curve, etc., is explained elsewhere in this paper and the tendency of total standard cost to go steadily downward with increase of the output rate is due to the plurality of generating units.

USE OF STANDARD COST CURVES

Practical use of such predetermined standard costs can be made extremely simple by the use of these graphs. For busy executives or owners, the entire cost record visualized by graphical representations of the items of account is found very convenient. An example of such a graph is seen in Fig. 3, wherein the actual unit cost and the standard unit cost are plotted to the same scale, the deviation of one from the other suggesting at a glance the degree of perfection of the performance. The total expense curve and the cumulative expense curve may be shown on the same graph to a suitable scale; the latter curve is found very serviceable for comparing these items with the appropriation made. A cost system kept on a card file in this manner will represent clearly in any desired detail for any length of time and at any period:

- *a* How much was spent
- *b* How much each unit of output cost
- *c* How much it should have cost
- *d* What the fluctuations of expenses and unit cost are
- *e* What the fluctuations of efficiency are
- *f* How close the actual amount spent in any time is to the appropriation.

The accuracy of such graphic records is sufficient for most practical uses and references, as it allows the interpolation of unit costs to 0.001 of a cent. If the exact total of expenditure is wanted it can be had at any time from the book records, whereas the use of books and figures exclusively lacks the comprehensiveness and visual instructive value of graphs.

Any comparison of production costs of various plants may now be made in a different light. By comparing standard costs of one plant with those of another, one gains the knowledge of how much cheaper the power can be produced in one plant than in another, due to its various physical advantages, corrections for load and output all being automatic. Again, by comparing how near the actual cost of one plant is to its standard cost with the difference between actual and standard cost of another plant, one has at once a measure of quality of methods and management. Thus, referring to our Figs. 1 and 2, the actual cost per kilowatt-hour of 35 cents in one plant means a worse operating efficiency than 48 cents in another plant under another load condition. Yet without such accurately predetermined standard costs that are individual for each plant and condition of load, no correct comparison is possible, and conclusions from a mere study of accountants' figures are apt to be grossly in error.

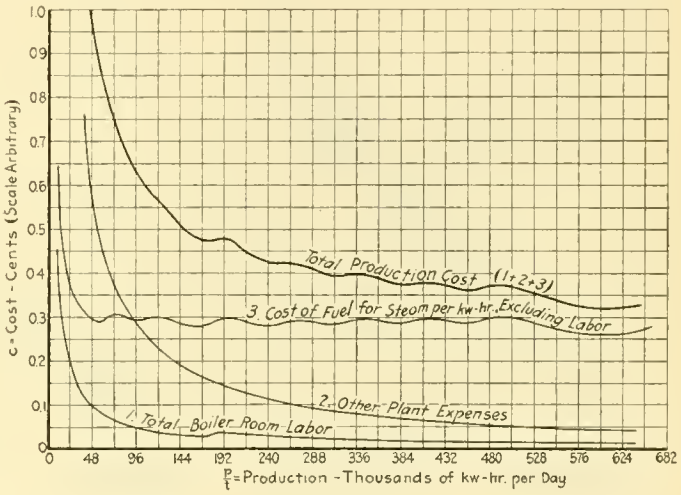

Fig. 2. Curves showing Variation of Standard Costs of Power Production at an Electrified Railway Central Plant

STANDARDIZATION OF OVERHEAD CHARGES

In the above discussion of standard cost we left out of consideration, however, a very important feature—namely, fixed charges borne by the plant. It is a very common policy to install in power plants considerable spare equipment, partly as a protection against possible breakdown and partly to take care of high peak loads. In both cases, it would not be logical

to adulterate production costs by the addition of all overhead charges incident to this idle equipment. If all charges due to policy, over-equipment, protection, spare units, new business anticipation and similar allied items are accounted where they belong—not against the operation—the cost of producing the current will appear constant unless prices of fuel, supplies, wages, etc., are changed or methods of management are not uniform.

Inasmuch as the spare equipment has a function identical to a stand-by plant at some distant point of transmission line or a breakdown emergency connection with a power company nearby, it seems entirely proper to segregate this portion of charges and treat them in the same manner as the bills of an emergency contract, *i.e.*, to carry the cost on a separate business account. The parallel between a breakdown connection contract and a plant's own breakdown reserve is apparent, yet it is only too often that the same concern, charging the bills on such a contract against the general business or protection account, insists that the power department shall absorb in its operating account all expenses accrued in the reserve plant or any part thereof.

The degree of safety and protection from interruptions with which it may be desired to maintain the service is dictated by the general policy of the concern; similarly, the decision to keep a stand-by station in readiness to go into service at a moment's notice or the policy of keeping within the central station a certain number of boilers banked, turbines warmed up and generators phased, should not obscure the cost and efficiency data pertaining to the generation of power. The expenses incurred in connection with such a *protective service* should not be charged to the operating or production account, but might be arbitrarily standardized, reduced or increased as the business policy might require and be *treated as an independent account.*

If, in the case of a plant built and equipped to produce twice the output it normally carries, fixed charges are dumped together with operation costs, it reflects unfairly on the ability of the superintendent and his operating force; whereas if they were properly charged to a separate account, the excessive charge against the stand-by equipment, both for fixed charges and running expense, would produce a stimulus for the new business, or commercial, or transportation departments to secure additional load. It is a quite common condition that these departments are not fully aware of the reserve capacity of the plant or plants or, on the contrary, secure more load than it is safe to carry permanently or until an additional generating equipment is provided. *Standard* cost of protective policy would act in all such cases as a gage on a tank of certain capacity with outlet and inlet valves subject to continuous adjustments. In other words, *the new business departments should at all times know the ratio between ideal protective costs* and actual cost of carrying the unutilized portion of power generating equipment.

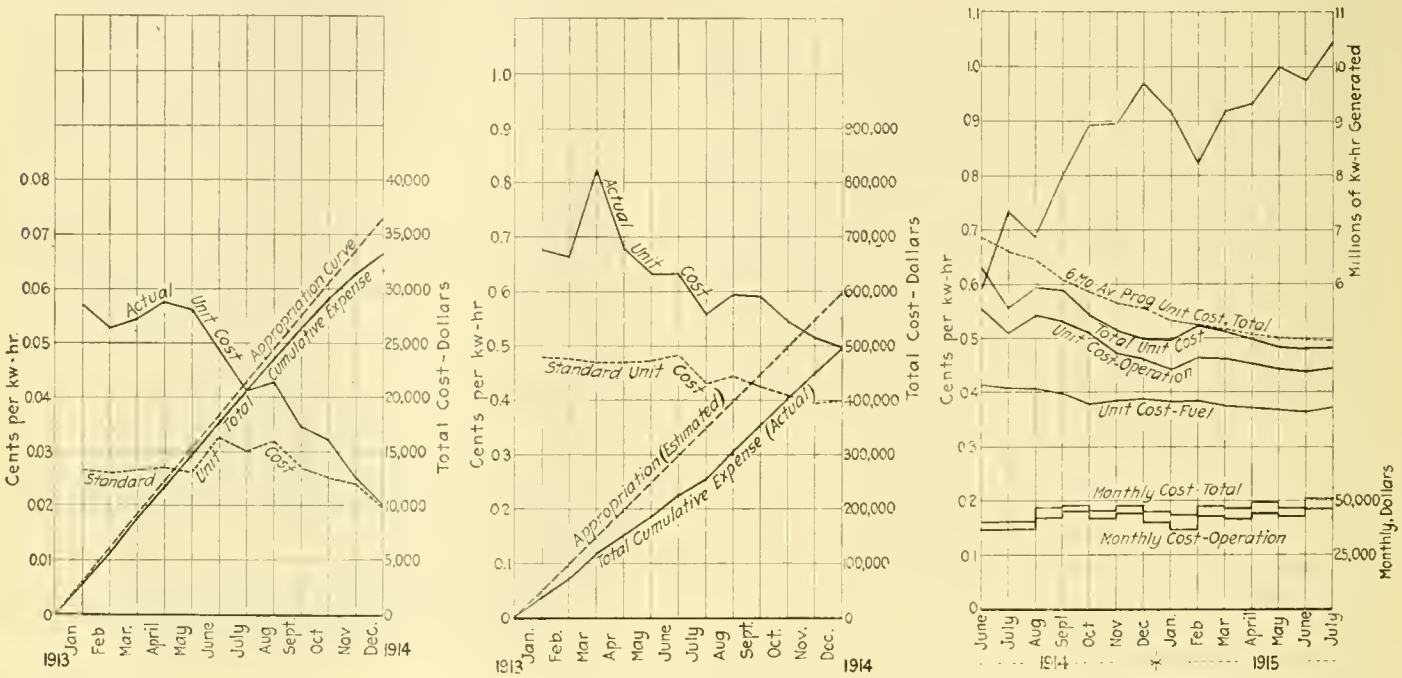

Fig. 3. Visualized Records of the Entire Cost of Power Plant Operation, in which the Actual Unit Cost and the Standard Unit Cost are Plotted to Same Scale

COMPARISON OF COSTS AND EFFICIENCIES

The cost system developed along the lines discussed will not only afford a means for clear understanding of operating and managerial problems, but offer a basis for cost comparison of different plants. The essentials of knowledge gained through a comparison of actual cost in conjunction with the standard are:

a Relative supremacy of plants proper
b Relative advantages of managerial methods
c Relative extent of preventable losses
d Relative advantages of prices of materials, etc.

These cannot be found unless there is a comparable basis or scale for comparison, which is offered by standard costs determined for each plant individually, as at least ten main variables must be accounted for, as follows:

a Nature of load
b Character of service
c Conditions imposed by location
d Inherent efficiency of equipment
e Arrangement of equipment, floor plan, etc.
f Cost-efficiency of fuel and supplies

g Legal requirements
h Methods of operation
i Labor conditions
j Methods of compensation for service

Each of these variables being in its turn a product of a plurality of factors, it is manifestly impossible to state, without the aid of carefully worked out standard costs, that the economy of one plant or another is satisfactory, or where and how it can be bettered.

Inasmuch as standard cost cannot be determined without first finding out how the maximum economy can be secured, the process of standardization of costs is also a process of devising the best way for operation and management. Once both methods and results are positively established, costs are but the form of expression of the final result. It is true that the standard cost is influenced by the price of commodities used in the course of generation of power, as well as by some conditions beyond the control of the management and operating engineers, but the adjustment of the standard costs to every change of these factors can be made as simple as the use of a slide rule. Furthermore, a separate account should be kept for such charges as are the part of business policy, so that a division of responsibility between those managing the production and directing the business could be drawn.

As long as costs of production of power come as an unexpected surprise and arouse the curiosity to an extent of comparing them with the preceding month, year, or any other plant's data—the management of such power plants is evidently a very haphazard undertaking, lacking the aim at any definite goal. Without pre-determined standards, superintendents and managers will continue to believe that they control the production and owners will remain in a happy ignorance as to how much of their money goes to waste and why. Only after the establishment of standards and ideal costs of production by means of the most rigorous analysis, will cost accounting be of help to engineers, and only then can it be said that the generation of power is directed by management and controlled by engineers.

DISCUSSION

R. J. S. Pigott (written). Mr. Polakov's instructive paper deals with graphic methods such as the writer is at present using in analyzing costs in the plant with which he is connected. Mr. Scofield of the Minneapolis Street Railway Company is also making use of similar methods, and has been for some years. In the Power Generation Committee report for the American Electric Railway Association for 1915, Mr. Scofield and the writer gave an analysis of steam power station cost along similar lines to the paper of Messrs. Stott and Gorsuch, in which Mr. Scofield gave in full the method of analysis of steam power station cost graphically.

There is another supplementary use of this method of analysis which is also very important, viz: laying out and selecting the apparatus in the design of a power station. The writer did a good deal of development work on this method while teaching at Columbia University in 1911 and 1912; earlier work was done by Horace W. Flashmann and C. E. Lucke. The method in general involves the use of the so-called Willans line, for both individual apparatus and for the station as a whole. The value of this method depends chiefly upon a thorough knowledge of the heat distribution in the plant.

William D. Ennis presented a written discussion in which he stated it is perfectly true that accountants' records in themselves are inadequate and that such records must be supplemented by more detailed information for engineering analysis; yet it must not be forgotten that the former records are the official and final figures, and that owners are interested only in the final result. They will not take kindly to the elimination of overhead charges on idle equipment from the operating account. It all goes in the jackpot. Furthermore, relative necessities for reserve equipment and breakdown service strongly influence the decision as to what is the best type of equipment for a given set of conditions. Certainly breakdown service is not provided for the sake of anticipated "new business."

While Mr. Polakov, who speaks from the operating rather than the design standpoint, regards the proper tabulation and distribution of costs as less important than their analysis, there is something to be said on the other side. Proper tabulation is the essential prerequisite for any sort of analysis, and in this respect our power plant management is defective or at least un-standardized. Table 1 gives operating and maintenance costs. It would be a matter of some complication for any power operator to line up these figures with his own. Different power companies classify their costs in different ways. There is not even a clear distinction drawn between the items "operation" and "maintenance." It would be a decidedly useful thing if we had a standard classification in power station accounting, such a standard classification as those used by all industrial corporations. The preparation of such a classification would be very properly the joint work of a number of national and commercial engineering societies, together with perhaps the representatives of public service commissions. It is too big a job for one man or even one committee. It should have been done long ago. Mr. Polakov's paper (perhaps unintentionally on the part of its author) emphasizes its necessity. The classification should be flexible enough to include any type of power-generating industry and specific enough to show at a glance the standard account chargeable for every possible item of expense. It should be accompanied by a standard list of subordinate data desirable, such as heat value of coal, load factor, service log, etc. Central stations would no more than at present be expected to publish their costs, but when costs were furnished, the reader would know without explanation the meaning of each item.

Geo. L. Fowler said that there is probably not one owner of a power plant in a hundred who has the slightest idea of what it costs him, and if Mr. Polakov can go out and persuade all the power plant owners in this country to find out what it costs them to run their engines and boilers, the saving he would be the means of effecting would be tremendous.

He related some personal experiences of what it costs to run a power plant under the condition of absolute apathy of the owners as to the conditions in the engine room. In one case he had found that the cost per horsepower per year in a number of plants in one town ranged from $28 to $150, and he thought this was typical of the condition of affairs all through the country.

He cited the case of an engine in which a slight shift of the eccentric varied the cut-off sufficiently to cause the efficiency to drop down 22 per cent, and he said that all over the country we have hundreds of engines in just that condition.

He admired the author's ambition in presenting this paper and endeavoring to get the engine owners of this country to accept his theory and work along these lines, but he thought the task was almost impossible of accomplishment.

Henry G. Stott. I think that by the word "standardization" in the title of this paper the author means "segregation," for he seems to advocate treating each plant by itself and establishing a standard for each plant. "Standardization" is to bring into one category a number of plants, each of which is different.

Real standardization can only be accomplished on two principal bases: *first,* the thermodynamic efficiency of the cycle used in the plant as compared to the ideal, and *second,* the measure of efficiency of management of the apparatus which has been put at the disposal of the man who is running the plant, and that is the cost of power.

There is no more complex subject than the cost of power, as there are so many elements entering into it. The paper touches upon only a few of these elements. Contrary to the author's statement, predetermination of results of power production is purely an engineering question, so far as the power operation is concerned. I have never heard of an accountant being asked to furnish an estimate of how much it costs to furnish power.

The items in Fig. 1 are interesting, but no basis is given as to how they are derived.

The author states the expense incurred in connection with keeping a standby unit should not be charged to the operation or production account, but should be treated as an independent account. That, of course, is absolutely impossible, because it is just as much a part of the cost of producing power to carry the reserve power as it is to carry the main unit in operation, and it is just as proper to charge a reserve unit into the cost of power as the operating unit.

W. F. Schaller. It seems that in attempting to establish a standard for any particular power plant, the coal and supplies used, the labor, to a certain extent, and also the method of keeping accounts, should be standardized. This leads to a series of accounts for power plants which can probably best be obtained from a central office.

A central power plant office of this kind can be maintained at rather low cost. For instance, one power plant in the vicinity of New York maintains such an office at an expense of about 0.4 of 1 per cent of the total payroll.

As to the proposition of figuring standby costs and charging them to separate accounts, if a plant has such a load that a number of extra boilers have to be kept on the line, and the plant is to be compared with another which has a steadier load, so that the smaller number of boilers need be kept hot in reserve, it is unfair to compare directly the coal per kilowatt.

William Kent. Some time ago we endeavored to learn what was the standard of performance for the woolen mills in the valley between Worcester and Pawtucket. We investigated the cost of production in every mill between those two cities, and obtained the steam cost as well as we could from data of boiler and engine tests, house books, etc. The minimum cost in a plant of 50 h.p. ran at about $110 per horsepower year. In a 2000 h.p. plant it was about $18. Plants which figured out higher than the minimum for their particular size were obviously variations from the standard.

The standard in this case was a first-class compound condensing engine with good vacuum and good boilers. Today we would say that this standard should be lowered. For instance $1 or $2 should be taken off on account of the use of first-class mechanical stokers.

For any plant, it is necessary to have the standard for the conditions, not the thermodynamic standard, nor the Diesel engine standard, nor the Carnot standard, but the standard for the best accepted practice in that size plant.

John W. Lieb. Mr. Polakov in his analysis has indicated, in addition to the analysis from the viewpoint of the operating engineer, certain factors, such as politics, business management, and fixed charges, which are not properly qualified operating costs, but elements of central station economics having to do with finance and management. From this point of view, the author has not been very happy in his standardization of terms. He starts out with a statement of production costs. Now production costs in central station economics have come to mean a definite thing. They are the items of operating cost comprised, for instance, within the standard classification accounts used by the company members of the N. E. L. A. They do not include any fixed charges, or general expense, but definite items of expense incurred within the walls of a power plant. They exclude all elements of interest, insurance, taxes, general expense, return on capital and depreciation of various kinds. They include merely the items that go into what is known as switchboard cost, which is a very specific and definite thing in the central station industry, and production costs are quite different from the cost of power.

In this question of production costs, some work has still to be done in the branch of standardization from year to year,—generally accepted standardization as to comparisons between which shall serve as the unit measurement of the production costs; whether that shall be the gross output of the generators, or the gross output less auxiliaries, or the gross output less excitation, or the gross output less lighting and power uses within the power plant, or the net output as delivered to the outgoing high tension feeders. Then, again, as to considering the load factors as the basis of comparison between one station and another, there is not a general agreement as to the time interval over which the so-called maximum demand on the plants shall be made, so that there is still adequate room for the standardization of production costs.

J. C. Percy. I believe that the system of standardized statistics, such as the United States Steel Corporation uses on their blast furnaces, is the greatest factor for improved operation. This guides the executive committee and aids each manager. By these statistics equipment, quality of material, chemical actions and skill in management are all compared. This leads to an improvement in operation which has no fixed limit for a standard.

Many of our large public service corporations, recognizing the value of this, have an elaborate system for the interchange of statistics and data.

The smaller power plants of the factories which interest many of us have not been touched upon; a greater good could come to these plants by establishing such a standard of interchange of statistics, giving a deadly parallel for comparison, than by a separate predetermined standard as given in Mr. Polakov's paper for each small plant.

J. A. Kinkead. It is evident that the central station plant and the isolated plant are separate propositions. There is no question at all that the large central plant can throw out obsolete equipment, and can employ the very best engineers to operate their plants, because their units are so immense that a very slight saving in percentage means a big saving at the end of the year. On the other hand, the smaller power plants cannot conveniently discard their obsolete machines and put in

new equipment, but it is of very great importance to the users of small plants to know whether their plants are being operated under the most economical conditions or not.

As I understand this paper, its idea is to give some basis on which to compare various power plants operating in this country,—not necessarily the central station power plants, because we know most of them are operated under the maximum conditions of efficiency.

Selby Haar. If a certain ideal condition is established, as suggested by Mr. Polakov, or one of a similar character, how long will it remain standard? Every hour even some improvement is brought forward, and the bottom is knocked out of all of our preconceived and carefully standardized ideas.

The Author. It is to be regretted that in the entire discussion drawn by this paper, both subject and method presented were not touched upon. It is true that an average owner of a power plant, as Mr. Fowler says, does not know much about the basic principles involved, but it is not true that accountants are never asked to furnish power cost data.

Mr. Lieb overlooks the division line drawn in the paper between production cost and overhead charges, and it is just the thing that the paper exposes as a harmful fallacy that Messrs. Percy and Ennis approve of. Again, Mr. Haar's criticism is applicable only to a hypothetical plant in which "every hour" a new improved equipment is installed, but the author's central and only idea in this monograph was silently accepted.

The cost of power is the result of method as well as of other factors. Price of commodity and labor used is known; efficiency of equipment used is known; nature of service is known, and their influence on cost of product is easily found from a comparatively simple study. In a given plant these factors remain constant until change is made by purchase. For different plants factors of merit could be established equalizing for the unequal condition. Now if costs vary it is due to variation of the methods of management of the plant. If these methods are standardized, and the costs still vary, other conditions being constant, it means that standard methods are not lived up to; that is, the management fails to manage.

The paper thus offers a method of measuring the efficiency of the plant management. If the principles and methods are right, the results will necessarily be the best obtainable and consequently the only best method or "standard method" finds its expression in the lowest possible cost or "standard cost."

Comparing such standard and actual results, with due allowance for uncontrollable factors, we get the measure, established on a scientific basis. Under such regime the plant management ceases to be a humpty-dumpty undertaking and most preventable losses are eliminated. Separate and aside from the operating and production costs are other elements of overhead charges, and a separate plea is made to analyze them independently, so that their reason and purpose be clearly indicated, and if expense is made for no useful purpose or on poor reason the remedy could be found.

The new buildings of the Massachusetts Institute of Technology situated on the Charles River Basin, Cambridge, Mass., will be dedicated on June 12, 13 and 14, 1916. The engineering buildings will contain extensive hydraulic, steam and chemical laboratories, in addition to the electrical department. The group of science laboratories, situated apart from the engineering laboratories, will be most complete in facilities for precise research work in addition to undergraduate instruction.

SPECIAL STEELS

BY SAMUEL L. HOYT,[1] MINNEAPOLIS, MINN.

Non-Member

THIS paper has a more direct bearing on the special steels used in automobile service than elsewhere. However, I understand that the demands made on special steels by gas tractor practice are in most cases similar to those made by automobile service. At any rate, the advantages possessed by the special steels over the ordinary carbon steels apply with equal force to the two services. Materials for certain tractor parts would be selected with reference to abrasion resistance, especially at somewhat elevated temperatures, whereas in automobile service material for the same parts would be selected with particular reference to its dynamic toughness.

Nickel Steel. The first important special steel, of the type used in automobile practice, was nickel steel; in fact, the nickel steel first described by Riley in 1889 was an entirely new type of special steel, the special steels up to that time being those used for tool steel, etc.

The nickel is added for two reasons—first, on account of the strengthening effect, as 3½ per cent nickel increases the elastic limit of carbon steel by 50 per cent; and, second, the dynamic toughness, as shown by fatigue tests and the notched bar impact test, is double that of carbon steel. It must be pointed out, however, that this great improvement in properties can be secured only by use of a proper heat treatment.

Chromium Steel. Chromium steel was introduced by Mushet in the 60's in England and by Bauer in New York at about the same time. Its most noteworthy effect on carbon steel is the increase in hardness produced, but the elastic limit like that of nickel steel is also in excess of the elastic limit of carbon steel. Chromium also improves the physical structure of steels by making them finer grained. This has the effect of offsetting the lack of ductility of chromium steels which is evident from the relatively lower elongation and reduction of area. In this way chromium steel furnishes an example of the fallacy of judging steels by static tests alone, as the real toughness of construction steel is brought out only by tests such as the dynamic tests and notched bar impact tests.

Chrome-Nickel Steel. Here we come to the most renowned of all automobile steels. In considering the effect of adding chromium and nickel to carbon steel, let us consider first the nickel and then the chromium. Nickel on being added to carbon steel dissolves almost entirely in the ferrite and the effect is to increase the elastic limit. The second influence is that of decreasing the grain size which causes a marked increase in toughness which I have already referred to. Chromium, on the other hand, forms a double carbide with iron and the effect of adding chromium to nickel steel is to increase the hardness by means of the double carbide. In this way chromium raises the elastic limit and elastic ratio of nickel steel, but does not destroy its toughness.

Hence it is clear that chromium and nickel added together to carbon steel increase, very materially, the elastic limit, the elastic ratio, the dynamic toughness, and the hardness. This steel is an excellent example of the manner in which one special element can reinforce another special element when added to carbon steel and combine to produce a much superior steel. There are numerous steels on the market which have equal or

[1] Assistant Professor of Metallography, The University of Minnesota.

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even better static properties, but it is doubtful if they are equally capable of standing up in service chiefly on account of the difference in dynamic properties.

Chrome-Vanadium Steel and Chrome-Nickel-Vanadium Steel. Vanadium added to chromium steel and chrome-nickel steel produces an increase in toughness due to the fact that it makes them finer grained, more uniform, and more susceptible to heat treatment. The chrome-vanadium and chrome-nickel-vanadium steels are classed with the chrome-nickel steels as being the best construction steels as yet developed for this type of service.

Silico-Manganese Steels. Certain types of silico-manganese steels have been developed which possess exceptionally high elastic limits and which can resist vibratory stresses and therefore are useful as springs.

Tungsten Steels. Tungsten steels were used originally as tool steel on account of their great hardness, but they also possess a property which makes them of use in automobile service; viz., that of resistance to abrasion at elevated temperatures. On this account they are used for valves.

The advantage of the special steels over the carbon steels for use as construction steel is due, more than to anything else, to the increase in toughness which is secured, especially dynamic toughness. The carbon steels can be made appreciably stronger by increasing the carbon content and by heat treatment, but they would be made brittle and therefore of no use. The special steels, however, can be made strong and tough at the same time.

The increased toughness can be utilized in three different ways, according to Le Chatelier:

1. Maintaining the same strength and toughness, the parts can be made appreciably lighter. This is of great importance in automobile construction where weight is of prime importance, especially as far as speed, endurance, economy, and upkeep are concerned. The diminished weight is also an important factor in the cost of production as the extra cost of the special steels is oftentimes more than balanced by the lower manufacturing costs due to the lower weight. In gas tractor service a saving in the weight of the parts, especially the moving parts, lessens the sudden strains which are imposed by forced stopping and other irregularities in the service. But the advantages of using light weight parts, in place of heavy parts comprise not only the saving in handling the material on the floor, in machining and in assembling, but also the advantages derived by the buyer.

2. With the same weight and toughness the parts can be more heavily loaded. This lessens the danger of over-loading which often results in deformations sufficient to put the overloaded part out of service.

3. With the same weight and strength much greater toughness can be secured which amounts to insurance against accidents and failures.

In what is presented above, I have referred not to static toughness as determined by static tensile tests, but to dynamic toughness as determined in dynamic and impact tests. In fact a great mistake is made by judging the value of special steels by means of static tests alone, not only that the relative values of special and carbon steels are not brought out, but that at times the results of static tests are directly misleading. This is not a pleasant thought for him who would go to but little trouble and expense in testing construction steels, but it is a fact and as such must be squarely met.

I wish to repeat another important point in connection with the production and use of special steels; viz., in order to make special steels worth while, to justify the increased cost, they must be properly heat treated. This is a subject which has not as yet, at least in our country, received the attention which it deserves and which in the future is bound to be paid to it. This neglect is due, I believe, not only to the fact that the special steel industry is in its infancy, but also to the special difficulties of a scientific nature involved, both in the determination of the proper heat treatment to be employed for each particular case and in properly carrying out the heat treatment of the parts concerned.

Also I might add that the solution of the problem lies in two directions. The users of special steels, such as gas tractor and automobile manufacturers, must be awake to the possibilities of such use. In other words, the manufacturer must create a demand for a superior product in order that he may produce a more salable, a more durable, and a more economical machine. But it is also necessary for the maker of special steels, not only to produce high grade steels of the proper chemical analysis, but he must also know the kind of steel to be used and, what is more important, the proper heat treatment to suit the individual requirements.

Whether the maker of the steel, the manufacturer or a middle-man shall actually perform the heat treating, depends on which one is best equipped to do that kind of work. Of prime importance is that the heat treatment be properly done. In other words, the steel maker should advise with the manufacturer and tell him which steel is best suited for his particular purposes, all things considered, and what heat treatment is necessary in order to bring out the desired properties.

From my own experience I cannot say that this ideal state of affairs exists in the United States. As a matter of fact, the steel makers, as represented by their salesmen, while ready at all times to recount the virtues of their special steels, seem to possess little serviceable information for the purchaser and transactions are carried on largely on a basis of the static properties. One cannot wonder that many manufacturers feel that special steels are but an expensive luxury.

Next the kinds of steel used for different parts will be taken up briefly and, incidentally, I shall have a few words to say about case hardening practice.

Axles. It falls to the lot of axles to receive some of the severest strains which are encountered. Axles must be statically strong (high elastic limit), dynamically tough, and, if poor design or workmanship must be considered,[1] they should also have both high static and dynamic notch toughness. Toughness is secured by nickel and vanadium while strength is secured by nickel and chromium so that the steels to be recommended for axle service are nickel, chrome-nickel, chrome-vanadium, and chrome-nickel-vanadium steels

Crank-Shafts. Many times it is desirable to reduce the weight of the crank-shaft and at the same time maintain a certain degree of toughness and stiffness. If so, it is advisable to use chrome-nickel or chrome-vanadium steel but of course the heat treatments would be different from those for axles. The requirements for this service are high resiliency in combination with comparatively low elongation so that heavy impacts can be absorbed without causing serious deformations in the crank-shaft.

Cam Shafts. The duty is naturally lighter on cam shafts than on crank-shafts and axles, but a saving in weight can

[1] It has come under my personal observation that both of these points require serious consideration.

be effected by using nickel, chrome-nickel, or chrome-vanadium steel.

Gears. Many heat treated gears are being used in place of case hardened gears. The combination desired is hardness and toughness, two properties which are difficult to combine in any one piece. However, a greater degree of toughness can be secured with the same hardness by using special steels. The chrome-nickel, chrome-vanadium, and chrome-silico-manganese steels are used for this purpose.

Springs. Springs require a combination of high elastic limit and high dynamic resiliency, and of course dynamic toughness. Springs and crank-shafts share the property of high dynamic resiliency in common. The difference for these two services is that in one case the permissible deformation is very small while in the other case it is necessarily large. The steels used for springs are chrome-vanadium and a special type known as silico-manganese.

Frames. Frames must be tough and have high resistance to vibratory stresses. Nickel, chrome-nickel, and chrome-vanadium steels are used extensively for this work.

Steering Arms. Steering arms are subject to a combination of stresses which is probably more complex than the strains on the other parts. For this reason the design and workmanship of steering arms are especially important. The steels used are nickel and chrome-nickel.

Roller Bearings. Roller bearings must be hard and yet not too brittle. There have been two types of steels developed for this work, viz., the high carbon-high chromium steel and chrome-vanadium steel oil-hardened.

Valves. If a special steel is desired for valves, it is usually tungsten steel, but certain high nickel steels are also used.

Case Hardening Practice. The first step in the process of case hardening, is annealing in the case hardening mixture or "cement" for a sufficient length of time and at a sufficiently high temperature to produce the case desired. The second step is called the first quenching which has as its object the regeneration or toughening of the core. The third step is the second quenching which has as its object the hardening of the case. There are many advantages secured by using the special steels and I shall mention several of them.

1. Certain of the special types are much less affected by the first annealing process than the carbon steels. That is, the annealing produces a much smaller growth in grain size which in itself, aside from the greater natural strength and toughness of the special steels, retains a greater tenacity and toughness in the core.
2. Certain special steels permit a modification of the heat treatment so that the first and second quenchings can be combined into one treatment which is so calculated that it is satisfactory for both the case and the core.
3. The results are rendered more certain by using special steels; i. e., the case can be made more uniform and harder while the core can be made stronger and tougher.
4. Deformations due to quenching can be more easily avoided with certain special types of steels, for instance, the air hardening steels. These steels belong to a class of steels that is not generally manufactured at present in the United States, and should not be confounded with tool steels.
5. A higher carbon content can be permitted in the core without losing the property of toughness. An example is furnished by the chrome-nickel steels with which a carbon content of 30 per cent can be used, a steel which also produces a hard case suitable for parts subject to wear and shock.
6. In carbon steels two of the constituents, ferrite and cementite, have a habit of forming in relatively large crystals, the presence of which is dangerous on account of the brittleness and liability of exfoliation produced thereby. This can be eliminated by using special steels.
7. The use of special steels greatly increases the efficacy of the treatment.

The parts which are commonly case hardened are cam shafts, roller bearings, and gears. For cam shafts a low carbon, nickel or chrome-nickel steel is used which is case hardened on the wearing surfaces of the cams. For roller bearings, low carbon, nickel, chromium, and chrome-nickel steels are used depending upon the service. Steels which are quite generally used for gears are low carbon, chrome nickel and chrome-vanadium steels, and it might be added that these steels properly case hardened give a more satisfactory combination of properties than is produced by the heat treated parts, although the expense is somewhat greater.

In the limits of a paper such as this, it is not possible to enumerate the many advantages aside from saving in weight, increased toughness, etc., which are derived from the use of special steels, but I wish to cite, in conclusion, a case which will show at least one of the possibilities.

This example is taken from the work of Guillet, the noted French metallographer. This steel was developed primarily to simplify the heat treatment and in fact it is simply necessary to heat the steel up to about 1550 deg. fahr. and allow it to cool in air. This treatment produces the desired properties in the same manner that the double heat treatment does for the carbon steels. The composition of the steel is as follows: C 0.75 per cent, Ni 3.82 per cent, Cr 1.28 per cent, Mn 0.52 per cent.

The properties are given in the following table:

	Tensile Strength	Elastic Limit	Elong. per cent	Elong. R. of A. per cent	Resistance to Impact
Annealed	138,000	110,000	12	40	3
Air Hardened	192,000	188,000	10	20	8

The elongation and reduction of area are less in the air hardened steel, but the resistance to impact is appreciably greater, showing a greater dynamic toughness, the property which serves better than any other to demonstrate the superiority of special steels over the carbon steels.

I wish to render my thanks to Mr. Wm. Howland, Jr., of the Illinois Steel Company, for information furnished me on the use of special steel in this country.

Very often the problems of the sugar industry do not touch so much on the design of new machinery as the adaptation of old machinery, and the increase in its efficiency, or duty, for a minimum outlay of capital. Nevertheless, a thorough knowledge of the principles of design and some actual experience in that branch of engineering are of incalculable assistance in solving the normal wet season problem of how to modify some apparatus to do better or achieve more work. Take the case of the multiple effect: this is one apparatus that is very often the capacity gage of the house; and given that the effect can be augmented in capacity, the other units can frequently be arranged to pass the increased volume of work.—Chas. E. Newbold, Mem.Am.Soc.M.E., in the *International Sugar Journal, February, 1916.*

THE FUTURE OF THE ENGINEERING PROFESSION

BY A. J. HIMES,[1] CLEVELAND, O.

Non-member

THERE is a widely prevalent feeling among engineers that the material rewards for the practice of their profession are in general and relatively to other lines of endeavor disproportionately low. Much can be said both for and against this proposition, but I have chosen rather to recite certain adverse conditions affecting engineering practice and to advocate therefor a specific and definite remedy.

First: There is the age-long antagonism to exclusive knowledge for which Galileo and other scientists have suffered persecution. It is well for us to understand that this deep seated aversion of humanity towards everything new and difficult of comprehension is a natural instinct intended as a safeguard against impending danger. The more mysterious the danger, the greater becomes the alarm and the more completely do people lay aside the usual staid and dignified behavior and give way to frantic and unreasonable thoughts and acts.

So when the young college man appeared on the railroad with his curve formulæ and logarithms and a text book on track, the Irish section foreman took fright and instituted a violent and unreasonable warfare. He had held a good position—here was a man of youth and inexperience who held essential knowledge beyond Pat's comprehension and Pat feared his doom.

In the struggle which followed at least a few of the Pats became captains of industry, men who with the dignity and thought of maturer life still preserve an armed neutrality toward the presumption of one who finds in books the inspiration for a successful life.

Second: During recent years there have come to me many applications for employment from men of prominence in the profession, earnestly pleading for employment at any salary.

Third: In casual discussions among older men it is sometimes asserted that the engineering profession is an ideal myth; engineering is only a trade.

Fourth: In this age of research, investigation and compilation, when the world is richer than ever before in vast accumulations of knowledge, great multitudes of people are dying, suffering with disease and infirmity, blundering through life with failure upon failure, because this great accumulation of knowledge is not within the reach of those who feel its need.

These conditions indicate:

a. The need of the profession that the mists and cobwebs of medieval times be cleared away so people may see distinctly and understandingly the great benefits to be secured through the free use of experimental and scientific knowledge.

b. That the accumulated knowledge stored away in the archives of colleges and public libraries shall be disseminated among the people so that, being available, it may be used.

It is conceivable that if the dissemination and utilization of knowledge were a commercial problem, there would not be wanting men who would bottle it up in convenient and useful, perhaps tempting, form, and by means of immense distributing organizations place a day's supply on each doorstep every morning along with the breakfast cream.

People do not rise to the height of their opportunities. We complain of poverty when the world is full of everything good eagerly awaiting our use. If we could understand that the proper use of the works of scientific men would rapidly multiply our material resources, enabling all to enjoy comforts and happiness, as yet hardly hoped for, our energies would be bent more intently upon the *use of knowledge already acquired.*

The use of knowledge is the justification of engineering and our present controlling problem is the *extension* of that *use.*

Reverting again to commercial forms and putting the ideas in plainest terms, I would say, "Let's advertise." Unprofessional, apostasy, heresy may fail to express the shock this proposal will bring to certain ethical minds, but we must admit, in view of the conditions stated, something shocking and shaking and revolutionary is needed.

Advertising is a very old, conservative, well tried, respectable, and successful device for stimulating business. Is it less fitting that we should acquaint the public with the merits of our wares by description and explanation in print than that we should utilize paper and ink in our computations? Does an inventor bury his product in the earth less perchance some poor unfortunate shall look upon it and be saved? What does the Bible say about hiding one's light under a bushel? It is a barbarous idea that, locked in the secrets of his heart, a man should take with him to the grave knowledge that might be useful to his survivors.

The Cleveland Engineering Society has been advertising three years. Look at the record. Does it pay? The increase of membership has been 48.1 per cent. The increase of assets has been 37.7 per cent. Have we suffered in prestige or reputation?

On the contrary. The eyes of the country are upon us, watching our success and eagerly seeking to imitate it.

Assuming it is agreed by the profession to advertise, we arrive immediately at the practical question of intersociety relations. *There must be coöperation.* We must work together. A mass of broken stone will not cohere—it is friable; it falls apart. Mixed with cement it will support great bridges. So with men.

Farmers are notoriously independent in thought and action. They will not cohere and their influence is small. Cemented together with a vital purpose, they have on more than one occasion proved the salvation of the country. We must see that certain great achievements involve collective effort. We cannot stand alone.

The public does not quickly sense the fine distinction between engineers of different kinds and grades. It has neither patience nor ability to differentiate their needs. *In their relations to the public all engineers should stand together.* For this reason it is well that the local society should, within its field, marshall the full strength of the whole profession. Its local standing will be higher. Its interests will receive greater attention and consideration than would be possible if it were broken into several units representing different branches of engineering.

The preparation and utilization of advertising matter is so laborious and expensive that matter once prepared should be available anywhere. In this way, if all local societies were interested, the unit cost would be a minimum. A publication bureau supported by a number of local societies would be an efficient device for handling such business.

The national societies do not seem to be in a condition to join such an undertaking. They are ultra-conservative, and

[1] Chairman Valuation Committee, N. Y. C. & St. L. RR.

Presented at a Meeting of the Cleveland Engineering Society, Cleveland, O., on November 9, 1915.

not inclined to coalesce. The function which they have filled so well in the past, of stimulating the publication of papers and their discussion and of conducting engineering investigations, is of prime importance and should be continued. As organizations there is small hope of aid from them in publicity affairs.

The increase of membership in local societies consequent upon a publicity campaign would undoubtedly increase the interest in national societies and stimulate their growth. For stability the growth must be from the bottom up and a more lively local interest in engineering would add greatly to the power and influence of the national societies. *If it were possible to combine all national societies in a single organization that in matters of legislation and public policy would represent the whole profession, the ideal condition of strength might thus be attained.*

The individual seeking employment may ask wherein this program may be of benefit to him. The answer may be found in a comparison to the development of travel. Make it possible to ride fifteen miles for five cents and travel will develop. Modern railroad trains and motor cars were inconceivable one hundred years ago.

Make the public familiar with engineering, its possibilities and limitations, teach the public how to use it efficiently and successfully and there will be no dearth of opportunity for engineering skill.

The temperature of the outside surface of a steam pipe is very nearly that of the (saturated) steam in the pipe. There is no appreciable difference in the temperature of the outside surface whether the pipe is bare or covered with a 1 in. layer of magnesia pipe covering. Therefore the conductivity of the iron in the pipe is so high that only a fraction of a degree of temperature drop between the two surfaces is needed to conduct through the metal all the heat that can be radiated from the outside surface of the pipe under almost any condition; also the rate of impartation from the steam to the inside surface of the pipe is so high that the metal is kept at the same temperature as the steam. This is undoubtedly due to the fact that saturated steam can give off a large quantity of heat by condensation without any change in temperature.

From the preceding deductions, it follows that in computing the heat losses through pipe coverings the resistance to the heat flow through the metal of the pipe can be dropped out of the problem and only the resistance of the covering material considered. That is, it is safe to assume the inside surface of the covering at the same temperature as the steam.

The above deductions hold true only for saturated steam. With superheated steam and hot water, both of which give off heat by drop in temperature, the results would very likely be greatly modified.—*Technical Paper 114, U. S. Bureau of Mines.*

No one thing has been more potent to contributing to the elimination of visible smoke than the advent of mechanical stokers and other forms of automatic furnaces.

Mechanical stokers provide for the progressive movement of the fuel into the furnace; they generally provide for an ample flameway and a brick arch under which the initial combustion may proceed. They are rarely installed except where satisfactory draft conditions are assured; as a consequence, it is commonly assumed that the mechanical stoker or hopper-fed furnace is a smoke-abating device, and in general this assumption is justified.—W. F. M. Goss, Mem.Am.Soc.M.E., in *Jour. Franklin Institute, March, 1916.*

ENGINEERS IN POLITICS

BY C. E. DRAYER,[1] CLEVELAND, OHIO

Non-Member

SPEAKING at the annual dinner of the Cleveland Engineering Society, last June, Mayor Baker said:

The part that I like to think about in the Engineering Society is that its members, a good many of them, day after day and week after week, have contributed to the public good with no compensation coming to them, with no fame or no political aspirations, no particular recognition. . . . If the city had been required to employ those men it would have cost a great deal of money; and the results of the labor they performed freely are undoubtedly highly beneficial to us.

In expressing my gratitude for that service, I, of course, speak as Mayor, and in doing so I express the sentiments of every citizen of Cleveland.

Lately we have heard a great deal from engineers about the lack of appreciation accorded their efforts by the public. Here a public official speaks in praise of the services of engineers as citizens, not in praise of their work as builders of material things. The building of railroads, canals, water supply and sewerage systems are fundamentally a public service, but they do not relieve the engineer of his other duties as a citizen. On the contrary the public character of his work creates new opportunities for civic leadership and increases his responsibility as a citizen. Even as the engineer is a product of modern times, so must he take his part in the solution of the human problems arising from his material achievements. Modern problems of citizenship are solved in most instances in the school of politics.

The intense seeking after technical knowledge in recent years and the great amount of work imposed by discovery after discovery in science, gave rise to a specialization among technical men until they lost in a measure sympathy with the people outside of their narrow field.

While specialization is necessary to scientific progress, there is need that we engineers study the relation of our occupation to the wider interests of mankind. Let us, as it were, break up the crystals of our old ideals, one of which is the time-honored precept that our achievements are sufficient witnesses to our ability, and see if the new crystallization does not take on a different form. Advertising, publicity, and politics may be commendable forms of activity if rightly practiced. The end to be sought must not be political preferment or personal reward, but service to the community. That is bedrock and cannot yield.

That the public is interested in the engineer is evidenced by the halo of romance that has been cast about him in literature. It will be far better for both the engineer and the public when the public learns that in civic affairs the engineer is an honest and efficient servant of the people, capable of taking administrative control.

Very recently a public official at the head of one of the engineering divisions of Cleveland told the author that the average councilman did not consider the *engineering* ability of the head of the department superior to that of a rodman or chainman, as the latter are *engineers* as well as he.

The implication of the public official who was a lawyer that the engineer could not be found with the judicial quality of mind to serve on the Interstate Commerce Commission would

[1] Secretary of the Cleveland Engineering Society and assistant engineer, Valuation Department, N. Y. C. & St. L. RR.

Presented at a meeting of the Engineering Society of Buffalo on December 15, 1915.

doubtless find general support today, for most people picture the engineer drawing hieroglyphic plans according to mysterious rules—he is silent and apart; his language is that of blue prints, and the desire of his heart finds expression before the public in terms of earth and metal, inanimate things.

As Berton Braley says, illustrating the talkativeness of "Leather Leggin's," the engineer:

When you need to dam a river or to turn it upside down,
Or to tunnel underneath it in the mud,
Or to bore an' blast a subway through the innards of a town,
Or to blow aside a mountain with a thud—

. . . . . .

Why you call on Leather Leggin's and he does that little thing,
An' then comes 'round an' asks you "Is that all?"

Our position with reference to the public is not unlike that of John Alden courting Priscilla for Miles Standish; let us speak for ourselves. And let us learn to speak where engineering principles are at issue with such clarity and vigor that in the trial of a case before the jury of public opinion we will get a unanimous verdict. We can.

Our training and habits have not endowed us with eloquent tongues, although the ability to talk well will be added when the awakening spirit impels us to reach up to our opportunities. But a channel by which our story can be favorably told the public lies within easy reach. There is a demand on the part of all people to know about the things which have a far-reaching influence on public welfare, on health and industry. So we find at our door an opportunity and a duty to place before the public dependable information about technical subjects.

What can the local society do? It can at least furnish through its committees and open meetings a forum where analytical minds can help solve problems about which engineers are qualified to speak. The engineering societies should be able to contribute to civic progress somewhat as they have to technical advancement. The same standardization of output cannot be effected, perhaps, and therefore many are discouraged.

Recently the Cleveland Board of Education set out to materially reduce the pay of teachers in our technical and commercial high schools. Its action was taken, notwithstanding the fact that the Cleveland Foundation was spending thousands of dollars employing experts in a survey of Cleveland schools and the subject of compensation paid teachers was receiving special consideration.

The Executive Board of the Engineering Society sent to the Board of Education a communication expressing its interest in the schools of the city and a desire to aid youth in procuring the best possible opportunities for education and self-advancement and petitioning the Board of Education to defer action until such time as legislation had been prepared to cover all steps that may be necessary to completely readjust the matter of compensation for teaching. We did not give a copy of this letter to the papers, but sent a copy to the Cleveland Foundation, as well as to the Board of Education. Action on salary cutting was deferred. It might be said that the Board of Education is hard put for money, but such economy as was devised was penurious and wasteful. It was our plain duty to keep the School Board from digging a pit and falling into it.

To the Mayor-elect who took office on January 1, we sent the following letter:

The Cleveland Engineering Society, being vitally interested in the welfare of Cleveland and the best administration of its public works, tenders you, through its Executive Board, its hearty coöperation in the advancement of the interests of the city.

Ordinances approved by the voters at the recent election call for the expenditure of many millions of dollars, much of which may be used to the best advantages of our citizens if proper professional knowledge and experience be employed in its administration. Many functions of municipal government, such as water supply, sewage disposal, street repairs and renewals, may be most economically and efficiently performed by men having engineering experience.

We recommend, therefore, that the positions of Director of Public Service and of Director of Public Utilities be filled by men having a broad engineering experience combined with administrative ability.

In this instance we gave the letter to the papers as soon as it was read before the Society in open meeting which was before it reached the Mayor-elect. One of the papers on the morning following gave the letter wide publicity in a manner above suggestion for improvement.

The Mayor-elect has appointed his cabinet apparently as different from our ideas as could be imagined. To be Director of Public Utilities, he appointed a labor leader who is graduated through labor councils from the waiters' union. To be Director of Public Service, he appointed a former councilman who is a lawyer. It should be said that it was not expected by the sponsors of this letter that its advice would be followed. But the chief object of the letter was accomplished, to place the principles before the public.

But how shall the public know that the engineer is a capable adviser and that the principles he enunciates are trustworthy? Education and acquaintance lead to mutual understanding. The most effective and direct method to bring about this desirable relation is in the use of the public print. It is not an exaggeration to say that the newspaper is the greatest educational factor, at least in its possibilities, of our present day civilization, and this takes into consideration the school, the college and the church. The more progressive editors recognize their responsibility and are opening their columns to signed articles by people of constructive ideas.

Referring to the civic activities of the Cleveland Engineering Society, Cleveland has been struggling lately with the revision of the building code. The actual work of revision was done by a joint committee composed of the Chairmen of the Building Code Committees of the Cleveland Engineering Society, Builders' Exchange, and the Cleveland Chapter of the American Institute of Architects. The code has been carefully studied by the Committee and some 460 sections have been revised and 260 new sections added, the City Council turning into law what the Committee approved. It has been a herculean task to which these men gave unselfishly of their time without remuneration of any kind.

The Civil Service Commission asked the Cleveland Society to assist it by taking charge of the preparation and marking of papers for engineering positions. Results to both the Society and the Commission have been very gratifying. The Commission secured the services of experts at no cost to the city, whereas during the previous year it had paid some $900 for examination of candidates for engineering positions, yet complaints had been made that proper relative weights had not been given to experience and theoretical training. The Secretary of the Commission told us that candidates were satisfied after the Engineering Society took charge. In this case our Publicity Committee tipped off the reporters and they dug up their own stories from the Commission.

Our first publicity work was in August of 1912, concerning the report of the Committee on Technical Education of

the Society after it had studied Cleveland's technical schools, and much publicity was devoted to arousing public sentiment against unnecessary smoke and to induce as many as possible to attend a popular lecture on "How to Burn Soft Coal Economically and Without Smoke," delivered by Dr. Breckenridge at a joint meeting between the Chamber of Commerce and the Engineering Society. The meeting was attended by 600 engineers, manufacturers and citizens.

Later the Bridge and Grade Crossing Committees of the Society found little had been done in planning the work of grade elimination in the city in a systematic manner and recommended that future work be anticipated in some general comprehensive scheme.

An aeroplane article that appeared in a Sunday magazine section was our first feature article. Attention was called to the meeting by an advance notice of the meeting, consisting of a picture of the speaker and some 100 words telling about him and what he was to talk about. When we went to the Sunday editor and asked him if he'd like a feature article on flying machines, he said, "Yes, only you engineers are too technical." We told him we were interested mainly in knowing whether he was receptive to the idea and that he didn't need to print the article if it didn't suit him. "That's a go," he said.

The Chairman of the Publicity Committee has been seeking the right sort of an assistant for a long time. When he found a young man ready to attempt the preparation of this article under his direction, he felt about the young man as the editor did toward the article—he might come through, but past evidence was to the contrary. The article was blocked out. The writer came back with a sophomoric composition, a good undergraduate essay. We went over it in detail and he rewrote it, improving it considerably and approaching newspaper style. Again it was given back to him to rewrite. He did it over the third time and never flinched. The editor was highly pleased. Now both our Sunday papers are eager for our feature copy and one article has been paid for. Pay had been offered us previously, but we then told the editor the material was not for sale. The effect this statement produced upon him was worth the sacrifice in money.

We stated before that any plan for publicity by engineers must be based on a systematic scheme to educate the public. From the standpoint of the engineer, the public includes the men who make the newspapers. For instance, an article entitled: How Gunners Pick Their Target Though Far Away, might just as well have been captioned: Long Range Trajectories. Had we attempted such an article in the early stages of our publicity work, the editor would have been inclined to view the attempt as too technical. Indeed, a good many engineers would be prone to say that the subjects of trajectories and ballistics are too involved to be understood by the average reader of the daily newspaper. After the article was published and opinions expressed as to its value, the Sunday editor wrote us characterizing the article as a "knockout" and asking if we couldn't write him another soon.

While no positive statements are made in the article, whether the Germans with reasonable care could have avoided the destruction of historic and sacred edifices in the cities they were bombarding with cannon located 20 miles away, no great acumen is required of the reader to judge correctly. The editors of both papers have expressed appreciation of the line drawings to make the text clear. We furnished text and diagram, while the newspaper furnished the "filling in" with pictures and sketches.

An article entitled: Why No Boat Can Withstand a Torpedo, was devoted to an explanation of the principles of buoyancy governing the design of ships. By picturing the difficulties an urchin meets in trying to keep a floating tomato can upright until he discerns that he must put some stones in the can, very technical terms like center of gravity, center of buoyancy, and metacenter can be introduced without frightening the nontechnical reader. Even an engineer came to us and told us that he enjoyed the article and learned several things from reading it.

Touching upon the point of timeliness of news, this article was cast for the presses when the Eastland capsized. One of the editors accused us of being accessories before the fact. In defense we would say, had the Eastland turned over a week earlier the caption would doubtless have been different. In this article, as in the gun pointing one, we furnished the text and diagram, the paper the "filling in." It was syndicated by the paper that published it, but no division of receipts was made with the Publicity Committee. We are going to try a little syndicating of our own in the no distant future.

The ability to meet new conditions with new methods is an ordinary attribute of the engineer. This was featured in an article on: How a Railroad Was Saved from Burial. This article describes how a railroad engineer stopped an earth slide by blowing up into a barrier the soapstone on which the superincumbent earth was slipping. The feat was performed on a railroad connecting Cleveland and Pittsburgh, hence had local color common to both cities. The story as published in a Pittsburgh paper was furnished by the Engineers' Society of Western Pennsylvania.

With the local story as a "news peg," several earth movements of interest were reviewed, some that had happened several years ago, and which had been written up in the newspapers at the time. It may be truthfully inferred that ancient history may be made into news.

The Good Will Number of the Journal of the Society is an argument for universal peace, but makes no reference to the present cataclysm in Europe. It is based on the idea that modern war is a mathematically scientific game played with deadly machines evolved by the engineer. With the same scientific principles in mind, if the efforts spent in war were turned to the works of peace—in peaceful rivalry instead of destruction—a tremendous advance in human welfare would be the result. The Publicity Committee sent copies of the Good Will Journal over the country, wrote reviews of it for periodicals and distributed several hundred copies to citizens of Cleveland, and placed them in downtown offices of physicians and dentists, libraries and the like, where they would be read by many people.

Engineers Are the Men Who Make Dreams Real. This was suggested as the subject of an article by the Publicity Committee to one of the sub-editors who was charged with writing an interesting story for each Sunday. Naturally the most difficult part of his task was to find a subject and material. We arranged for an interview with an engineer who could talk in an interesting manner to a reporter. The definition of "engineer" the newspaper evolved is rather apt. "An engineer is a man who somehow, some way, tames the forces of nature, helped by science, and makes them do man's bidding."

At a time when the electrification of railroads entering Cleveland was being agitated, the Engineering Society invited N. M. Storer, of the Westinghouse Electric & Mfg. Co., to lecture on the subject. The meeting was held at Case School and was attended by several of the city officials.

On a Tuesday evening, our regular meeting night, we had three newspaper men tell us about the making of a newspaper. One spoke from the standpoint of the editor, a second about the business and advertising end, and a third, a member of our society, gave the principal address which was devoted to the power presses and other machinery of a newspaper plant. On the following Saturday afternoon we visited the largest three plants in the city, each within a few minutes' walk of the others. The Press took our pictures just after we had started through its building and in 42 minutes had the paper printed ready to hand to us as we left.

A very pleasant and profitable custom of visiting back and forth has grown up between the engineering societies of our section. We have visited the Engineering Society of Pittsburg, Buffalo, and Detroit, and plan a trip to Toledo. The Detroit engineers on September 11 returned our visit of last spring.

I am inclined to place greater value on the social and good-fellowship part of these programs than on the professional benefit gained from visiting plants in other cities, large as that may be. Trips by boat are effective in getting members acquainted with each other, out of which grows a common interest.

An article entitled Bridge Foundations a Mighty Problem, properly may be classified as service to the community. The building of the foundations of a great high-level bridge, the main artery between two parts of Cleveland, gave rise to a lively controversy as to their safety. The public had a right to know the truth. The county bridge engineer was asked to read a paper before the society describing the foundations. His paper was abstracted with technicalities omitted or so worded as to be understood by the reader of average education, and published in one of the papers on the Sunday following the meeting.

An article entitled: Local Men Will Be Prominent in American Electric Railway Association Meeting, appeared in the sections of our papers devoted to railroads. The longest article that appeared was signed by the railroad editor, and the text is verbatim as we prepared it. Railroad Engineers Conclude Convention was the title of a telegraphic report sent from Chicago, press rates collect, to the Cleveland papers after one of the railroad editors had suggested that we do it. When Hunter McDonald, then president of the American Society of Civil Engineers, was being mentioned as possible head of the construction forces for the Government's Alaskan railroad, an excellent "news peg" was at hand on which to hang quite a story about the American Railway Engineering Association and American Society of Civil Engineers.

Shortly after the new weather forecaster took up his work in Cleveland he became a member of the Engineering Society. It was quite proper that both the man and his lecture on the U. S. Weather Bureau and Its Work should be given some publicity, introducing him to the community. Cleveland is in a district subject to so many and sudden changes of weather that the lot of the weather man is a precarious one.

When we came to write the advance notices, we got down our cyclopedia and discovered some interesting things, one of which was that a Clevelander while in Congress had a hand in the formation of the Weather Bureau. This and several other interesting points were ancient history, unless there could be found a "news peg" to hang them on, that is, to justify them. The new weather man and his lecture was the peg.

As to publicity work done by other local engineering societies, in St. Paul a special committee of the Engineering Society made a careful study of the depot approaches and traffic distribution. The report was published in the daily papers in advance of the meeting in order that engineers and the public generally might be fully informed and be prepared to discuss the report at the meeting.

In Buffalo, an arrangement was made with one of the papers whereby the equivalent of two columns of space in the Sunday issue was placed at the disposition of the Engineering Society. Several columns, of which Mr. Swasey's picture is a part, set forth quite fully information about the Engineering Foundation and its possible uses and was published on March 21, nearly two months after the dinner at which the gift was announced.

Space obtained for this subject by the Publicity Committee of the Cleveland Engineering Society consisted of the two 6-in. items headed: "$200,000 Gift for Science" and "Swasey Aids Science." These placed alongside the Buffalo article for contrast illustrate graphically a fundamental law of newspaper work. It is to be borne in mind Mr. Swasey is a Cleveland man. If information had been available three-quarters of a column would have been used to announce an event of such importance as the Engineering Foundation. Our efforts by letter and wire brought nothing to the papers the night of the dinner but the next day, after the papers to which it was addressed were out, there came a long wire from the engineers in charge of the function. From the standpoint of news, the message was then ancient history.

In other words, news is a commodity of a most perishable nature. Unless the time element is clearly understood, a good item may be lost due to its reaching the paper an hour late.

Early in our publicity work there was published in one of the local papers a letter from a young man to the editor asking what the opportunities are in civil and mechanical engineering. The editor printed below the letter a request that engineers of each of these branches answer the question. Of course, we are amused that anyone should expect the editor of a daily paper to answer the question, but the asking indicates at once the opportunity to perform public service through the medium of the daily papers.

Here was an opportunity for the Publicity Committee. It accordingly asked the President of the Society to prepare an article in answer to the question to be offered to the editor of one of our papers. The editor liked the idea so well that he called for more, and the series grew until there were fourteen articles. These articles with a few on the branches not treated in the Cleveland series have just appeared in book form, Engineering as a Career, from the press of D. Van Nostrand Co.

In any local engineering society there are men preeminently qualified to tell the young man what the opportunities are in the engineering profession and what is required in the way of training to succeed. Thousands of youths, their guardians and parents would eagerly welcome such advice, but they don't know how or where to get it. We are of the opinion that such a series as was run in Cleveland could be written in any engineering society and that the papers would gladly share in the opportunity to place such dependable information before the community.

There are several ways that may be used by engineers to educate the public besides the public press, where an un-

sympathetic editor may inhibit our efforts. The Engineers' Society of Pennsylvania has conducted Industrial Welfare and Efficiency Conferences to the evident satisfaction of all participants.

As soon as time permits we plan in Cleveland to enlist a few of our younger engineers to give illustrated lectures on engineering subjects before small gatherings in churches, schools, libraries and the like. It is hoped that a sympathetic understanding of engineering knowledge and skill can be brought about more quickly by a personal contact of this sort. In addition, the speakers will gradually acquire by practice that facility of expression on their feet which is necessary in order that we may argue on equal footing subjects in dispute before legislative bodies or large gatherings of citizens.

It is evident that the first missionary work must be done among engineers and that the measure of our progress in civic activities will be determined largely by our working together, not only in communities but everywhere—in a word, Engineering Coöperation.

The experience which has been gained in one society should not only be the common property of all, but the peculiar conditions existing in each place should be interterpreted so that general principles may be formulated. For instance, in Philadelphia the local sections of national societies are affiliated with the local society. In Detroit the quarters of the Engineering Society are rented to local sections, but coördination of effort is still to be worked out. In Cleveland the formation of sections of the national societies comes about slowly because it is felt that the local society fills the field. Here are suggested the large questions:

Can the interests of the national societies be best forwarded by having local sections in affiliation with or separate from the local society; and, on the part of the local societies, do local sections of the national societies tend to strengthen or disintegrate the local organization. The author inclines to the opinion that interest in the local society is the parent of prosperity in the national organization.

It seems apparent that the interests of all engineers and technical men have so many points in common—dovetail, as it were—that in any community there should be one home for all and that along certain lines all shoulders should be to the wheel for the best interest of the community and the engineering profession.

It can be truthfully said that legislation has often failed to take the constructive form favorable to public interest, and largely because the engineer has not taken his just responsibility as a citizen. To what extent should we enter politics? It might be rashness to enter actively in political campaigns as yet, for the stage is not properly set nor are the actors trained to reach the audience in public debate. But in matters of pending legislation, the lawmakers are ready to listen to what engineers say. In Cleveland the present Mayor would, I venture, not think of appointing a committee of citizens where engineering principles are under consideration without selecting a due proportion of engineers, and that after asking for nominations by the board of the Society. Our recently appointed City Plan Commission is headed by a member of our Society. Two out of three members of the committee having charge of building our new $2,000,000 library building are members of our Society.

Licensing of engineers by states is advocated in many quarters, by engineers as well as by the public. This is a subject for consideration in a broad minded and unselfish way—Engineering Coöperation.

To sum up, in the discharge of his ordinary duties the engineer is usually contributing to the substantial advancement of the community. Yet there remains a large undeveloped opportunity for him to aid in promoting public welfare.

The age of selfish, although valuable, specialization is giving way to the age of coöperation. The engineer at once has the right and rests under the obligation, because of his training and ability to act as leader in the changing conditions.

If we are to make progress along the course just outlined, the engineer and the public must first get well acquainted. There must be a systematic direction and education of the public to a realization that in civic affairs the engineer is an honest and efficient servant of the people.

Let me add one thought in closing. Suppose we engineers should publish regularly a magazine devoted to engineering written in such a manner that it would be attractive to the intelligent layman. To make the idea concrete for comparison, make it something after the standard of the National Geographic Magazine but devoted to engineering, controlled and published by engineers. Would it not contribute more than any single thing we can do to advance the interests of both the public and the engineer?

We in Cleveland plan to get out a special issue of our Journal in 1916 tending toward the ideal pictured above. Suppose engineers in Buffalo, Detroit, Boston, Philadelphia, Pittsburgh and elsewhere should contribute copy, and that the engineering societies of these several cities should buy and give away in their cities, as we did our Good Will number of our Journal in Cleveland, only a thousand copies each. Then suppose the idea grew and we published regularly to paid subscribers a magazine that would bridge the gap between the engineer and the layman. Who has the imagination to measure the future? Let us think on it.

In 1914-15, the first year of operation, 1,317 ocean-going vessels passed through the Panama Canal. This included commercial, naval, and pleasure vessels. The aggregate net tonnage, according to the Panama Canal measurement, was 4,596,644 tons, and the aggregate gross tonnage 6,494,673 tons. The average net tonnage per vessel was 3,490 and the average gross tonnage 4,931.

Very considerable attention has been given to the composition and treatment of tool-steel for machine tools, but the three implements of the hand worker—the file, the chisel, and the hammer—have been comparatively neglected. Important work has recently been done in testing the former of these, and there is little need of improvement with the last-named, but it is believed that the chisel has not received the systematic attention its importance deserves.

The material usually employed for chisels is not ordered by specifications, but a well-known and tried brand purchased. After considerable experiment it was decided to order chisel steel to the following specifications: Carbon, 0.75 to 0.85 per cent; manganese, 0.30; silicon, 0.10; sulphur, 0.025; phosphorus, 0.025.

The analysis of a chisel which had given excellent service was: Carbon, 0.75 per cent; manganese, 0.38; silicon, 0.10; sulphur, 0.028; phosphorus, 0.026. The heat treatment this chisel received was unknown.—*Jour. Inst. Mech. Engrs., February, 1916 (February 18 meeting.)*

In the modern high-speed steam and internal combustion engines, cast iron is, up to the present, the only metal which has given satisfactory working results when used for the construction of certain vital parts, such as pistons, piston rings, and cylinders. This fact, coupled with the serious drawbacks of cast iron in other ways, is sufficient to prove the tremendous importance of a careful study of the subject.

The two chief properties required of cast iron for the purposes named are maximum resistance to wear, and the most perfect running properties under the conditions existing in the engine. The mechanical properties, such as tensile and transverse strength, can usually be obtained sufficiently high to withstand the stresses involved in the use of the generally accepted thickness of material. The modern tendency, however, seems to be to cut down the weights of members, and for this reason higher tensile strength irons will be more and more in demand.—*Engineering, February 18, 1916.*

One of the most important problems that has to be solved by any organization is the problem of pay. This is especially true of an organization operating under scientific management. In the first place, there has been so much discussion of the matter that the men who became members of the organization are prone to be critical upon the subject. Another reason is that the education of the workers under this type of management occupies so much time, and is so expensive, that it is a decided loss to have a trained man leave because of dissatisfaction with his pay. The third is that this type of management depends absolutely for its permanence and success on the spirit of coöperation that exists. Finally the pay system under the scientific type of management is scientifically determined.

The problem of pay is one upon which close attention must be continually concentrated. When this pay problem based on time study is solved to the satisfaction of all concerned, an important part of the success and the permanence of the installation of scientific methods of management is secured.—F. B. and L. M. Gilbreth, in *The Iron Age, March 9, 1916.*

The temperature of a boiler tube is within 10 to 20 deg. cent. the same as that of the boiler water, and the temperature of the tube is affected very little by the temperature of the hot gases, but follows the temperature of the boiler water.

As the temperature drop along the path of heat travel is nearly proportional to the resistance to heat travel, the resistance appears to be very high from the hot gases to the gas-side surface of the tube and very low from this surface to the boiler water. This fact indicates that a boiler tube can transmit very easily all the heat that can ever be imparted to it by the hot gases, and that as long as the tubes are kept free from scale, oil and other deposit, and filled with water, it is impossible to overheat the tubes, no matter how hard the boiler is worked.

The slow part in the path of heat travel is from the hot gases to the boiler tube. It is this part of the path that is responsible for the slow rate of heat transmission in boilers as now designed and operated. Anything that will increase the rate of heat impartation by the hot gases to the boiler tube will almost directly increase the rate of working of the boiler. This is an important fact and should be kept in mind by the designer when designing a boiler which is to be operated at high capacity.—*Technical Paper 114, U. S. Bureau of Mines.*

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

Provisions have been made by the Publication Committee for Correspondence Departments in The Journal as follows:

A Department for contributed discussions on papers previously published, or new matter.

A Members' Correspondence Department including suggestions on Society affairs.

Contributions for these departments are earnestly solicited.

TURBINES VS. ENGINES IN UNITS OF SMALL CAPACITIES

To the Editor:

In the paper on Turbines Vs. Engines in Units of Small Capacities, by J. S. Barstow, published in the September issue of The Journal, a statement is made in the last paragraph that engines are particularly applicable for condensing units where the condensing water supply is limited and where the water must be recooled and recirculated.

A compound condensing engine or a single cylinder uniflow engine has high efficiency—that is, utilizes a large share of the available energy between the terminable pressures, provided the exhaust pressure is not too low. A vacuum of 26 in. is about as high as it pays to go with an engine. Now where water must be recooled by a spray pond or a tower, very high vacuums are not attainable because of the physical and commercial limits to the temperature to which the water can be cooled, to say nothing of the cost of pumping the water if a large quantity is circulated. Thus the reciprocating engine has a field of peculiar applicability in plants of this kind.

The steam turbine is at a disadvantage under these conditions of moderate vacuum. In a turbine the efficiency of conversion of energy of the steam into mechanical energy is greater, the lower the existing pressure. High vacuum is doubly important to the steam turbine—to furnish more energy and to furnish energy which can be abstracted most efficiently.

The turbine is cheaper than the engine, requires less space and foundations, is cheaper to operate and can be built in larger units than the engine, and therefore it is pertinent to inquire how far it is possible and profitable to go in obtaining high vacuum, so as to reduce steam consumption to that of the engine.

The higher the vacuum, the greater the power of the auxiliaries (and it is to be remembered that the circulating water is pumped against considerable head) and the greater the fixed charges for the condensing and water cooling apparatus. These charges offset the gain in the turbine. The critical vacuum varies with conditions, but is usually found to be around 27 in. vacuum for atmospheric conditions of 75 deg. and 70 deg. humidity. The chart of Fig. 1 is taken from an article by the writer in Power, of November 11, 1913, entitled: Best Vacuum with a Cooling Tower. It shows that there is a saving of $200 per year by increasing the vacuum from 26 to 27 in. for a 500 kw. turbine with $3.00 coal, 50 per cent load factor and other assumptions given in the article. Further investment, however, to obtain a higher vacuum, actually results in a smaller gain, until at slightly over 27½ in., the net gain (above 26 in. operation) is nothing. The increased fixed charges and operating cost wipe out the gain in turbine economy.

Let us assume steam conditions of 175 lb. pressure, 100 deg. superheat and 26 in. vacuum for the engine and 27 in. vacuum

for the turbine. The engine efficiency referred to the Rankine cycle may be taken at 70 per cent and the turbine efficiency at 65 per cent. We then have the following:

a Reciprocating engine, 26 in. vacuum.

Theoretical steam consumption, 7.8 lb. per br. h.p.

Actual steam consumption at 70 per cent efficiency, 11.15 lb. per br. h.p.

b Turbine, 27 in. vacuum.

Theoretical steam consumption 7.4 lb. per br. h.p.

Actual steam consumption at 65 per cent efficiency, 11.40 lb. per br. h.p.

There is a difference of 0.25 lb. per br. h.p. in favor of the engine, to which must also be added the difference in power consumption of the auxiliaries.

The average turbine efficiency of 65 per cent corresponds approximately to an efficiency starting at 55 per cent at the high pressure end and increasing to 75 per cent for the wheels operating in high vacuum steam. If it were profitable to install

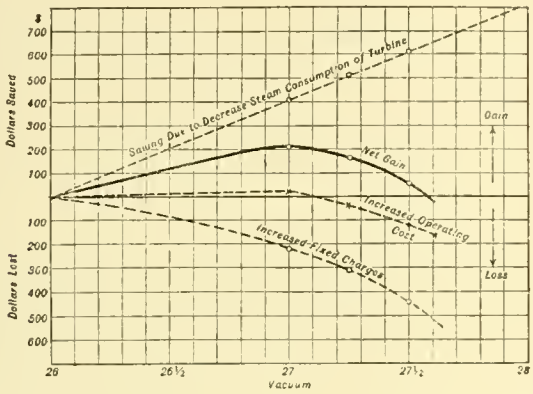

Fig. 1 Diagram Indicating Saving Due to Increase of Vacuum

cooling tower equipment for 28 in. vacuum (for the same atmospheric conditions), the increase in available energy would be 20 B.t.u. per lb., of which 75 per cent would be utilized by the turbine and as the energy available at 27 in. vacuum is 344 B.t.u., the percentage gained in output would be 75 per cent x 20 ÷ (344 x 65 per cent) = 6.7 per cent, and the steam consumption would be reduced from 11.4 lb. to approximately 10.63 lb.

Now suppose that the turbine is operated with only half of the steam expanded to the 28 in. vacuum, and the other half expanding to the original 27 in. vacuum conditions. No additional investment in condensing or water recooling apparatus would be needed. The steam consumption would be the average of the two figures given, or

c Turbine, vacuums of 27 and 28 in.

Average steam consumption 11.02 lb.

This steam consumption is slightly lower than that of the engine; the difference 0.13 lb. would offset the greater power consumption of the condenser auxiliaries required with the turbine, as compared to the engine equipment.

In order to condense the steam exhausted from the turbine at two vacuums, a two-stage condenser is necessary, as shown in Fig. 2.[1]

Ordinarily the condensing water is heated to its final temperature in one step while condensing all of the steam at 27 in. vacuum. In the two-stage condenser it is heated through the first half of its total rise while condensing half of the steam at 28 in. vacuum, and through the final half of its rise while condensing the remainder of the steam at 27 in. vacuum. The size and cost of the cooling tower, the amount of water circulated and the cost of pumping, all remain the same.

Half the steam is condensed at 28 in. vacuum in the upper section (Fig. 2) and the other half at 27 in. vacuum in the lower section. The air is withdrawn from the high vacuum section by steam jets which act as augmenters to improve the vacuum by withdrawing the air in a very rarified state, at the same time reducing the amount of condensing surface necessary. Another feature of the construction is the arrangement for heating the cold condensate from the upper part of the condenser by bringing it into contact with steam in the lower part of the condenser. All the condensate is thus returned at the temperature of the hottest steam.

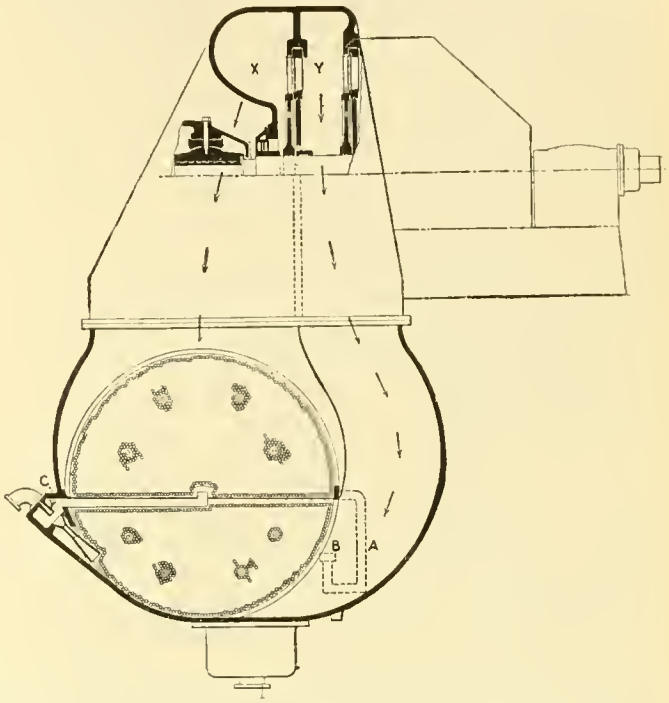

Fig. 2 Two Stage Condenser for Operation in Connection With a Turbine

The decrease in turbine steam consumption from 11.40 lb. per h.p. to 11.02 lb. per h.p. is obtained without added cost of cooling tower or spray pond, pumps, piping or condenser. It is true that even this recooling and condensing equipment, which is the same size as that required for standard 27 in. vacuum operation is more costly than that for 26 in. vacuum with the engine, but on the other hand the engine is more costly than the turbine.

The two-stage condenser is also applicable to plants having a natural supply of water. Take for example a turbine and condenser installation for 28½ in. vacuum with 70 deg. water. Half the steam can advantageously be expanded to 29 in., making a gain of a very valuable half inch of vacuum on half the steam. The efficiency of a complete turbine of a large size may be taken at 75 per cent. The efficiency of the last blades is 85 per cent or more. The percentage gain in power per pound of steam is found to be one half of 5.7 per cent or 2.8 per cent for steam conditions of 200 lb. pressure and 150 deg. superheat. With a 10,000 kw. turbine this is worth from $2000 to $5000 per year, depending on coal price, load factor, etc.

New York, N. Y.

Paul A. Bancel.

[1] See article in *Power* on The Two-stage Condenser, Sept. 21, 1915.

THE DIESEL ENGINE AND ITS APPLICATIONS IN SOUTHERN CALIFORNIA

To the Editor:

In view of the high value and profit that can accrue from a correspondence department dutifully supported by the members of the Society, I feel it incumbent upon me to offer my contribution to this good work on an occasion when so many others will perforce not find scope to assist. I have had some reluctance to overcome, for I have so frequently refrained from comment when the oil-engine and particularly the Diesel oil engine has been the subject of wrongful or inaccurate statements, that I fear to be thought guilty of an ulterior motive in selecting Mr. Adams' paper for criticism. The explanation seems due to Mr. Adams that his errors occur when he has had to rely for guidance upon printed sources, not aware that much is published which arises from ignorance.

Referring to the statement in the paper by Mr. Adams, that "air inlet and exhaust valves are not required," it is more usual to find the flow of scavenging air controlled by valves. Of only three designs can it be said that the exhaust valves and air admission valves are absent. Between the extremes there occur two interesting intermediate styles: *a*. the Sulzer fashion, in which the scavenging air is admitted through ports at the base of the cylinder, but with a positive cut-off in the shape of a valve controlling the flow of air to the ports, and *b*. the Sabathé mode, in which part of the scavenging air enters through ports and part through a valve in the head of the cylinder. The trend is markedly towards the control of scavenging air by valves.

The statement that "in marine work the reduction in number of valves makes it easier to reverse a 2-cycle engine" is ambiguous. The probability is that this remark will generally be interpreted as an assertion that the 2-cycle Diesel engine is easier to reverse than the 4-cycle engine, which would be a sorry impression to give. What has been the least simple reversing mechanism applied to any Diesel engine has been that fitted to all the Carels 2-stroke sets. On the other hand the small Polar 2-cycle sets have had a simpler reversing device than any other engine has possessed, but this is not true of the larger Polar engines, such as were for a while in the tankship Sebastian.

Again while the designs of the M.A.N. 2-cycle submarine engine (as exemplified in NLSECO construction, for instance) and of the FIAT submarine engine show extremely simple reversing mechanism, they do not derive it from having fewer valves than the 4-cycle type possesses, for they have two scavenging valves, besides the injector and the starting-valve. By contrast, the larger Polar engines (Sebastian type) have no scavenging valves in the head, but their reversing mechanism is not simpler than that of the 4-cycle engines.

There is no general rule governing the case, and the most that can be said to the favor of the 2-cycle engine in this regard is that it *can be adapted* to have a simpler reversing mechanism than the 4-cycle engine can possess. I have preferred to refer to "simplicity of mechanism" rather than to "ease of reversing," because all the marine Diesel engines of any credit reverse very easily. Mr. Adams' phrase suggests a different state of affairs.

Literally it is correct that "the use of the 2-stroke cycle has also made large units possible," and that 1200 h.p. per cylinder in a single-acting engine has been built, but without the qualifications that would show the limits of this statement, the remark is misleading. Would it not be thought by Mr. Adams' audience and circle of readers that the large 2-cycle unit is a commercial realization and not merely the experimental production which it is at present? Would it not also appear that Mr. Adams had indicated the maximum cylinder power yet furnished in the experimental construction of the large European firms?

As a matter of fact, Sulzer's have been making trials with a single-acting unit which develops about 2000 h.p., but of which I cannot quote either the maximum "overload" power or the "normal" test-bed output. And in the double-acting style of construction, which it seems appropriate to mention at this place, over 2000 h.p. per cylinder has been attained in the experimental sets of the Krupp shipyard and of the Nuremburg works. Yet, of all this costly effort no practical, commercial result has been born.

The Sulzer factory has made a great showing of orders for 2-cycle Diesel engines of considerable power and has made some deliveries. If the six-cylinder 4000 h.p. engine for the Harland & Wolff shipyard at Belfast has not been erected and started in regular service then the largest 2-cycle engine operated in independent service is a four-cylinder 2400 h.p. set by Sulzer. How trustworthy such engines are in their particular service has not yet been established by independent testimony. If they are not worked for long periods or under continuous full load they probably are satisfactory, but that they can develop full power and assume occasional brief overloading during uninterrupted periods of 300 hr., or even of 200 hr. we know from marine experiences to be improbable. The largest 2-cycle engines that have rendered in marine service the equivalent work and satisfaction of steam machinery are the four-cylinder 800 b.h.p. sets in the "Monte Penedo," these sets also being of Sulzer construction. The famous Swiss firm has achieved more in the development of the 2-cycle Diesel engine than any other factory has to its credit.

And here comes a further qualification of Mr. Adams' remark that "the 2-stroke cycle has made large units possible," a figure of 335 h.p. per cylinder having proved thoroughly successful in a single-acting engine under arduous marine conditions, this being to the credit of the Burmeister & Wain works of Copenhagen, while moreover in the 4-cycle double-acting tandem design the development has proceeded to 2000 h.p. per crank-throw, not in an experimental shop engine, but in the Augsburg engine delivered to one of the compressed air stations in Paris.

Will Mr. Adams state that cylinders of 50 in. diameter will not prove satisfactory in 4-cycle engines and will he aver that the tandem double-acting style of construction does not alter the cost comparison between the two types, to which he refers in the early part of the paper? The man who will today venture on a prophecy of the outcome of the battle between the cycles has much to learn. Design, it is true, produces occasional advances in technics—witness the heat shield conceived during the collaboration of the engineers of the Blohm & Voss shipyard and of the M.A.N. Company, several interpretations of which are being tested on the six-cylinder 2000 h.p. engine at the Brooklyn Navy Yard.

It is, however, to metallurgical science that one must turn prayerfully for assistance in striving to overcome the difficulties presented by the large Diesel engines. To speak of the number of heat units passing through a unit of surface in the space containing the burning or burnt gas is to divert attention to problems overcome. All is well where the heat units pass: the troubles come where the heat units accumulate and do not pass. To think in averages does not help one

here; reflection rather must be directed to the extreme conditions.

Can Mr. Adams name sailing vessels in which Diesel engines have been installed other than: Stein, Orion, Fram, Cornelis, San Antonio, Sound of Jura, Quevilly, France, a small Italian schooner and a German training ship (a Danish training ship now building is to have a Diesel engine)? There are a few other small craft in which pole masts are stepped for a small spread of canvas to stiffen the vessel in a nasty cross-sea or to assist in quickening a passage before the wind, but they do not handle properly under canvas alone and cannot thus be classified as "sailing vessels." Of the craft enumerated, only the Quevilly, France and two training ships exceed 500 tons, and of these the first-named has had her machinery removed. Under particular local conditions an auxiliary vessel can be profitable, but the concensus of opinion, backed by general experience, is that such a craft does not suit the economics of remunerative ship-owning. Hence the very small number of Diesel engines installed as auxiliary power in sailing vessels.

The very first engines built at Augsburg to the order of customers were entirely satisfactory, and the patriarch of of them all was doing its daily work at a match factory in Kempton, Germany, when the war started—and probably nothing has since interferred with its satisfactory operation. As in all branches of mechanical construction, the Diesel engine industry has known factories that could not, or certainly did not, produce as well as they should have done, but these have prevailed more of later years than at the start. Occasionally one of the leading firms has gone astray, sometimes effecting a quick recovery, but sometimes—more's the pity—remaining a confirmed delinquent for long. To relate what was done that was bad and to show how much was done that was good would carry one through the whole crowded history of the Diesel engine. In sum, however, it may be stated that most of the work has always been good, and it is totally wrong to believe that "engines giving satisfactory service have only been made in Europe within the last five years." As if any type of engine could survive 13 years of unsatisfactory service in the competition of modern days!

There would have been considerable advantage in adding to the footnote a reference to the 1914 paper by Mr. Setz. There has not been published in this country any exposition of the Diesel engines which is sounder in its consideration than this monograph by Mr. Setz. It expresses mature opinions and displays a fine, clear sense of the fundamental factors which should rule all reflections about the Diesel engine. The 1911 paper by the same author should not be read until after the later article has been studied.

Not having at hand the references which would enable me to quote the cylinder dimensions of the smallest Diesel engine that has been marketed I can amend Mr. Adams' citation only by the bald assertion that the Delaunay-Belleville establishment, of Paris, exhibited at the Turin exposition, 1911, a single-cylinder 4-cycle unit developing 5 h.p. at about 500 r.p.m. Mr. Louis Nobel has furnished from his Petrograd factory to the Russian Imperial Navy, 50 h.p. four-cylinder 4-cycle sets to furnish the propelling power in the diminutive submarines of 50 tons displacement commissioned about 1911 or 1912. He has supplied similar sets for other purposes also. The Polar firm at Stockholm has a special tool equipment for the production of the 12½ h.p. 4-cycle cylinders which it builds into units or sets as required. The Daimler Engine Co. constructed at the Marienfelde Works, near Berlin, a considerable number of 65 h.p. four-cylinder 4-cycle motors for boats of German ships-of-the-line. Also at Berlin, the A.E.G. had begun the production in quantities of 25 h.p. two-cylinder 2-cycle engines direct-coupled with generators. Sulzer's even have not ignored the possibilities of the small Diesel engine. Not one of these small sets enumerated has cylinders larger than those quoted by Mr. Adams as the lowest of which he had knowledge. Several of them have cylinders appreciably smaller and all have a lower rated power at their respective high speeds.

The higher limit is reached certainly in the 2000 h.p. single-cylinder built by Sulzer for trial; this, being operated on the 2-stroke cycle, has a cylinder diameter of probably about 44 in. In all likelihood, the big Krupp & M.A.N. double-acting sets with about 2000 h.p. per crank have a larger cylinder diameter than that quoted by Mr. Adams for the Carels engine. This latter is given as developing 1250 b.h.p. and its mean effective pressure as 106 lb. per sq. in. Obviously this should read 1250 i.h.p. and 106 lb. per sq. in. mean indicated pressure, if the complementary figures are correct. One may also observe that to obtain even this indicated power a piston speed of nearly 1000 ft. per min. is utilized and the mean pressure is not such as Carels have ever succeeded in maintaining for long in a 2-cycle cylinder.

It is apparently impossible that the development of the double-acting Diesel engine be mentioned without some statement or retort that there is difficulty in keeping the stuffing-boxes tight. Can it not be understood that if a piston can be packed in a cylinder, a connecting rod can be packed in a stuffing-box? There is no trouble with this detail, the experience obtained in double-acting gas-engine practice with cylinders up to 54 in. in diameter having in this regard proved applicable.

What then, it will be asked, is the bugbear of the double-acting engine development? So far as the 4-stroke cycle is concerned, one may state that steady and consistent progress has been made by at least one firm, viz., the M.A.N. branch at Augsburg, and I have been fully convinced that the users of these engines obtain full satisfaction. The upper stage of this advance is marked at present by 2000 h.p. on a single crank, but the proof of independent service is still lacking in the case of this power.

Four other firms to my knowledge have proceeded along this path without going further than the first experimental set. With the 2-cycle double-acting engine the case is wholly different. The stresses arising from the temperature-differences within the inner walls of the cylinder covers have so far proved insuperable obstacles. Fair progress had been made against these faults by more than one German firm, but those people still had far to go. There is this, however, to be said in favor of the 2-cycle double-acting engine that it does not suffer from the bearing troubles which are the bane of the 2-cycle single-acting engines.

Referring to the matter of crossheads, in Europe all Diesel engines of 500 h.p. designed for the propulsion of mercantile sea-going or ocean-going vessels have crossheads. In Russia some engines for Caspian Sea and River Volga service have been built without crossheads even in sets of 600 h.p. No submarine engines have them, although the U. S. Navy has encouraged the construction of a twin pair of powerful sets with crossheads. All double-acting engines naturally have them and at least two manufacturers have produced vertical single-acting land engines with this feature.

Regd. W. Crowley.

22 Madison St., Geneva, N. Y.

COMMENT ON ARTICLE LISTED IN ENGINEERING SURVEY

To the Editor:

On page 274 of The Journal for March, 1916, appears the following heading at the top of the page: Selected Titles of Important Engineering Articles, and the sixth one of these *selected titles* is "Air in Compression and Expansion, C. K. Bennett, Power, Feb. 8, 1916."

One wonders whether an engineer read this article before the selection was made, or whether it is the policy of the Editors of The Journal of the American Society of Mechanical Engineers to select Important Engineering Articles merely from the title without regard to contents. It would seem not altogether unreasonable to expect the official organ of the Society to select articles having real merit to place under such a heading.

In order to enable those who may not have seen the article by Mr. Bennett, to appreciate the viewpoint of the writer, the following discussion of it is offered.

The first statement in the article is: "In the compression of air all the work done is converted into heat and shows itself in the temperature of the compressed air." This is made as a general statement and as such it is entirely wrong regardless of the interpretation of the indefinite phrase, "in the compression of air." If this phrase refers only to that part of the stroke during which the pressure is being increased, but no delivery of air to the receiver is taking place, then it would be incorrect for all cases, except the adiabatic. If, on the other hand, the phrase was intended to include all the processes involved in the air compressor cycle, the statement becomes even worse. Thus imagine a compressor with such perfect cooling that isothermal compression may be attained; then such a compressor, once started, would run itself, if it be true, as the article states, that "all the work done shows itself in the temperature of the compressed air"!

Then follows a discussion of a chart which was intended to give the temperature and volume of air after compression according to the law $PV^n = \text{const.}$ One statement is: "The curves marked 1.41, 1.35 and 1.25 are plotted for the given exponents representing the ratio $c_p \div c_v = K$, and express the ratio of specific heat at constant pressure and constant volume." It will be news of considerable importance to most engineers to learn from this *selected article* that this ratio of specific heats of air, by some magical power perhaps, has suddenly acquired the property of changing its value to anything from 1.25 to 1.41!

Examining the chart itself one finds many more incorrect values than correct ones. Thus for the temperatures, the only curve which is even approximately correct is the one for which $n = 1.41$, the errors in the other curves in some cases amounting to 20 deg. fahr. or more.

On the right hand side of the chart appears a scale labeled: "Thousands of B.t.u. given up to the air per hour when compressing 100 cu. ft. of free air per min." This is an indefinite expression but *might* mean one of two things. First, it might be taken to mean the gain in intrinsic heat of the compressed air. Second, it might mean the net work in B.t.u. per hour required by an ideal compressor when handling 100 cu. ft. of free air per minute. It fails to do either, however, since the values given are about 40 per cent too high for the former and could be correct for the latter meaning only for the one curve in which $n = 1.41$. The author has evidently erroneously assumed that the net work of the compressor cycle is independent of the exponent, n. He has therefore apparently plotted the values on the right-hand side of the chart as though they depended on the temperature rise of the air alone.

The article closes with the statement: "the heat available for heating from the compressed-air transmission pipes can also be readily determined." It is implied that this information might be obtained from the chart, but the method is left to the reader's imagination.

F. O. Ellenwood.

Ithaca, N. Y.

[The articles listed in each issue at the conclusion of the Engineering Survey are selected with reference to their scope or originality, as judged by a cursory examination; and the Editor is glad to have comments upon them from any members who have had the opportunity to study the original articles more thoroughly.—Editor.]

NOTES

The Russian Ministry of Finance, through the Commercial Attaché to the Imperial Russian Embassies, 44 Whitehall Street, New York City, announces an extension till September 1, 1916, of the time for presenting for competition for prizes methods of utilizing alcohol for industrial purposes.

As a result of the great increase in the price of red prussiate of potash, extensively used as a coating material for blueprint paper, an economical method of preparing the substance has been devised by the U. S. Department of Agriculture. The Department has issued a circular describing the necessary apparatus, which has been developed primarily for use in the government service, but is equally available for other purposes.

Elaborate theories of multiple evaporators have been founded on the basis of equal temperature differences in each vessel, but it is well known that the temperature distribution corresponds much more closely to equal pressure differences, though no good explanation has been offered.

It has been suggested that the transmission depends on absolute temperature, on absolute pressure, on vapor density, etc., but none of these explanations carry conviction.

A new theory is that the explanation of the observed results is to be found in the kinetic theory of gases; the application of this theory to multiple evaporators at once gives results so closely in accordance with practice that there appears to be good reason for considering the application justified.—*The Engineer, February 18, 1916.*

The Department of Engineering of the Johns Hopkins University has organized a course in gas manufacture and by-product recovery. This course involves essentially the study of the distillation of carbon and the utilization of all the products of the process. It deals with the principles underlying the gas industry and the production of most of the chemicals used in the industries of the world. The work is taken up in both lecture room and laboratory, for which special equipment is provided. Capt. Frederick H. Wagner, Mem.Am.Soc.M.E., chief engineer of The Bartlett Hayward Company, Baltimore, is delivering the course of lectures.

It is the intention of the Department of Engineering to publish monographs covering the work done and to distribute copies to those interested. The facilities of the laboratory will be available so far as possible for special research work in the gas industry, full reports of which will be published.

WORK OF THE BOILER CODE COMMITTEE

AT a meeting of the Council of the Society in January 1916, the entire Boiler Code Committee was reappointed as constituted for the year 1915, to serve for another year. The inquiries which the Committee had been authorized by the Council to consider for the purpose of making interpretations, have been submitted to the Committee in increasing numbers as additional States have applied the Boiler Code for local regulation, and an organized effort was seen to be necessary to meet the requirements in this direction.

At the meeting of the Boiler Code Committee called in January, however, Mr. John A. Stevens tendered his resignation as chairman of the Committee, feeling, as he stated, that on account of his appointment to the Council as one of the Managers, the honor of chairmanship might properly be incumbent on some other member of the Committee. The resignation was tendered with the idea that there were other members of the Committee whose activity in the early work of formulating the Code entitled them to consideration for the position.

The resignation was considered by the Committee in session, Dr. Jacobus presiding in the absence of the Chairman, and as a result the following resolution was unanimously passed:

RESOLVED: that the members of the Boiler Code Committee, appreciating the untiring energy and service of Mr. Stevens in formulating the Boiler Code, request him to withdraw his resignation and remain Chairman of the Committee.
(Signed by all of the Members of the Committee.)

Mr. Stevens, when tendered this resolution, expressed his appreciation of this action and in withdrawing the resignation, he promised his best efforts in the Committee's future work.

Three meetings of the Committee have been held since the report published in the January issue of The Journal of the interpretations rendered in 1915, which included forty-three cases in all. Cases Nos. 47-58 have been considered by the Committee and replies formulated and approved by the Council of the Society; Case No. 45, which was reported in the January issue of The Journal as in the hands of the Committee, is now complete. In addition to the above cases that have been approved, Cases Nos. 59-66 are now under consideration by the Committee.

The procedure in the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed on at a regular meeting of the Committee. This interpretation is submitted to the Council for approval, after which it is issued to the party making the inquiry and later published in The Journal, in order that any one interested may readily secure the latest information concerning the interpretations.

In this issue are presented 12 interpretations rendered in Cases Nos. 45 and 47-58, with the exception of Case No. 49 which is in the hands of the Committee. In this report, as previously, the names of inquirers have been omitted.

Case No. 45

Inquiry: Pars. 19 and 20 of the Code require a minimum thickness of ¼ in. for shells and ⅜ in. for heads; are these thicknesses necessary in small vertical tubular boilers of a type built for laundry purposes to work at pressures from 15 to 100 lb., which are 10 in. in diameter by 36 in. long and contain seven 1¾ in. tubes 30 in. long? Would shells formed of 10 in. lap welded standard boiler tubing 0.202 in. thick which has been tested to 500 lb. pressure be acceptable?

Reply: The thickness and material for the shell of this boiler does not comply with the Code requirements. In order for such construction to be stamped with the Code symbol it would be necessary for the material to be of such quality as called for by the Code, and other details to comply with the requirements as set forth.

Case No. 47

Inquiry: An opinion is requested as to whether a particular design of pressed steel lugs for horizontal return tubular boilers, which are of dimensions shown in catalogue, are made in accordance with the Boiler Code? Par. 323 does not specify the dimensions required on lugs for boilers up to 78 in. in diameter.

Reply: All such lugs must be large enough to permit of using the number and size of rivets required by Par. 325 and where the boilers are over 78 in. in diameter they must meet the requirements as to dimensions called for by Par. 323.

Case No. 48

Inquiry: Is or is not a bushing required on the feed connection where it enters any type of boiler. Is a bushing required where the blow-off connection is threaded directly through the dished head of a boiler drum, and if so, how many pipe sizes larger than the normal diameter of the pipe must it be. If a flange is riveted to the head is a bushing required?

Reply: The boiler bushing or equivalent is obligatory only where both external and internal pipes making a continuous passage are used. The brass or steel bushings referred to in Paragraphs 307, page 76, and 315, page 77, are provided for the purpose of making the external and internal pipes absolutely separate with definite clearance between their ends so that the removal of either will not disturb the other; a properly designed flanged construction which will effect this will comply with the intention of the Committee. See also Rule 300, page 76, and Table 7, page 68.

Case No. 49

(In the hands of the Committee.)

Case No. 50

Inquiry: It is recommended that in the steel tube specifications in the Boiler Code that the flange test be not required for tubes over 5 in. diameter, that tubes over 6 in. diameter should be tested to 500 lb. per sq. in., and that in gaging the tubes as to size, the measurements should be made, according to the usual custom, near the ends of the tubes, the variation in diameter of tubes over 4 in. not to exceed ½ of 1 per cent either way.

Reply: The tube specifications in the Boiler Code were prepared at a joint conference of the tube makers and were adopted by the Boiler Code Committee in precisely the way they were presented. It can, therefore, be seen that should any amplifications be made it is no more than fair that all affected interests be consulted. No changes can be made in the Code except at a revision period at which all interested parties may be heard, which will probably be deferred until near the limit of the two years specified in the Code. The Committee, however, renders interpretations for features not covered explicitly by the Code, and would gladly consider suggestions from the boiler tube manufacturers who prepared the specifications now in the Code.

Case No. 51

Inquiry: Please explain the application of Par. 182, 182-*a*, and 182-*b*, to rivet lay-outs for quadruple butt strap joints.

Reply: Par. 182 of the Boiler Code fully describes the rivet lay-outs for quadruple butt strap joints. To explain in detail, rivet lay-outs are shown in Fig. 5 to indicate its application. The "back pitch," which is the distance A between center lines of any two adjacent rows of rivets measured at right angles to the direction of the joint, must be not less than twice the rivet diameter (Par. 182). In details like B, Par. 182-*a* is applicable, which specifies that the sum of the two diagonal sections of the plate between the inner rivet and the two outer rivets must be at least 20 per cent greater than the section of the plate between the two rivets in the outer row; that is, $a + b$ must be at least 20 per cent greater than c. In details such as C, Par. 182-*b* is applicable, which specifies that the sum of the two diagonal sections of the plate between the two inner rivets and the two rivets in the outer row shall be at least 20 per cent greater than the difference in the section of the plate between the two rivets in the outer row and the two rivets in the inner row; that is, $e + f$ must be at least 20 per cent greater than $g - d$.

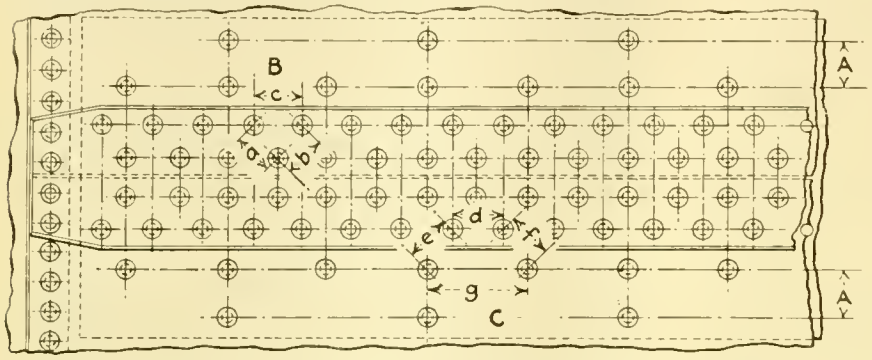

Fig. 5 A Typical Quadruple Butt Strap Joint, Showing Application of Par. 182

Case No. 52

Inquiry: Why was the factor of safety of 5 adopted for stationary boilers, while the Interstate Commerce Commission has established the minimum factor of safety of 4 for locomotive boilers, and there have no doubt been many boilers in operation at lower factors of safety without any trouble?

Reply: The factor of safety of 5 was selected for stationary boilers for the reason that all types of such boilers under all variations of efficiency of maintenance had to be covered with one factor of safety. Rules for locomotive boilers, not subject to Federal inspection, may be formulated later and added to the Boiler Code rules, which are not intended to cover locomotive boilers subject to Federal inspection.

Case No. 53

Inquiry: Par. 21 seems to work an injustice to manufacturers of water tube boilers who are using 3 in. tubes, as for this size one gage heavier than standard is required.

Reply: The gages of tubes to be used have been specifically mentioned on page 10 of the Boiler Code, edition of 1914 with Index.

Case No. 54

Inquiry: Please state the authority for the requirements in Par. 195 that "dished heads with the pressure on the convex side shall have a maximum allowable working pressure equal to 60 per cent of that for heads of the same dimensions with the pressure on the concave side," and give the formula on which it is based.

Reply: The rules on dished heads referred to were adopted after investigation of the general practice on the subject, and practically agrees with other standards. It was found that all rules in use are empirical and not theoretical, the latter being too complicated for general use.

Case No. 55

Inquiry: In ordering a new boiler stamp to replace one that is worn out, is it necessary to submit a new affidavit to the Boiler Code Committee?

Reply: When a user of the A.S.M.E. boiler stamp returns a wornout stamp, a new one may be issued in its place, at the usual price, without requiring the filing of a new affidavit.

Case No. 56

Inquiry: An opinion is desired as to whether a particular make of automatic water gage conforms to the interpretation given in Case No. 35.

Reply: The Committee has decided that it will not express opinions on types of boilers or of apparatus and it will therefore be impossible to comply with the request for an opinion. If there is anything ambiguous in the reply to Case No. 35, the Committee will gladly answer any inquiry respecting same.

Case No. 57

Inquiry: Ordinary shop practice does not seem to be covered by the Code. For instance, Par. 239 applies only to furnaces of $^5/_{16}$ in. plate or thicker; in actual practice, however, furnaces 20 to 40 in. in diameter are built of ¼ in. plate, more or less staybolted.

Reply: The furnace of a vertical fire-tube boiler need not be stayed if the maximum allowable working pressure computed by Par. 239 of the Code is equal to or in excess of the pressure under which the boiler is to be operated. If the pressure computed by Par. 239 is less than that at which the boiler is to be operated, the furnace should be fully stayed in accordance with the rules for flat surfaces. Furnace sheets should in all cases be $^5/_{16}$ in. thick or over.

Case No. 58

Inquiry: Please advise as to what the Committee proposes to do about correcting the rule limiting pressure on malleable iron to 160 lb. so as to permit a proper pressure on malleable iron junction boxes?

Reply: Attention is called to Par. 9 on page 8 of the Boiler Code, which reads as follows:

> 9. Cross pipes connecting the steam and water drums of water tube boilers, headers and cross boxes and all pressure parts of the boiler proper over 2 in. pipe size, or equivalent cross sectional area, shall be of wrought steel, or cast steel or class B grade, as designated in the Specifications for steel castings, when the maximum allowable working pressure exceeds 160 lb. per sq. in.

This rule was adopted after the matter had been given very careful consideration by the Committee and after an extended conference had been held with the boiler using and boiler manufacturing interests.

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SOCIETY AFFAIRS

THE SPRING MEETING AT NEW ORLEANS

IT has been said that one of the most important functions of a society is the offering of the right of association, and such association makes for a sense of distinction and of pride. The member of a society feels that in cities which are strange to him he has yet the right to fellowship with other members there so far as the right may be wisely exercised, and in turn he is stimulated to do his own share as he is bound by an *esprit de corps* to confer benefits upon his associates similar to those he has himself received.

It is very gratifying that there is at the present time a spirit of association pervading the whole membership of the Society. The Local Sections are strengthening their bonds with the Society proper and with one another, as are also the Student Branches.

In the preliminary work for the Spring Meeting, the Committee on Meetings in New York has experienced the closest coöperation with the Committee on Arrangements in New Orleans, and there is no question but what the good-fellowship spirit will permeate the whole meeting, and that members and guests will take with them to their homes an impression of

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View in City Park, New Orleans

the hospitality of our Southern friends which will stimulate them to return to their fellow-member hosts, by contributing in increased measure to the activities of the Society, benefits of equal value to those they receive.

Full particulars of the New Orleans meeting, April 11 to 14, were given in the last issue of The Journal, in an article which included the program of the meeting, transportation arrangements, hotels, social features, etc. It only remains therefore to list the papers to be presented and discussed, which are as follows:

Wednesday morning, April 12

Organizing for Industrial Preparedness, Spencer Miller, Member of Council, Am.Soc.M.E., Member Naval Consulting Board.

Thursday morning, April 13

Capacity and Economy of Multiple Evaporators, E. W. Kerr, Mem.Am.Soc.M.E.

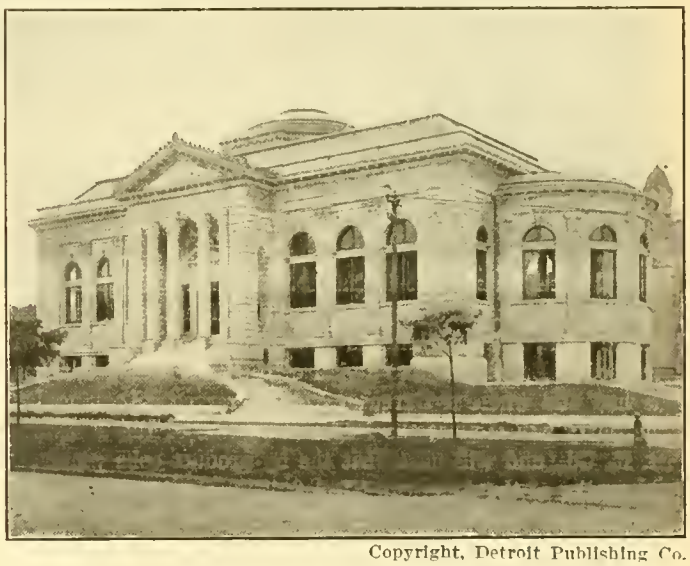
The Evolution of Low Lift Pumping Plants in the Gulf Coast Country, William B. Gregory, Mem.Am.Soc.M.E.

Mechanical Equipment Used in the Port of New Orleans, William von Phul, Mem.Am.Soc.M.E.

Friday morning, April 14

Establishing a Standard of Measurement for Natural Gas in Large Quantities, Francis P. Fisher, Mem.Am.Soc.M.E.

Deviation of Natural Gas from Boyle's Law, Robert F. Earhart and Samuel S. Wyer, Mem.Am.Soc.M.E.



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Some Experiments on Water-Flow Through Pipe Orifices, Horace Judd, Mem.Am.Soc.M.E.

The Measurement of Viscosity and a New Form of Viscosimeter, H. C. Hayes and G. W. Lewis.

Dynamic Balance, N. W. Akimoff.

Disastrous Experiences with Large Center-Crank Shafts, Louis Illmer, Mem.Am.Soc.M.E. (Contributed by the Gas Power Committee.)

On the Transmission of Heat in Boilers, E. R. Hedrick and E. A. Fessenden, Mem.Am.Soc.M.E.

The topic of the first of these papers is timely, and it is expected that the paper will call forth some interesting discussion.

Three of the papers are "Southern" papers—dealing with engineering problems peculiar to the sugar and rice industries of the South.

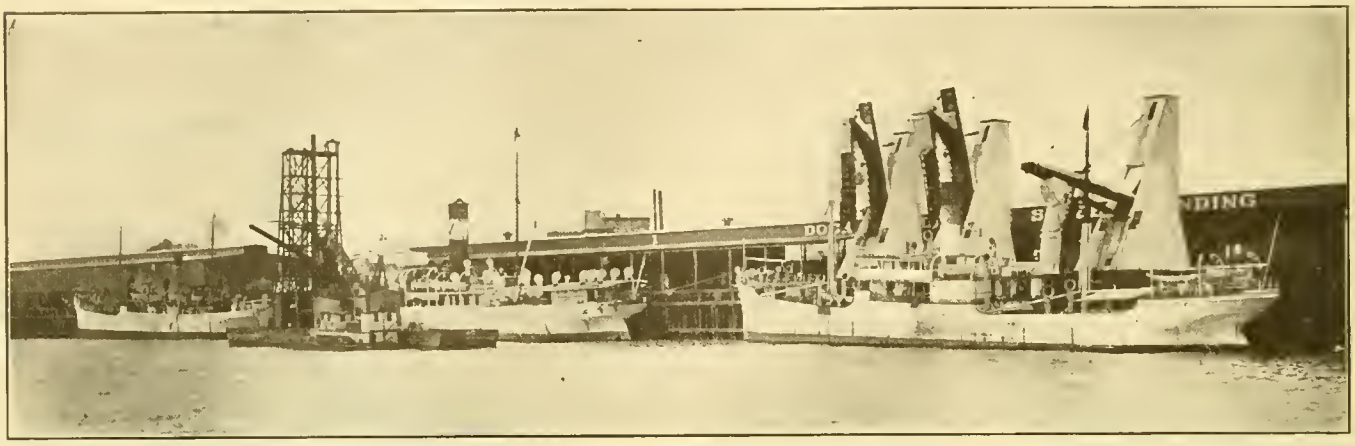
The remaining papers cover a wide field, and include results of highly important experiments and developments in their respective subjects.

Abstracts of the papers are included below in order that members may obtain an idea of their purport, and request

copies of the papers for contributing discussion if they have not already done so.

THE STOP AT BIRMINGHAM

A unique entertainment will be provided by the Birmingham Local Section for those who stop over at Birmingham on the way to New Orleans. The program that has been arranged is as follows: The guests will assemble at the Tutwiler Hotel at 9 a.m., and from there proceed to the Louisville & Nashville depot where they will board a special train for a trip around the district. This train will stop first at the Republic Iron & Steel Company's furnaces at Thomas, and then at the Ensley blast furnaces, open hearths and mills of the Tennessee Coal, Iron & Railroad Company. From there it will proceed to Bayview where a view of the impounding dam may be had and where a Barbecue will be served. Leaving here the party will stop at the Edgewater Mine of the T. C. I. & R. R. Co., and will next visit the by-product coke plant and the works of the American Steel & Wire Company, and from there return to Birmingham. The party will finally be taken through the Manufacturers Exhibit Building. At about 6:45 p.m. a dinner will be served in the banquet hall of the Tutwiler Hotel for the nominal price of $1.50 per plate, which it is hoped that the visiting members will arrange to attend in order to become better acquainted with the local members in Birmingham. The dinner will be entirely informal and evening dress is not expected.



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Shipping Scene on the River Front, New Orleans

PAPERS FOR THE SPRING MEETING

In this issue the complete list of the papers for the Spring Meeting is given in the program and abstracts follow below of all but that by William von Phul, on Mechanical Equipment Used in the Port of New Orleans, which it is expected will be received in time for the meeting. These papers are of a high order of merit and are miscellaneous in character, treating of a variety of subjects. All of these papers are being printed in pamphlet form for distribution in advance of the meeting and copies of any or all of them will be sent gratis to members applying *to the Secretary* prior to the meeting. After the meeting extended abstracts of the papers and an account of the proceedings, with discussion, will appear in The Journal so that members will have early information concerning the events of the meeting. Finally, the papers, together with the discussion, will be printed in complete form in the annual volume of Transactions for 1916 for permanent reference.

ORGANIZING FOR INDUSTRIAL PREPAREDNESS

By Spencer Miller

The engineer is active nowadays in army and navy affairs, as witnessed by the appointment of the Naval Consulting Board, the nomination of representatives for the Industrial Census, the movement for an Engineer Reserve Corps and the notable lectures on Military Engineering which are being given to the engineers of New York and vicinity.

In recognition of this trend in the engineering profession, the author raises the question for discussion of how the engineer may best serve his country as a result of the call by the government for coöperation in organizing for preparedness, a movement which is obviously very largely dependent on engineering.

The first step in this direction was the invitation from Secretary Daniels of the U. S. Navy, to The American Society of Mechanical Engineers and ten other organizations, to form a U. S. Naval Consulting Board to be headed by Thomas A. Edison, Hon.Mem.Am.Soc.M.E. This board resolved itself into committees, one of which, the Committee on Production, has as its Chairman Howard E. Coffin, Mem.Am.Soc.M.E.,

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Bonzano House, Jackson's Headquarters, Chalmette, near New Orleans

who formulated a plan for organizing the industries for preparedness. This led the President of the United States to invite this Society and four others to nominate a representative in each state to assist the Naval Consulting Board in "collecting data for use in organizing the manufacturing resources of the country for the public service in the case of emergency." Its immediate work will be to make an inventory of the facts necessary to be known to the army and navy relating to the resources of the nation for the supply of munitions of war in case of need.

The author shows that with the facts of this census properly collated we shall learn where we are weak and where strong. Not only will it be known where munitions, which include supplies of all kinds, can be obtained, but how rapidly they can be produced; to what extent America is independent of foreign countries for raw materials and manufactured products; for what kinds of munitions we have ample manufacturing facilities, and wherein we must provide means for making up the deficiency.

These and other questions are suggested by the author and it is hoped that by way of discussion the membership will present other aspects of the situation which will have a helpful bearing on the problem of how the engineer may best serve his country.

Among the topics which suggest themselves are the following:

How can mechanical engineers consolidate their efforts in a way to oversee effectively the manufacture of munitions?

Should there be modification of standards for arms and ammunition to facilitate their manufacture?

What part should tools, gages, jigs and machine tools play in Industrial Preparedness?

What part should the textile schools take in the training of men for responsible positions in munitions manufacture, and in the testing of materials?

What should be done in the way of storing materials—nitrate and tungsten, for example—against a time of need?

Inasmuch as this paper is to be presented at the New Orleans meeting, there are certain questions relating to southern industry which may profitably be discussed. The resources of the South might supply the country with many materials needed during a period of curtailment of commerce with other nations. For example, products, and especially by-products, to be derived in manufactures of wood; in the production of sugar, cotton oil and molasses; and in the petroleum and chemical industries, especially with reference to crude oil, gasoline and sulphur.

CAPACITY AND ECONOMY OF MULTIPLE EVAPORATORS

By E. W. Kerr

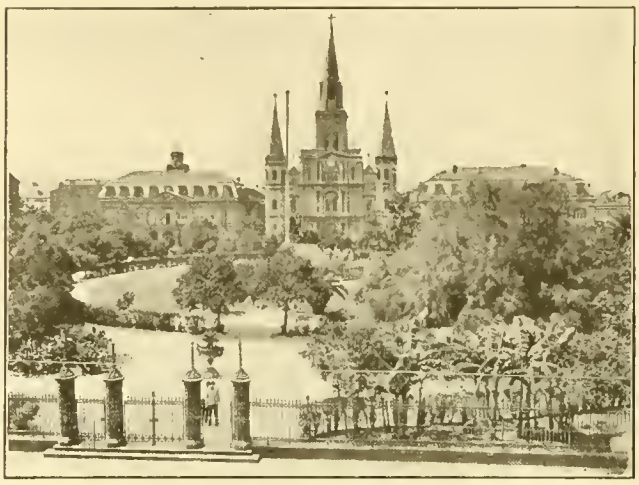
In 1913, the author presented a paper before the Society entitled "Tests upon the Transmission of Heat in Vacuum Evaporators," giving the results of a series of experiments upon laboratory apparatus at the Louisiana State University. The present paper gives the results of further experiments on the laboratory apparatus, though the larger portion of the paper is devoted to the results of 38 tests made on full-sized evaporators in sugar factories. The evaporators tested included the following types:

A Vertical submerged tube (so-called standard)
B Horizontal steam tube
C Horizontal film
D Vertical film
E Vertical submerged tube with special baffles in calandria for distributing steam (vacuum)
F Vertical submerged tube with special baffles in calandria for distributing steam (atmospheric)
G Vertical steam tube with vent pipe for each tube (double tube)

and among these were double, triple and quadruple effect apparatus.

Preceding the results of the experiments a general discussion of the factors affecting heat transmission in evaporators as compared with surface condensers is given.

The tests showed a great variation in the coefficient of heat transmission, not only for different types, but in different evaporators of a given type. This variation was due to difference of design and operation, including steam velocity and density, method of venting, cleanliness of heating surface on both steam and juice sides, velocity of liquor circulation, density and purity of liquor and height of boiling.



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Jackson Square and the Cathedral, New Orleans

The coefficients of heat transmission in the factory evaporators were, as a rule, lower than those obtained with the laboratory apparatus and higher than is usually obtained with surface condensers. The average coefficients obtained in the tests of different types were as follows, the coefficient for type A being taken as 100:

A	100
B	108
C	199
D	135
E	126
F	255
G	149

These, however, cannot be taken as an absolute measure of the heat transmitting capacity per unit of heating surface in the different types, because conditions were not equally favorable in all cases.

In thirteen of the tests, the steam condensed in the first body was determined and from this and other data, the thermal efficiency has been calculated. The thermal efficiency varied from 85 to 97.5 per cent. The variation was due to difference in the radiation losses and vent losses. The radiation loss varied with the capacity of the evaporators, the number of bodies, the proportion of external surfaces covered and the difference between the temperature of the steam inside and the atmosphere outside.

The paper includes illustrations of the types tested, also tabulated data relative to heat transmission and economy. From the tests, curves are presented showing the coefficients

of heat transmission found in each of the different types plotted against steam pressure or vacuum.

THE EVOLUTION OF LOW-LIFT PUMPING PLANTS IN THE GULF COAST COUNTRY

By W. B. Gregory

It is the object of this paper to show the part that pumping machinery has had in the development of the City of New Orleans and in the reclamation of the fertile wet prairie lands of Louisiana and Texas; also to show the importance of pumping plants to the rice industry of the Southwest. To this end the history of pumping in this section is briefly related and examples of typical pumping plants are given.

About ten years ago a movement was started by Edward Wisner to reclaim the wet prairie lands lying at or near Gulf level. The work is now being carried out on an extensive scale. More than a quarter of a million acres of agricultural lands have been reclaimed or are at present in the process of reclamation in the state of Louisiana. The land reclamation has been of such recent development that there is no adequate record of the magnitude of the pumping plants, such as was furnished by the Special Censors of 1910 for irrigation, and this the paper aims to furnish.

In this section it was only natural and normal that pumps used successfully in drainage work would be employed in the irrigation of rice when that industry developed. Often the lift for irrigation did not exceed that in common use in drainage plants and especially in relift irrigation pumping plants. Drainage by pumps was an accomplished fact before the irrigation of rice assumed proportions that made the industry of economic importance. Later on drainage received a fresh impetus from the reclamation of the wet prairie land while the rice industries had obtained maturity. The story of pumping plants in this section therefore deals at times with drainage and at times with irrigation.

ESTABLISHING A STANDARD OF MEASUREMENT FOR NATURAL GAS IN LARGE QUANTITIES

By Francis P. Fisher

Some three years ago the author became associated with the reorganized management of a natural gas pumping system in the Mid-Continent field. In the course of investigations preparatory to outlining a general policy, there was discovered between purchase and sales a loss of gas which seemed wholly unreasonable. The total loss could be made up from leakage in field lines, leakage in main lines, leakage in distribution systems, errors in large capacity meters, errors in domestic meters and errors in estimates of unmeasured gas.

The first step in eliminating this waste in various parts of the system was to provide an accurate gas measurement at strategical points. Manifestly the first problem was that of large capacity meter installation, and with part of the losses possibly due to meter inaccuracy, the first step was establishing a definite standard of accuracy in meters.

A catalogue of the weaknesses and objections to all known and available methods was formulated, and is given in the paper. It was determined that the relative objections be weighed and one of the systems chosen as a standard to be developed to a closer degree of accuracy than heretofore available. The method chosen for development was the orifice meter, in the belief that the objections to the existing types could be overcome at less cost and more simply than to any of the others.

The work done to establish a standard has been continued for approximately two and one-half years; it has now passed the second phase of installing measuring stations to segregate and locate definitely the remaining leakage losses.

There is no question but what any of the other methods of measurement than the orifice meter is capable of an equal degree of refinement, but the present paper is chiefly concerned with the work actually done on this type of meter.

DEVIATION OF NATURAL GAS FROM BOYLE'S LAW

By Robert F. Earhart and Samuel S. Wyer

In this paper the magnitude of the natural gas compressing and measuring problem, and known data regarding probable deviation of natural gas from Boyle's law, are summarized.

Tests were made by the authors in the laboratory of the Department of Physics, Ohio State University, Columbus, Ohio, on eight representative natural gas samples from various parts of the United States, to ascertain by accurate volumetric measurement whether or not these natural gases did deviate from Boyle's law, and if so, under what conditions. The apparatus used and methods followed are illustrated and described in detail. The data obtained are given in tabulated and graphical form.

These data shows conclusively:

- That all of the observed deviations of natural gas from Boyle's law are in one direction—in favor of the buying company where gas is measured under high pressure conditions
- That the different gases have marked peculiarities and marked differences of deviation
- That there is no direct relationship between the deviation and ethane content
- That the direct application of Boyle's law to high pressure natural gas measuring problems gives only an exceedingly rough approximation.

EXPERIMENTS ON WATER FLOW THROUGH PIPE ORIFICES

By Horace Judd

During the past ten years papers upon the flow of fluids have appeared from time to time in the Transactions of the Society; most of these have dealt with the flow of air and gas, although a few have treated of the flow of steam, and the methods set forth have for the most part centered around the venturi meter and the pitot tube. During this period, also, many forms of meters have been brought out for the measurement of air, gas and steam, as well as of water, all more or less successful in operation, and of these, also, a great many have made use of the principles of the venturi meter or the pitot tube.

The pipe orifice has not hitherto met with much favor for the measurement of the flow of steam or water in a pipe, although it is coming into use for air and gas measurement and has been used with certain types of steam meters of German make and also in Bailey flow meters. The chief objections to the pipe orifice have seemed to be that a special form of orifice flange was needed and that considerable uncertainty prevailed concerning the pressure conditions adjacent to the orifice, so that the working coefficients for an orifice in a pipe were not so reliable as those of the venturi meter or the pitot tube.

About two years ago, while employing the Bailey meter to measure the steam used by an engine, the writer became in-

terested in the orifice as a pipe-flow measuring device. It was important to know at what point near the orifice the attachment should be made in order to measure correctly the pressure drop of the steam flowing through the orifice, and it was thought that an investigation would reveal many valuable points concerning the flow conditions through the orifice in a pipe. The present line of work is the final outcome of this thought and has been carried on in connection with water flow, since water could be more easily handled than steam, the intention being to continue later with a study of the flow conditions in a steam line.

The paper is really a record of progress, for only a few points are touched upon, such as the pressure changes in the vicinity of the diaphragm, or orifice; the probable location of the least section, or zone of greatest velocity, of the water jet; and the working coefficients of the diaphragms; leaving many other points of equal interest and importance to be studied into later. The experiments were confined to one size of water pipe (5-in.) and the pressure drop through the diaphragm did not run much in excess of 6 ft. of water, which was considered to be the probable maximum drop desirable to use in connection with any automatic registering device. For the largest diaphragm this range of pressure drop gave an average velocity of 17.5 ft. per sec.

THE MEASUREMENT OF VISCOSITY AND A NEW FORM OF VISCOSIMETER

By H. C. Hayes and Geo. W. Lewis

This paper deals with the measurement of viscosity. It predicts the errors which are introduced by the various types of viscosimeters and verifies these predictions in case of the short capillary types such as the Sayholt, Engler, and Redwood and the orifice types such as the Carpenter, by comparing the temperature vs. viscosity curve for a light and a medium lubricating oil, as given by these meters, with the true curves as determined by a modified form of Poiseuille's capillary tube method.

The work shows that the short capillary types give results about 50 per cent too small and the orifice types give results about 100 per cent too small, and further, none of these meters give accurate comparative results for two different oils or for the same oil at different temperatures.

The only type of viscosimeter on the market that can be expected to give accurate results on theoretical grounds is the Stormer. This instrument attempts to measure the viscosity in terms of the torque required to spin a disk within the liquid, but the mechanical difficulties met with are such as to debar this type.

The authors have designed and thoroughly tested out a viscosimeter which embodies all the good points of the Stormer and none of its defects. They measure the viscosity in terms of the torque which a cylinder experiences when suspended within a rotating liquid. This method eliminates all error due to friction. The results given by this meter agree with the true curves for the light and medium oils to within 1 per cent and can safely be used as a standard.

The advantages of this viscosimeter are evident. The instrument can be calibrated to give direct readings of the viscosity; the oil is not handled during a complete test at various temperatures; the design of the instrument is such that the temperature of the specimen follows closely the temperature of the bath, so the data for the temperature vs. viscosity curve can be taken while the sample is cooling; the meter gives the viscosity of mixtures, such as paints, as well as for liquids that have been carefully filtered; there are no glass parts to break; the personal error is eliminated and the meter can be made self recording.

DYNAMIC BALANCE

By N. W. Akimoff

Dynamic balance is a part of mechanics of engineering and not merely a shop method. The problem is perfectly capable of a definite solution if proposed in a rational manner and treated along rational lines. The importance of running balance in high speed machinery is well understood. The author separates the problem into two parts, static and dynamic balance, and explains dynamic unbalance by the so-called centrifugal couple.

He describes his machine for creating a centrifugal couple at will, which may be adjusted by trial to exactly counteract the one that may be present in the body to be tested. This additional couple is created in the machine by means of a so-called squirrel cage, which at the same time permits of definitely establishing the plane and the sign, and of estimating the exact numerical value of the centrifugal couple of the body.

Applications of these principles to actual practice of balancing, together with explanation of working methods and remarks as to what does and what does not come under the problem of dynamic balance, are made in the paper.

DISASTROUS EXPERIENCES WITH LARGE CENTER-CRANK SHAFTS

By Louis Illmer

This paper is descriptive of some disastrous experiences with large gas engine shafts of the center-crank type. Investigations as to the cause of the repeated shaft failures, revealed inherent structural weakness. The reënforcements undertaken to remedy this condition were based upon a careful stress analysis of actual sag determinations conducted upon the wheel shaft.

The shafts in question were mounted in three-point bearing supports and carried a very heavy flywheel between the intermediate and outboard bearings. The diagrams show that this mode of support sets up a pernicious interaction of bearing load, which culminates in excessive wear in the intermediate bearing.

When the wheel shaft lacks adequate stiffness, the appreciable lift of the free end of the web portion of the shaft exerts a pressure against the cap of the outer main bearing, which in turn causes the intermediate journal to become overloaded. The drop resulting from rapid wear reduces the upward thrust against the outer main bearing cap and this finally relieves the intermediate bearing of overload. Still further wear causes a portion of the downward shaft load to be transferred from the intermediate bearing to the outer main bearing.

It was found that when this readjustment is complete, the load upon the two main bearings becomes approximately equalized. The attainment of this state of equilibrium as to wear, involves putting an excess stress upon the shaft fibers, which is likely to lead to ultimate breakdown of the wheel shaft.

The observed wear in the intermediate bearings was found to exceed ⅛ in. in less than thirty days of operation when starting with newly aligned bearings, but after the intermediate bearing had dropped sufficiently to equalize the load

upon the two main bearings, the wear became more nearly normal.

The stress curves corresponding to the actual shaft deflection curves show the critical surface fibers to be subjected to a reversing stress ranging from 16,000 lb. per sq. in. compression to more than 29,000 lb. per sq. in. tension stress.

The life of these shafts, as expressed in observed running time required for breakdown service, appears to be in accord with the expected number of revolutions as determined by Stromeyer's Law of Fatigue.

The character of the reënforcements that were necessary to strengthen the shaft design, is outlined and the resulting improvements in stress and sag relations are recorded in the diagrams. In making replacements, both carbon and nickel steel forgings were tried out, but the nickel steel shafts did not come up to expectations.

Specification details and acceptance tests are also tabulated and the results of tests bars taken from some critical sections of the defective nickel steel shaft are compared with somewhat similar tests made upon a carbon steel shaft. These tests point to elongation as being the vital factor in shaft specifications.

The working stresses which broke the defective nickel steel shaft are analyzed and the proper proportions for web design are discussed. When carrying a heavy wheel, the web dimensions should be made heavier than usual so as to allow for the increased span between the wheel supports, which invariably results from excess wear in the intermediate main bearing.

In order to keep the wheel shaft stress within desired limits under load conditions found in these engines, it became necessary finally to enlarge the intermediate journal to 3/2 of its original diameter, thus making its dimensions fully as large as would be required for side crank construction.

The conclusion arrived at is, that for large stationary gas or oil engines, it is advisable to use the side crank construction rather than a center-crank shaft, since the former type eliminates the troubles encountered when carrying a heavily loaded wheel shaft upon a three-point bearing support.

Appendix I briefly outlines the method used in arriving at the sinuous deflection curves resulting when a wheel shaft is mounted in three aligned bearing supports. Appendix II prescribes the safe stress limits for shaft design and defines the shock allowance suitable for varying engine speeds. The rate at which shafts may be expected to deteriorate from fatigue when subjected to excess stress is also discussed.

The aim of the paper is to call attention to the importance of making careful analysis of the underlying stress conditions, before fixing upon the final dimensions for a center-crank shaft carrying heavy flywheels. The method advocated provides against wheel shaft failure and admits foretelling whether or not a given crank shaft has a sufficiently large net factor of safety to withstand a heavy wheel load without ultimate breakdown.

ON THE TRANSMISSION OF HEAT IN BOILERS

By E. R. Hedrick and E. A. Fessenden

The authors have found difficulty in checking the results of experiments quoted in the literature with the theories commonly proposed for the transmission of heat from the hot gases to the water in the boiler. In particular the formulae given by Sir John Perry and others appear not to check with the data given by various writers.

In working over this matter the authors have been led to an assumption which seems particularly reasonable in view of the fact that the resistance to heat transfer almost certainly changes with the temperature on account of the dependence of the resistance on the behavior of the film of gas next to the pipe and of the film of water next to the pipe, rather than on the material of the pipe itself. The authors were led to make the assumption that the quantity of heat lost by a given small weight of gas falls off as the gas passes down the pipe in accordance with the ordinary damping law usual in physical phenomena. After working with this hypothesis for some time and finding that it agreed with the data better than the formulae usually given, the authors have found that an equivalent assumption of simple character can be stated in terms of the difference in entropy of the gas at the temperature of the gas and of the gas at the temperature of the water. The assumption is that the rate of change of this difference is proportional to this difference, where the rate is taken with respect to the actual distance down the tube.

The theoretical consequences of such an assumption are worked out in some detail, and they are brought to the point where graphical check with numerical data is easily possible. The actual comparisons with the theory of Sir John Perry and with that of this paper are shown by a number of graphical figures so arranged that the points should lie on straight lines in each case in case the corresponding theory is correct. It is found that the agreement is quite a little better with the theory of this paper than with that of Perry. The data used are the old French experiments, a set of experiments furnished by Wm. Kent, several sets of experiments conducted by the Pennsylvania Railroad, and a large series of tests conducted at the University of Missouri by Prof. E. A. Fessenden.

COUNCIL NOTES

At the meeting of the Council on March 10, 1916, the following members were present: D. S. Jacobus, *President*, John H. Barr, R. M. Dixon, *Chairman Finance Committee*, A. M. Greene, Jr., W. B. Jackson, C. T. Main, H. de B. Parsons, John A. Stevens, E. H. Whitlock, Wm. H. Wiley, *Treasurer*, and Calvin W. Rice, *Secretary*.

The President announced the appointment of the following Nominating Committee as the result of the coöperation of the Local Sections with him: H. M. Montgomery, *Chicago;* E. H. Ohle, *St. Louis;* Walter B. Snow, *Boston;* D. Robert Yarnall, *Philadelphia;* J. T. Whittlesey, *San Francisco.*

Interpretations of the Boiler Code Committee, Nos. 47-58, were approved and ordered published; they appear elsewhere in this number of The Journal. On the announcement by the Committee of the retirement of its Secretary, Mr. C. W. Obert, to become Secretary of the American Society of Heating and Ventilating Engineers, it was voted to concur in the following resolution of the Committee:

"The Boiler Code Committee of the American Society of Mechanical Engineers having been informed of the retirement of their Secretary, Mr. C. W. Obert, take the opportunity this day, by resolution in executive session, of thanking Mr. Obert for his faithful and untiring devotion and assistance in the work of formulating and promulgating the A.S.M.E. Standard Code, as well as his untiring efforts in behalf of the Code and Committee in the past.

"We, the members of the Boiler Code Committee, sincerely regret the loss of his efficient services, and trust that Mr. Obert will meet with the full measure of success in his new position which he deserves."

Messrs. Olof Ohlson, B. M. W. Hanson, Carl A. V. Carlsson, Gustave Fast, Bruno V. Nordberg, Erik Oberg, Harold P. Norton, C. von Philp, Alfred H. Raynal and H. A. Gillis were appointed to represent the Society in Washington and appear in favor of a Memorial to John Ericsson. A report appears elsewhere in The Journal.

It was voted to approve a resolution from the Pan American Engineering Committee, composed of appointees from the four national engineering societies, to make this committee a permanent committee to promote greater engineering and scientific intercourse and the welfare of the engineering profession of South and Central America and the United States.

Calvin W. Rice, *Secretary.*

C. W. OBERT SECRETARY OF HEATING AND VENTILATING ENGINEERS

Mr. C. W. Obert, for the past three years Associate Editor of the Society's publications, has accepted an invitation by the Council of the American Society of Heating and Ventilating Engineers to become the Secretary of that organization, with headquarters in the Engineering Societies Building, New York. He will take up his new duties at once.

Mr. Obert's connection with the office of The American Society of Mechanical Engineers began when the Boiler Code Committee had completed the first draft of its report, which led to his being drawn into the service of the Committee during the long and arduous period of meetings and conferences which preceded the issuance of the report in its revised and completed form. In February 1915, when the Advisory Committee was added to the membership of the Boiler Code Committee, he was made a member of the enlarged committee, and its Secretary, and it is hoped that he may find it possible to continue in this capacity. Appreciation of his untiring efforts and a sincere desire for his success in his new undertaking have been fittingly expressed by resolutions of the Committee, in which the Council of the Society was pleased to concur.

Besides his editorial position with this Society, Mr. Obert has previously acted in an editorial capacity on other publications, including The Engineering Record, when it was devoted largely to heating and ventilating subjects, which gave him an acquaintance with engineers in this field, and a familiarity with their work, admirably equipping him for his new position.

The American Society of Heating and Ventilating Engineers is progressing rapidly, three new chapters in Cleveland, Detroit and Philadelphia respectively having been organized, and should constitute a favorable field for the abilities of its new Secretary, to whom all good wishes are extended by his many friends and former associates in The American Society of Mechanical Engineers.

CONFERENCE ON ABBREVIATIONS AND TERMINOLOGY

In line with efforts that are being made by a number of organizations to standardize engineering abbreviations and terminology, a conference was recently held by the Committee on Electrical Measurements, Values and Terminology of the National Electric Light Association, for the purpose of definitely starting the movement and putting on record such terms as could be unquestionably agreed upon. The conference which was held in the Engineering Societies' Building in New York, on March 9, was attended by representatives of the editorial departments of The American Institute of Electric Engineers, The American Institute of Mining Engineers, The American Institute of Wiring Engineers, The American Society of Mechanical Engineers, The American Society of Heating and Ventilating Engineers, and The Illuminating Engineering Society. The chairman of the Committee of The National Electric Light Association is Dr. A. E. Kennelly.

The conference was devoted largely to a study and analysis of the abbreviations employed by the various engineering societies for terms in common use and of the practice of these societies with reference to the use of compound words. Careful study was made of the abbreviations in general use, and complete agreement was reached concerning the abbreviations given in the list below. All abbreviations upon which unanimous agreement could not be had were omitted from consideration.

Name	Abbreviation
Alternating current	a.c., when used as a compound adjective; spell out in other cases.
Ampere	amp., or spell out.
Boiler horse power	boiler h. p.
Brake horse power	b.h.p.
British thermal units	B.t.u.
Candle power	c.p.
Centigrade	cent. (c. in tabular matter)
Centimeters	cm.
Circular mils	cir. mils (c. m. in tabular matter)
Counter electromotive force	counter e. m. f. (c. e. m. f. frequently used)
Cubic	cu.
Diameter	spell out
Direct current	d. c. when used as a compound adjective; spell out in other cases
Electric horse power	e.h.p.
Electromotive force	e.m.f.
Fahrenheit	fahr.
Feet	ft.
foot pounds	ft. lb.
Gallons	gal.
Grains	gr.
Grams	g.
Gram calories	g. cal.
High-pressure cylinder	spell out
Hours	hr.
Inches	in.
Indicated horse power	i.h.p.
Kilogram	kg.
Kilogram meters	kg. m.
Kilogram calories	kg. cal.
Kilometers	km.
Kilowatts	kw.
Kilowatt hours	kw.hr (kwh. frequently used)
Linear	lin.
Liter	l.
Magnetomotive force	m.m.f.
Mean effective pressure	spell out
Millimeters	mm
Milligrams	mg.
Minutes	min.
Meters	m.
Meter kilograms	m. kg.
Ohms	spell out
Per	spell out
Per cent	spell out (or % in tabular matter)
Pounds	lb.

Power factor	spell out	
Revolutions per minute	rev. per min.	(r. p. m. frequently used)
Seconds	sec.	
Square	sq.	
Square root of mean square	r. m. s.	
Ton mile	spell out	
Tons	spell out	
Volts	spell out	
Volt amperes	spell out	
Watts	spell out	
Watt hours	watt hr.	
Watts per candle	spell out	(w. p. c. frequently used)
Yards	yd.	

Note: In certain kinds of technical work the periods following the abbreviations are omitted where ambiguity is impossible.

1. Use "Fig.", not "Figure." Example: "Fig. 3" and not "Figure 3."

2. In all decimal numbers having no units, a cipher should be placed before the decimal point. Example: "0.32 lb."; not ".32 lb."

3. Use the word "by" instead of "x" in giving dimensions. Example: "8 by 12 in." not "8 x 12 in."

4. Never use the characters (′) and (″) to indicate either feet and inches or minutes and seconds as periods of time.

5. When two or more words are compounded as a noun they should be written as separate words with space or spaces between or as a single word without the hyphen.

6. The hyphen should be employed mainly in compound words used adjectively.

HOW TO ORGANIZE A SECTION

The Committee on Sections is anxious to extend the benefits of the Society as rapidly and as far as possible. Obviously the initiative must be taken by the members themselves and in those centers where the numbers and interest are sufficient to warrant meetings being undertaken. In the places where Sections are now established, those participating in the work find it interesting and beneficial, and much good has resulted to the individual members as well as to the Society.

A Section of the Society may and preferably should coöperate with and help build up the local engineering organizations by the holding of joint meetings, and invite all members of such organizations and all engineers generally to its meetings. This phase of Section work has been especially well developed at St. Louis and Philadelphia.

The Society through the Committee on Sections is anxious to assist the membership in the organizing and developing of Sections both by appropriation to cover fixed expenses and by practical advice, such as suggesting names of prominent engineers to make technical addresses and also arouse enthusiasm.

Birmingham, Ala., with eighteen members, is the last place to form a Section. By including those members within a radius of sixty miles the membership of this section is brought up to about twenty-eight. At the March meeting there was an attendance of sixty-five per cent and much enthusiasm shown. All are united in making preparations for the reception of members attending the Spring Meeting. The Birmingham Section has invited all members and guests of the Society to visit their city on Monday, April 10, and have arranged an elaborate program.

There are numerous cities where the strength of the Society is as great as it is at Birmingham and it is suggested that some member arrange a meeting in all places where there are twenty or more members and discuss the question of organizing a Section. A pleasant way of holding such a meeting is to get together informally at luncheon or supper. Such a movement can be started with little effort and almost no expense. As it usually works out in this world that one gets out of a thing in proportion to what he contributes to it, those taking the initiative are usually well repaid for their public spriit.

JOINT MEETING OF STUDENT BRANCHES

Situated Near the City of New York

An innovation in Student Branch activities will be held at the Engineering Societies Building on Friday evening, April 14, when the four Student Branches of the Society located within the Metropolitan District of New York will hold a joint meeting followed by a smoker in the rooms of the Society. The Branches taking part in this affair are those at Columbia University, New York University, Polytechnic Institute of Brooklyn and Stevens Institute of Technology. A prominent speaker will make an address, followed by an illustrated technical paper of general interest. Following this there will be a smoker and good fellowship meeting, so that all may have the opportunity of increasing their acquaintance among their future colleagues.

All members of Student Branches resident outside New York, visiting New York at the time of this meeting, are invited to attend.

The Committee in charge of arrangements is L. H. Nielson (Columbia University), *Chairman*, C. A. Pines (New York University), Herman Brandt (Polytechnic Institute of Brooklyn) and J. M. Wilcox (Stevens Institute).

GREETING THE NEW COMER

At the last meeting of the Committee on Sections the following resolution was adopted:

"Voted to advise the Chairman of each Section that the Committee on Sections and the Council have approved placing on the mailing lists of Sections the address of every graduate member of a Student Branch who shall locate within the territory of any Section and that the Secretary of the Section may expect to receive additions from time to time as these students graduate and locate in the vicinity of the Section.

"Such notification will automatically enroll the graduated member of a Student Branch as a member of the Section in which he locates. Allowance will be made in making the annual appropriation for each Section for each graduate student member so enrolled."

Responses have already been received from a number of the Chairmen of Sections and of Student Branches expressing the opinion that this will prove of great assistance to the young engineer. It should also benefit the Society by encouraging undergraduates in colleges where no Student Branch now exists to petition the Council for the establishment of Student Branches.

There are now forty Student Branches and these are doing an excellent work as will be seen by a perusal of the pages of The Journal devoted to a description of Student Branch activities. About fifteen hundred students are enrolled in the membership of these Branches, more than half that number subscribe to The Journal, and later about one-fifth become members of the Society.

The above procedure of maintaining the hold on men whose interest we have once obtained is obvious.

LECTURES ON MILITARY ENGINEERING

The success of the military engineering lectures given in New York under the auspices of the officers of the national engineering societies by officers of the U. S. Army provided by Major General Wood has exceeded the most sanguine expectations.

Over 3000 men are attending the lectures every Monday in the Engineering Societies Building and the building of the American Society of Civil Engineers respectively.

In response to requests for advice as to literature on the subjects of the lectures, the following textbooks have been secured. These constitute a special course of reading for engineers in civil life who desire to inform themselves on military subjects:

Infantry Drill Regulations, 1911. Can be obtained from the Superintendent of Documents, Washington, D. C. Price about 60 cents. (Govt. Printing Office.)

Field Service Regulations, 1914. Can be obtained from the Superintendent of Documents, Washington, D. C. Price 60 cents. (Govt. Printing Office.)

Notes on Field Fortification, Army Field Engineer School. Can be obtained from Book Dept., Army Service Schools, Ft. Leavenworth, Kansas. Price 30 cents.

Engineer Field Manual. Can be obtained from Superintendent of Documents, Washington, D. C. Price $1.00. (Govt. Printing Office.)

Military Topography for Mobile Forces, Sherrill, 2nd Edition. Banta Publishing Co., Menasha, Wis. Price $2.25.

Studies in Minor Tactics, Army Service Schools, 1915. Can be obtained from Book Dept., Army Service Schools, Ft. Leavenworth, Kansas. Price 50 cents.

The Service of Coast Artillery, Hines and Ward. Goodenough & Woglom Co., 122 Nassau Street, New York City. Price $3.50.

A free circular issued from the office of the Chief of Engineers, War Department, Washington, D. C., gives a complete bibliography of the subject of military engineering. From this the above titles have been selected.

JOSEPH A. HOLMES MEMORIAL

The Joseph A. Holmes Safety Association, formed to perpetuate the memory and work of the first director of the bureau of mines, who died last July, was formally established by old associates on March 3.

It was agreed that the association shall each year make awards with honorariums to those who perfect the most efficient safety devices in the mining, quarrying and metallurgical industries, these awards to be known as the Holmes awards. It was also agreed that the heroism of miners shall be rewarded.

Suitable medals are to be given to those who distinguish themselves at mine disasters in saving life and to those whose services in directing the work at mine disasters are conspicuous. The association will meet once each year in Washington, when the awards and medals will be publicly announced. The next meeting will be held March 1, 1917.

A campaign to raise an endowment fund will be started as soon as the permanent secretary is selected. The officers elected were: Van H. Manning, director of the bureau of mines, president; Dr. Charles D. Walcott, secretary of the Smithsonian Institution, first vice president; Samuel Gompers, president American Federation of Labor, second vice president. These officers also constitute the executive committee, with the addition of Hennen Jennings, Washington, and Dr. John A. Brashear, Past-President of our Society.

NAVAL CONSULTING BOARD

At the meeting of the Naval Consulting Board held in the Engineering Societies Building on March 8, the main topic of discussion was the securing for this country of an adequate supply of nitrogen products, vital to the military and agricultural interests of the country. The members discussed the creation of a synthetic plant for the fixation of nitrogen from the air, the laying in of a store of nitrogen sufficient to last through the first year of any war, and the investigation of possible nitrate fields in the United States.

Spencer Miller, Member of the Council, and W. L. R. Emmet, the Society's two representatives on the Board, were present.

ERICSSON MONUMENT

Capt. John Ericsson, a former member of this Society and one of the greatest engineering geniuses of the nineteenth century, was proposed as an Honorary Member of the Society at its formation in 1880, but he declined to be so ranked, preferring to be considered as still among those bearing the burdens of active practice. His friends in the Society desired in 1886 to give him a testimonial banquet in recognition of his marvelous talent, but he would not hear of it, even when solicited by his most intimate friends. He died in 1889, but all through the years following, the effect of his epoch-making inventions, notable among them the screw propeller, has been cumulative, making it fitting that the American nation, the prosperity of greatness of which has been largely achieved through engineering, should erect a perpetual memorial to his name.

A bill has now been introduced in Congress for the consummation of this plan, and the mechanical engineering profession at large and the Society in particular will look upon its passage as the expression of the country's desire to pay full tribute to one of its greatest representatives. A hearing of this bill was held in Washington on March 13, at which Messrs. Erik Oberg, C. A. V. Carllson, Gust Fast, H. A. Gillis, O. Ohlson, C. von Philp and A. H. Raynal, representing the Society, were present. Our thanks are due these gentlemen for their efforts to attend this hearing and for their service in our interest.

The Society possesses some unique memorabilia of Captain Ericsson, which are on exhibition in the Engineering Societies Building and which it will repay all members visiting the Society's rooms to see. Among these are:

An oil portrait executed by the artist Ballin and believed to be the only portrait painted of him.

A bust in plaster, presented by the late James M. Dodge, Past-President of the Society, together with a reproduction of it in bronze.

A most valuable set of models, with ease, to illustrate his inventions and experiments in connection with his work on the hot air engine, the solar motor, and other products of his inventive capacity. This set was originally prepared for and exhibited at the Centennial Exhibition. It was presented by Captain Ericsson's executors to the Metropolitan Museum of Art in New York, which in turn presented it to the Society.

Further, there is in the library a monumental work written and published by Captain Ericsson himself in 1876, entitled Contributions to the Centennial Exhibition, a statement of his principal labors and an account of his philosophical instruments, engines and other structures.

UNITED ENGINEERING SOCIETY

REPORT OF TREASURER

TO THE BOARD OF TRUSTEES,
UNITED ENGINEERING SOCIETY.

I respectfully submit the following report of your Treasurer for the year ending December 31st, 1915.

FINANCES

Due to the growth of the activities of the United Engineering Society, it was found desirable early in the year to consolidate the various accounts and financial records of the Society and of the Library, heretofore kept separately, and to have all the data pertaining to the building and its operation in the charge of one individual. An assistant secretary especially assigned to this work has been appointed, and a separate office has been established. The Finance Committee has had all of the records brought fully to date and has prepared a new set of account books to meet the new conditions.

The Real Estate Account now includes the following items:

Land	$ 540,000.00
Building	1,050,000.00
Equipment	33,171.16
Founder Societies, Preliminary expenses	24,000.00
Total	$1,647,171.16

The principal of the mortgage on the land held by Andrew Carnegie, amounting originally to $540,000, has been finally satisfied in full by payments from the Land and Building Funds of the Founder Societies. These payments were $5000 from the American Institute of Mining Engineers in January and $54,000 from the American Institute of Electrical Engineers in June.

The gross operating expenses for the year 1915 were $44,440.28, an increase of $4858.64 over the gross expenses of the preceding year. This increase was due chiefly to the unusual alterations on the sixth floor, amounting to $4258.36. The total revenue for the year was $48,028.20.

The funds available for the uses of the Library Board during the year were $17,444.87. The expenditures of the Library Board were $16,415.14, leaving an unexpended balance of $1029.73.

The General Reserve Fund of $10,000 created by the Board of Trustees at a meeting held November 19th, 1914, to be available to take care of unforeseen fluctuations of income and outlay, has been preserved intact, there arising no calls on this fund during the year 1915.

At the beginning of the year 1915 the amount of Contingency and Renewal Fund was $51,441.39. To this amount has been added the sum of $2404.28 for interest earned by the investments for this fund during the year, and $5000 added from surplus at the end of the year, bringing the total at the end of the year to $58,845.67.

The following summary shows the reserve accounts and the investments therefor:

Depreciation and Renewal Fund	$51,441.39
Add: Interest on Invested Funds during Year 1915	2,404.28
Transfer for the Year 1915	5,000.00
	$58,845.67
General Reserve Fund	10,000.00
Engineering Foundation Fund	200,000.00
Library Endowment Fund	5,000.00
	$273,845.67

The Astor Trust Company of New York is the official custodian of the securities of the United Engineering Society.

During the year the Finance Committee with the assistance of experts has revised the assessments for space occupied by all Societies, Founders as well as Associates. In doing this, consideration has been given to location as well as area occupied, and the system of assessment made uniform. The schedule of rates is available for examination by any interested person or society.

GIFTS AND ENDOWMENTS

On January 27, 1915, Mr. Ambrose Swasey presented to the United Engineering Society the sum of $200,000 in securities, the income only therefrom to be used for the purposes of the Engineering Foundation, for "the advance of the engineering profession and the benefit of mankind."

On April 5, 1915, Dr. James Douglas presented the sum of $5000 to the United Engineering Society to form the nucleus of an Endowment Fund for the Library.

BUILDING

Meetings or Lectures. The record of the number of times the rooms were used during the year 1915 for meetings or lectures (not for office occupancy) is:

MEETING ROOM		NUMBER OF TIMES OCCUPIED 1914	1915	Change
1st floor Foyer		0	1	1 more
Auditorium	3rd and 4th floors	76	42	34 less
No. 1 Assembly Room	5th floor	58	53	5 less
2 Assembly Room	5th floor	94	76	18 less
3 Assembly Room	5th floor	46	49	3 more
5 Assembly Room	6th floor	0	2	2 more
Small Committee Room on	1st floor	18	34	16 more
Assembly Room 1201 on	12th floor	53	30	23 less
Total		345	287	58 less

LIBRARY

During the year the administration of the Library has been made the subject of an agreement executed by the three Founder Societies and the United Engineering Society under which all expenses of the Library are paid from the United Engineering Society office. Each Founder Society has contributed $4000 and the remainder of $2500 has been paid by the United Engineering Society. The total appropriation for books and administration amounted to $14,500 for the year. In addition there were derived from searches, $2410.80, and from sales and income, $534.07, making a total revenue of $17,444.87.

In June there was effected a consolidation of the various insurance policies heretofore held separately by the Founder Societies and the United Engineering Society, into one policy covering all.

Full details as to the Library are shown in the annual report of the Library Board. (See THE JOURNAL, February, 1916.)

Respectfully submitted,
(*Signed*) JOS. STRUTHERS, *Treasurer.*

UNITED ENGINEERING SOCIETY

ASSETS AND LIABILITIES, DECEMBER 31, 1915

ASSETS

Real Estate	$1,647,171.16
Investments—Engineering Foundation Fund	200,000.00
Library Endowment Fund	5,002.50
General Funds	58,138.75
Cash	11,307.05
Unexpired Insurance	3,949.16
Accounts receivable	3,785.36
	$1,929,353.98

LIABILITIES

Founders Equity in Property	$1,647,171.16
Due the General Reserve Fund	10,000.00
Due the Depreciation and Renewal Fund	58,845.67
Due the Engineering Foundation Fund	200,000.00
Due the Library Endowment Fund	5,000.00
Due the Library Board, 1915, Unexpended balance	1,029.73
Surplus, December 31, 1915	7,307.42
	$1,929,353.98

Certified by
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Correct
Chas. F. Rand
Jesse M. Smith
H. H. Barnes
Finance Committee.

NOTES

The Case School Student Branch has arranged to visit the Engineering Societies Building on April 4. The party will be in charge of Prof. F. H. Vose.

The Engineering School of Pennsylvania State College, in charge of Prof. Hugo Diemer, Professor of Industrial Engineering, will visit the Building on April 17.

Prof. Joseph W. Roe and about 75 members of the Senior Class of Yale University will visit the headquarters of the Society on Thursday, April 13, while in New York on their Annual Inspection Trip. An invitation has been extended to them to be the guests of the four metropolitan Student Branches of the Society who will hold a joint meeting that evening at the Engineering Societies Building.

The Institute of Metals has reconstituted its Corrosion Committee. This committee exists primarily to investigate the question of the corrosion of brass condenser tubes, though at a later date the corrosion of other metals (except iron and steel) may be subjected to inquiry.

The final report of the Director of Congresses of the Panama-Pacific International Exposition shows that 928 congresses and conventions were held in or near San Francisco from February 20 to December 4, 1915. This establishes a new world's record for conventions.

The American Academy of Political and Social Science announces its twentieth annual meeting on April 28 and 29. The meeting will be held in Philadelphia and will partake of the nature of a national conference on the general topic, "What America Stands for in International Relations," and a discussion of the most important political, social, economic and financial problems which have been forced on this country by the abnormal conditions abroad. The President of the Academy is Dr. L. S. Rowe, University of Pennsylvania.

Changes in the conditions governing the use of gas for domestic purposes have caused the New York Public Service Commission to consider altering the method of testing it, on the grounds that modern appliances require that gas should have a heating value only, and that the present candle-power standard was a hindrance to distribution without corresponding advantages, in that it increased the cost because of the rising price of the enriching oils that had to be added, and the present standards were wasteful and burdensome both to the consumers and to the companies.

The Cleveland Engineering Society, which has secured a reputation for unique publicity methods, is planning to issue a special publication sometime during the current year designed to acquaint the intelligent public with the work of the engineer and the manner in which it is performed, in the hope that a more intimate knowledge of this subject will increase and improve the opportunities for engineering activity, and facilitate the proper and efficient execution of engineering projects. The society solicits suggestions concerning the design of the publication or the manner of handling its physical make-up.

The following letter to the Secretary from a member of the Council who was asked to endeavor to ascertain why a certain member of the Society living near him had sent in his resignation, indicates the splendid work our Chairmen of Sections are doing in greeting members who are strangers but who wear the Society's pin:

Dear Mr. Rice:

Your letter of March 4 regarding Mr. ..... came duly to hand.

I have just returned from a call on Mr. ..... in company with Mr. ....., Chairman of the Local Section, and found that Mr. ..... was already prepared to withdraw his letter sending in his resignation on account of a rather interesting coincidence.

Mr. ..... happened to be a guest at the Club one noon. The Chairman of the Section noted his A.S.M.E. pin and introduced himself with the remark that he was glad to meet him but believed he had never seen him at any of our local meetings. Mr. ..... promptly replied that he had not been at any of the meetings and that he had sent in his resignation to the Society. The Chairman remarked that he felt he ought not to resign, especially in the light of the excellent local meetings that we are having.

I telephoned Mr. ..... this noon and said that I would like to call on him and talk about The American Society of Mechanical Engineers. He told me that he had sent in his resignation but would be glad to talk with me as he was rather inclined to reconsider his action, since he had met a gentleman at the Club who had told him something about the local activities of the Society. I then suggested that the Chairman and I would like to call on him toegther, and he said that he would be glad to talk to us.

He informed us that he would send his check for dues right along.

Mr. ..... is a fine fellow and it would have been a serious loss to the Society to have lost him from its membership roll.

I have written you so fully regarding this matter more particularly so that you will have so fine a concrete example in mind of what a well conducted Local Section of the Society means to our membership, since in this case the activities of the Local Section have brought back to us of his own volition a splendid member, who under other conditions would have been brought back only after most strenuous urging and explanations, if at all. I am personally confident that this can be considered as a good indication of what we can expect from the activities of our Local Sections along one line and that there are many other directions in which we may expect the Local Sections to strengthen the Society with equally marked effectiveness.

Cordially yours,

.....

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON MAY 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. Unless objection is made by some member by May 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary about June 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ALLINGHAM, HENRY W., Cons. Prod. Engr., British Govt., Nortendon, Cheshire, England
ANTONSANTI, LOUIS, Contr. Engr., Ponce, P. R.
BREAKER, HARRY O., Mgr. Economizer Dept., B. F. Sturtevant Co., Boston, Mass.
BRINER, EMIL A., East. Rep., New York Blower Co., E. Orange, N. J.
BROWNE, GAIL H., Asst. Engr., Ford, Bacon & Davis, New Orleans, La.
CARY, ARTHUR F., Supt. of Trade School, Mass. Reformatory, Concord Junction, Mass.
COLE, WILLIAM E., Supt., Connecticut Elec. Mfg. Co., Bridgeport, Conn.
CONN, CHARLES F., Mgr., San Francisco Office, J. G. White Engrg. Corp., San Francisco, Cal.
FERGUSON, WILLIAM B., Prod. Engr., Remington Arms & Ammunition Co., Bridgeport, Conn.
GAETJE, JOHN H., Mech. Engr., Western Elec. Co., Hawthorne, Ill.
HAUSLER, HARRY F., Ch. Draftsman, Amer. Sugar Refining Co. of N. Y., Brooklyn, N. Y.
HENDERSON, JOSEPH W., Bureau Ch., Bureau of Smoke Regulation, City of Pittsburgh, Pa.
HOLMES, OTIS W., Prop., O. W. Holmes Co., Boston, Mass.
KELLER, ALFRED R., Draftsman, The Morgan Constr. Co., Worcester, Mass.
LUCAS, CHESTER L., Associate Editor, "Machinery," New York
MCMUNN, WILLIAM N., Contr. Engr., Private Business, Chicago, Ill.
MACDONALD, HOWARD D., Supt. Experiments, Tractor Wks., Internatl. Harvester Corp., Chicago, Ill.
MEAHL, PHILIP J., Inventor, Summit, N. J.
REESE, OLIVER P., Asst. Engr. Motive Pwr., Penna. Lines West of Pittsburgh, Pittsburgh, Pa.
SALISBURY, ROBERT W., Mech. Engr., Texas & Pacific Ry., Marshall, Tex.
SHREVE, EARL O., Mgr. Apparatus Dept., Genl. Elec. Co., San Francisco, Cal.
SIMON, JOSEPH J., Cons. Lubrication Engineer, The Texas Co., New York
SMITH, PHILIP C., Supt. Fdy. Dept., Ingersoll-Rand Co., Phillipsburg, N. J.
STANGLAND, ROBERT S., Operating Engr., W. S. Bartow & Co., Inc., New York
STANSFIELD, WILLIAM T., Genl. Insptr., Globe Indemnity Co., New York
THOMPSON, RALPH C., Supt., Cutting Tool Supply, Remington Arms Co. of Del., Eddystone, Pa.
WEBRE, ALFRED L., Engr., J. H. Murphy Iron Wks., New Orleans, La.
WEST, RALPH H., Pres. and Genl. Mgr., West Steel Casting Co., Cleveland, Ohio
WILLIAMS, LEWIS E., Ch. Draftsman, Dredging Div., The Panama Canal, Off. of Res. Engr., Paraiso, C. Z.
WOOLFOLK, WILLIAM G., Mgr., Chicago Office, Sanderson & Porter, Chicago, Ill.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

FERGUSON, CHRISTIAN W., Asst. Supt., Outside Erecting Dept., Henry R. Worthington, Harrison, N. J.
GAW, FREDERICK W., with Babcock & Wilcox Co., Bayonne, N. J.
HAMILTON, DOUGLASS T., Assoc. Editor, "Machinery," New York
HAMMOND, JOHN H., JR., Inventor, Gloucester, Mass.
HARLOW, ARCHIBALD S., Dept. Head, Bosch Magneto Co., Springfield, Mass.
HAYNES, CLAUDE P., Prod. Engr., Curtiss Aeroplane & Motor Corp., Buffalo, N. Y.
HORTHY, WILLIAM A., Mech. Engr., Tractor Wks., Internatl. Harvester Co., Chicago, Ill.
LEWIS, ALEXANDER T., Mem. Firm, Lewis, Robinson & Gant, Engrs., Philadelphia, Pa.
LUNDGREN, FREDERICK G., Mech. Engr., Amer. Car & Fdy. Co., Terre Haute, Ind.
MAYER, LEO, Constr. Engr., Otis Elevator Co., Cleveland, Ohio
POLLOCK, ROBERT T., with New England Westinghouse Co., Springfield, Mass.
ROWE, HAROLD E., Asst. Wks. Engr., The Carborundum Co., Niagara Falls, N. Y.
SHUSTER, MYER M., with Remington Arms Co., Eddystone, Pa.
WIESE, OSCAR H., Draftsman and Checker, McIntosh & Seymour Corp., Auburn, N. Y.

FOR CONSIDERATION AS JUNIOR

BARRY, J. JOSEPH, Asst. Supt., Internatl. Trade Exch., Inc., Boston, Mass.
BEARD, JAMES T., JR., Dist. Mgr., Combustion Engrg. Corp., Cincinnati, Ohio
BROWN, HAROLD A., Overseer of Planning, Winchester Repeating Arms Co., New Haven, Conn.
BRUBACK, THEODORE M., Asst. Engr., Vulcan Soot Cleaner Co., Du Bois, Pa.
CORBETT, WILLIAM B., Mech. Designer, Terry Steam Turbine Co., Hartford, Conn.
EASTMAN, ROBERT L., Tech. App., Aultman & Taylor Mchy. Co., Mansfield, Ohio
FAULKNER, FRED L., Exper. Engrg. Dept., Western Elec. Co., Chicago, Ill.
HUNT, CHARLES W., Asst. Estimator for C. W. Hunt Co., Inc., W. New Brighton, N. Y.
KASPER, WALTER F., Mech. Engr., Fairmont Gas Eng. & Rwy. Motor Car Co., Fairmont, Minn.
KUHLEN, FREDERICK, JR., Safety Engr., Globe Indemnity Co., New York

Lassiter, Robert R., with The Texas Co., New York
Le Vally, John R., Engr., Burrell Belting Co., Chicago, Ill.
Marshall, William A., with Mech. Dept., Jones & Laughlin Steel Co., Woodlawn, Pa.
Maxfield, Lewis S., Draftsman, Motive Pwr. Dept., Interborough Rapid Transit Co. and New York Rwys. Co., New York
Mayer, James L., Mech. Draftsman, Mark Mfg. Co., Zanesville, Ohio
Metcalf, George R., Jr., Lab. Asst., Engrg. Dept., Yale Univ., New Haven, Conn.
Miller, Clarence A., Student Grad., Yale Univ., Franklin, Pa.
Pearce, Clinton E., Instr. in Mch. Design, Mech. Engrg. Dept., Lafayette College, Easton, Pa.
Riggs, George, Asst. in Mch. Design, Yale Univ., New Haven, Conn.
Ritter, Ralph B., Valve Engr., Detroit Lubricator Co., Detroit, Mich.
Sampter, Herbert C., 322 West 76th St., New York
Smith, Lloyd G., Asst. Foreman, Boiler Shop, Standard Oil Co., Whiting, Ind.
Swinney, Stuart L., with The Texas Company, Port Arthur, Tex.
Tehle, Charles J., Student App., Aultman & Taylor Mchy. Co., Mansfield, Ohio

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Breckenridge, Clarence E., Asst. Ch. Engr., Aetna Explosives Co., Inc., New York
Christie, Alex. G., Assoc. Prof. Mech. Engrg., Johns Hopkins Univ., Baltimore, Md.
Taylor, Cecil H., Cons. Engr., Taylor & Neuteboom, Detroit, Mich.

PROMOTION FROM ASSOCIATE-MEMBER

Henderson, Herbert, Constr. Engr., Gulf Refining Co., Port Arthur, Tex.
Staniar, William, Mech. Engr., E. I. du Pont de Nemours & Co., Wilmington, Del.

PROMOTION FROM JUNIOR

Barnes, Arthur F., Dean of Engrg., New Mex. College of A. & M. E., State College, N. Mex.
Hagy, James L., Instr. in Mech. Draft. and Mch. Design, Philadelphia Trades School, Philadelphia, Pa.
Honywill, Albert W., Jr., Engr., Terry Steam Turbine Co., Hartford, Conn.
Otto, Henry S., Cons. Engr., and Treas., Albert T. Otto & Sons, Special Mchy., Importers and Exporters, New York
Polledo, Ysidoro Y., Cons. Practice, Havana, Cuba
Reed, Chester T., Secy., Reed & Prince Mfg. Co., Worcester, Mass.
Van Cleve, Horatio P., Ch. Draftsman, Harrington, Howard & Ash, Cons. Engrs., Kansas City, Mo.

SUMMARY

New applications	68
Applications for change of grading:	
Promotion from Associate	3
Promotion from Associate-Member	2
Promotion from Junior	7
Total	80

SUMMARY SHOWING AVERAGE AGE AND POSITIONS OF APPLICANTS ON BALLOT CLOSING APRIL 8, 1916

Average age of applicants:	
Members	45
Associates	35
Associate-Members	31
Juniors	24
Positions held by applicants:	
Executives, including Presidents, Vice-Presidents, Treasurers, Directors, Members of Firms, General Managers	8
Professors, Associate-Professors, Instructors	5
General Superintendents, Superintendents, Assistant Superintendents, Mechanical Superintendents	14
Consulting, Contracting and Constructing Engineers	3
Chief Engineers, Assistant Chief Engineers	6
Mechanical Engineers, Engineers, Assistant Engineers	15
Chief Draftsmen, Assistant Chief Draftsmen, Designing Engineers, Estimators	12
Managers, Assistant Managers, Sales Managers, Sales Engineers	3
Other classifications	12
Total	78

GEOGRAPHICAL INDEX

(Applications for promotion from any grade will be indicated by the initials of that grade)

California
San Francisco—Conn, C. F.
Shreve, E. O.
Canal Zone
Paraiso—Williams, L. E.
Connecticut
Bridgeport—Cole, W. E.
Ferguson, W. B.
Hartford—Corbett, W. B.
Honywill, A. W., Jr. (J.)
New Haven—Brown, H. A.
Metcalf, G. R., Jr.
Riggs, Geo.
Cuba
Havana—Polledo, Y. (J.)
Delaware
Wilmington—Staniar, W. (A.M.)
England
Nortendon—Allingham, H. W.
Illinois
Chicago—Faulkner, F. L.
Horthy, W. A.
Le Vally, J. R.
McMunn, W. N.
MacDonald, H. D.
Woolfolk, W. G.
Hawthorne—Gaetje, J. H.
Indiana
Terre Haute—Lundgren, F. G.
Whiting—Smith, L. G.
Louisiana
New Orleans—Browne, G. H.
Webre, A. L.
Maryland
Baltimore—Christie, A. G. (A.)
Massachusetts
Boston—Barry, J. J.
Breaker, H. O.
Holmes, O. W.
Concord Junction—Cary, A. F.
Gloucester—Hammond, J. H., Jr.
Springfield—Harlow, A. S.
Pollock, R. T.
Worcester—Keller, A. R.
Reed, C. T. (J.)
Michigan
Detroit—Ritter, R. B.
Taylor, C. H. (A.)
Minnesota
Fairmont—Kasper, W. F.
Missouri
Kansas City—Van Cleve, H. P. (J.)
New Jersey
Bayonne—Gaw, F. W.
E. Orange—Briner, E. A.
Harrison—Ferguson, C. W.
Phillipsburg—Smith, P. C.
Summit—Meahl, P. J.
New Mexico
State College—Barnes, A. F. (J.)
New York
Auburn—Wiese, O. H.
Brooklyn—Hausler, H. F.
Buffalo—Haynes, C. P.
Niagara Falls—Rowe, H. E.
New York—Breckenridge, C. E. (A.)
Hamilton, D. T.
Kuhlen, F., Jr.
Lassiter, R. R.
Lucas, C. S.
Maxfield, L. S.
Otto, H. S. (J.)
Sampter, H. C.
Simon, J. J.
Stangland, R. S.
Stansfield, W. T.
W. New Brighton—Hunt, C. W.
Ohio
Cincinnati—Beard, J. T., Jr.
Cleveland—Mayer, Leo
West, R. H.
Mansfield—Eastman, R. L.
Tehle, C. J.
Zanesville—Mayer, J. L.
Pennsylvania
Du Bois—Bruback, T. M.
Eddystone—Shuster, M. M.
Thompson, R. C.
Franklin—Miller, C. A.
Lafayette College—Pearce, C. E.
Philadelphia—Hagy, J. L. (J.)
Lewis, A. T.
Pittsburgh—Henderson, J. W.
Reese, O. P.
Woodlawn—Marshall, W. A.
Porto Rico
Ponce—Antonsantl, L.
Texas
Marshall—Salisbury, R. W.
Port Arthur—Henderson, H. (A.M)
Swinney, S. L.

PERSONALS

THIS department is intended for items about members of the Society, their professional work and incidents concerning them which may be of interest to the membership in general. Items are solicited upon important engineering developments in which members have been associated, and also newspaper clippings or manuscripts of addresses delivered by members at meetings of any kind are desired. It is hoped that every member of the Society will furnish an interesting item occasionally for publication in the Journal.

William H. Burleigh has become affiliated with the Burleigh Engineering Company of Kansas City, Mo.

H. D. Kemp has become affiliated with the British Munitions Company, Ltd., Montreal, Canada.

A. G. Christie is the author of an article on Calgary's Principal Power Plant, which appears in the March 14 issue of Power.

Reginald Trautschold has contributed a paper on Jackets for Gas and Oil Engines to the March 15 issue of the Practical Engineer.

S. F. Savage has accepted the position of mechanical engineer with Harry R. Westcott, consulting engineer of New Haven, Conn.

J. A. LeBlond was elected secretary of the Cincinnati branch of the National Metal Trades Association, at the annual meeting, March 3.

Robert T. Kent is the author of an article on Transmitting Power by Leather Belting, which appears in the March 2 issue of The Iron Age.

Leon C. Welch, superintendent of the cygnet division of the Buckeye Pipe Line Company, Cleveland, O., has been transferred to Lima, O.

H. A. Cozzens, Jr., has contributed an article on Testing Plant Materials for Break-Down Voltage to the March 11 issue of Electrical World.

G. L. Knight has contributed an article on Building an Unusual Foundation for a Heavy Machine, to the March 2 issue of Engineering News.

Frederick A. Geier, president of the Cincinnati Milling Machine Company, sailed from New York, March 11, for a month's cruise in the West Indies.

A brief article on Planning Delivery Dates in a Textile-Machine Plant by Arthur O. Berry, appears in the March 16 issue of the American Machinist.

Carroll E. Adams has severed his connection with Jenks and Ballou to accept the position of engineer with the Glenlyon Dye Works of Saylesville, R. I.

Dugald C. Jackson of the Massachusetts Institute of Technology, will talk on High-Power Traction before the Detroit Engineering Society, April 7.

John McK. Ballou, formerly with the Babcock and Wilcox Company, Bayonne, N. J., has entered the employ of the Ford Marine Appliance Company of New York.

David C. Fenner, formerly in the employ of the General Vehicle Company, Inc., New York, has become identified with the International Motor Company of New York.

An informal library talk, illustrated by lantern slides, on Engineering Fallacies, was given by H. de B. Parsons, Manager, Am.Soc.M.E., at the March 30 meeting of the Brooklyn Engineers' Club.

Curtis A. Mees has resigned as designing engineer of the Southern Power Company, Charlotte, N. C., and will engage in practice as consulting engineer at Charlotte, N. C., after May 1.

J. E. Lawton, for the last nine years inspector and chief inspector of The Panama Canal, has resigned to accept a position as consulting engineer and sales manager for Ward and Company, manufacturers' agents, at Washington, D. C.

A. D. Stancliff, until recently in the employ of the Texas Portland Cement Company, Dallas, Tex., as field engineer, has become identified with the Hawkeye Portland Cement Company, Des Moines, Ia.

L. M. Allison has become associated with the aeronautical department of the Polson Iron Works, Toronto, Canada. He was until recently in the employ of the Sturtevant Aeroplane Company, Boston, Mass., as chief draftsman.

Frederick P. Nehrbas has severed his connections with the Lyons Atlas Company, Indianapolis, Ind., as factory manager, to accept a position with the Premier Motor Corporation of the same city in the capacity of production manager.

E. P. Worden, until recently connected with the Fred. M. Prescott Steam Pump Works, Milwaukee, Wis., as manager, has been appointed chief engineer of Henry R. Worthington, Harrison, N. J.

Russell J. Hawn has accepted the position of manager with the Ohio Chemical Company of Springfield, O. He was until recently connected with the Virginia Portland Cement Company, Fordwick, Va., as manager.

Arthur Walser returned, April 1, to Rio de Janeiro, Brazil, where he is connected with the Brazilian General Electric Company as engineer, after spending a few weeks at the Schenectady, N. Y., works of the General Electric Company.

H. M. Montgomery and C. W. Humphrey, consulting and contracting engineer, have formed a partnership under the firm name of Humphrey and Montgomery, with offices at 327 S. La Salle Street, Chicago, Ill.

George H. Houston until recently connected with the Root and Van Dervoort Engineering Company, East Moline, Ill., in the capacity of superintendent, has become associated with the Premier Brass and Forgings Company, Cleveland, O.

Boyd Nixon has accepted a position with the Niles Tool Works Company, Cleveland, O. He was until recently Pacific coast representative of the Eastern Machine Tool Builders of Glassboro, N. J.

Daniel M. Rugg has become associated with the Gas Machinery Company of Cleveland, O. He was formerly connected with the Chattanooga Gas and Coal Products Company, Chattanooga, Tenn., in the capacity of superintendent.

William L. Saunders was the principal speaker at the sixth annual banquet of the Westinghouse employees in the Pittsburgh district, held at the Fort Pitt Hotel, March 11, under the auspices of the Westinghouse Club. Mr. Saunders chose for his subject, Industrial Preparedness for Peace and War.

Robert G. Nye, for the past 5½ years connected, in various capacities, with the Buffalo Forge Company of Buffalo, N. Y., has tendered his resignation as factory manager to accept a similar position with the Alberger Pump and Condenser Company of New York at the Newburgh works.

Papers by Robert W. Hunt and H. B. MacFarland on The Nick and Break Test in the Inspection of Steel Rails, and Test of Douglas Fir Bridge Stringers, respectively, were presented at the 17th annual convention of the American Railway Engineering Association held in Chicago, March 21 to 23.

William Tietze has accepted the position of chief engineer with Cudahy Brothers Company, Cudahy, Wis. He was formerly affiliated with the Pierce Phosphate Company, Pierce, Fla., as chief engineer of power plants.

Arthur L. Westcott, formerly assistant professor of mechanical engineering at the University of Missouri, Columbia, Mo., has been appointed superintendent of buildings of the University. This position includes the supervision of the University lighting, heating and plumbing plant.

C. M. Wilkinson has accepted a position with the Briscoe Motor Corporation, Jackson, Mich., in the capacity of superintendent of buildings. He was formerly associated with M. C. Schwab, consulting engineer of Chicago, Ill., as engineer and construction superintendent.

F. Leroy Newcomb has left the employ of the Standard Oil Company of New Jersey with which he was connected as assistant chief draftsman in the general engineering department, to accept the position of draftsman with the Ammo-Phos Company of New York.

Lester B. Paterson, formerly electrical tester at the Van Nest electrical shops of the New York, New Haven and Hartford Railroad, Van Nest, N. Y., has been appointed scheduling engineer with the same railroad, with headquarters at the Readville, Mass., shops.

Daniel W. Mead, formerly professor of hydraulic and sanitary engineering at the University of Wisconsin, Madison, Wis., has announced his association with F. W. Scheidenhelm in the practice of engineering, with offices in the Equitable Building, New York.

P. P. Bourne, formerly chief engineer of Blake and Knowles Steam Pump Works, East Cambridge, Mass., is again associated with the International Steam Pump Company in connection with special engineering work, with headquarters at the New York office.

George K. Parsons, until recently associated with the American Vulcanized Fibre Company of Wilmington, Del., has opened offices in the Equitable Building, New York, and also in the Riggs Building, Washington, D. C., to practice consulting engineering.

Ellis Soper of the Soper Engineering Company of Chattanooga, Tenn., construction engineer on the Market Street Bridge, has been appointed chief engineer of design and construction of the plant of the Cuban Portland Cement Company, Havana, Cuba.

E. T. Spidy is the author of an article entitled The Locomotive: From Early Efforts to Modern Developments, which was read before the Western Canada Railway Club, Winnipeg, Man., and published in the March 9 issue of Canadian Machinery.

At the 14th annual meeting of the Worcester branch of the National Trades Association, March 10, Jerome R. George was elected president, and Geo. I. Alden and Albert J. Gifford were elected members of the executive board. John W. Higgins, retiring president, was made an honorary member of the Association.

A. V. Wadsworth, for many years foreman in the shops of the National Transit Company, Oil City, Pa., and for the past four years general superintendent of the Buckeye Traction Ditcher Company, Findlay, O., has accepted the position of general manager of the Dayton Pipe Coupling Company, Dayton, O.

Thomas R. H. Murphy, former member of Joseph H. Wallace and Company, New York, has recently become identified with the engineering staff of the Mattagami Pulp and Paper Company, Ltd. Mr. Murphy will be the company's resident engineer in charge of building their hydro-electric power development and a 75-ton high grade bleached sulphite pulp mill at Smooth Rock Falk, Ontario, Canada.

George M. Basford, chief engineer of the railroad department of Joseph T. Ryerson and Son, has severed his connection with that company to assume the duties of president of the Locomotive Feed Water Heater Company, New York. This company, which has just been organized, will develop and handle for locomotive use the film heater designed and patented by Luther D. Lovekin, chief engineer of the New York Ship Building Company. E. A. Averill, formerly with the Standard Stoker Company, New York, is connected with the new company in the capacity of vice-president. Mr. Basford will also form the G. M. Basford Company to handle the advertising accounts of a number of railway supply concerns.

NECROLOGY

ERASMUS DARWIN LEAVITT

Erasmus Darwin Leavitt, Honorary Member and oldest living Past-President of the Society, died in Cambridge, Mass., on March 11, 1916, where he lived for many years. He was born in Lowell, Mass., on October 27, 1836.

He received his education in the public schools of Lowell, and in 1852 he entered the Lowell Machine Shop as an apprentice, where he served for three years, after which he was employed by Corliss & Nightingale for one year. In 1858 he was employed by Harrison Loring at the City Point Works at South Boston as assistant foreman, and had charge of the construction of the engine of the U. S. S. (flagship) Hartford. From 1859 to 1861 he was chief draftsman for Thurston, Gardner & Co., Providence, R. I., then among the few builders of high class steam engines; from there he entered the United States Navy in 1861.

He served in the Navy during the Civil War, and until 1867, when he resigned. During this time he saw service on the gunboat Sagamore in the Eastern Gulf Squadron from September, 1861 until July, 1863, when he was promoted to the office of second assistant engineer, and afterwards was engaged in construction duty at Baltimore, Boston and Brooklyn. Two years later he was detailed to the Naval Academy at Annapolis as instructor in steam engineering, and from there resigned from the service.

He immediately (1867) entered the practice of mechanical engineering and from that time began to be well known and became, probably, the most prominent mechanical engineer in office practice in the United States.

In 1869 a simple condensing engine having a steamboat walking beam and cam valve gear was built from his design for the Plymouth Cordage Co. by Harrison Loring at the City Point Works, Boston, Mass. The engine is still in working order, but has a Corliss cylinder and valve gear. Mr. Leavitt remained consulting engineer for the Plymouth Cordage Co. from that time until two or three years ago, when poor health caused him to resign. Mr. Gideon F. Holmes, late treasurer of that company, stated some years ago that nothing but good came to the Plymouth Cordage Co. from Mr. Leavitt's connection with it.

Mr. Leavitt's fame as an engineer may be said to have begun with the installation of the pumping engine at Lynn, Mass. The economy of pumping engines had long interested him, and

with the assistance of George H. Norman of Newport, R. I., he was able to design an engine for Lynn that embraced all his ideas for economy. This engine was a beam compound, the cylinders being at the bottom and the beam overhead. The cylinders were inclined, and had their lower ends together, and one drove one end of the beam and the other the other end. The pump was vertical and connected to one end of the beam, and the connecting rod on the other. The Thames-Ditton bucket and plunger pump was used, the suction being single and the discharge double acting. After this, Mr. Leavitt adopted differential plungers, these being single acting on the suction and double on the discharge.

This engine marked an era in the economy of pumping engines throughout the world. It was officially tested by W. E. Worthen, J. C. Hoadley, James P. Kirkwood, Charles Hermany and Joseph P. Davis, their final report being dated June 1, 1874. The duty was based upon the work done per hundred pounds of coal and the quantity of water was determined by weir measurement. The duration of the test was from 11 a.m., December 10, until 3 p.m., December 12, 1873, or 52 hours, without a stop. Upon this basis the duty was 103,923,215 ft. lb. per 100 lb. of picked Lackawanna anthracite coal.

The Lynn engine was quickly followed by a pair of similar engines coupled together, but of somewhat larger size, for the water works of Lawrence, Mass. The test was conducted by W. E. Worthen, J. C. Hoadley, and Joseph P. Davis, and a duty of 96,186,979 ft. lb. of work per 100 lb. of coal was reported, the water being measured by a weir. In the report of this test was included a combined indicator diagram, which was the first, probably, to be made in this country. It was plotted by Mr. Hoadley, and its appearance caused much interest among engineers, and the use of the word "adiabatic" in connection with it created a new interest in the behavior of steam.

Upon the recommendation of James B. Francis, the famous hydraulic engineer of Lowell, Mr. Leavitt was appointed consulting and mechanical engineer of the Calumet & Hecla Mining Co. in 1874, a position which he retained until 1904. Here Mr. Leavitt had many opportunities to display his powers as a designer of heavy machinery for pumping, general power purposes, hoisting, and stamping.

Water was needed in large quantities for condensing, washing out copper, and domestic consumption for the town of Calumet. Mr. Leavitt abandoned the Lynn type of pumping engine, placed the beam at the bottom and the steam cylinders above. At first one cylinder only was inclined and the other vertical, but soon afterwards both cylinders were vertical, the pumps in all cases being below and vertical. At the time of placing both cylinders vertical, instead of having the high pressure exhaust and low pressure inlet valves work simultaneously, as previously, the latter was made a cut-off valve and re-heaters were placed between the cylinders. The engine was thus changed from having continuous expansion through both cylinders to one having interrupted expansion, but no doubt with improved economy.

The engine "Superior," with cylinders 40 in. and 70 in. diameter, stroke 6 ft., 60 r.p.m., was the largest engine built for the Calumet & Hecla Co. This was an inverted compound beam engine and was used for driving hoisting drums and air compressors. The connecting rod ran from a pin in the top of the beam, and the crank was at one end. The crank was double armed and drove in both directions, the hoisting machinery being on one side and the air compressors on the other. The crank pin was 18 in. by 24 in. The flywheel was 36 ft. in diameter and was also a belt wheel.

As the plant used a great deal of compressed air Mr. Leavitt had necessarily to consider the problem of its supply, and after a time designed some 42 in. x 60 in. wet compressors in pairs. Two pairs of this design were built, but later additions were dry compressors.

Water was used at the stamp mills more than elsewhere, and after building several ordinary sized pumping engines for this work, he built one of 60 million gallons capacity in 24 hours. This had two plungers of 48 in. diameter and its stroke was 90 in.

Up to 1886 Mr. Leavitt's standard steam pressure was 135 lb. per sq. in., but in that year he began the design of triple expansion engines and adopted 185 lb. pressure. His triple expansion engines were modifications of the compound in having the high and intermediate pistons operate on one end of the beam and the low on the other. Engines of this type for hoisting, pumping and general power work were designed but later some with three cranks were built.

One of the most important pieces of work he did for the Calumet & Hecla Co. was the improvement in steam stamps by which a very important economy and rapid stamping were secured. The Leavitt stamp consisted of a steam cylinder having two pistons, one with boiler pressure on top to deliver the blow and the other with reduced pressure constantly under the other piston for the purpose of lifting the stamp, and this steam squeezed back to the boilers with every downward stroke. These stamps were operated condensing.

Mr. Leavitt was a very strong advocate of gridiron valves and all his designs employed them. He was equally strong in his advocacy of cams for operating them, but some of his later designs employed other mechanism with dash pots.

Still another field for good engineering appeared in an opportunity to change the construction of the sand wheels from wood—the construction used in the Lake Superior region—to metal, and Mr. Leavitt designed sand wheels of 50 ft. and 60 ft. diameter on the principle of the bicycle wheel.

The hoisting gear used with constant running engines opened again another field in the operation of brakes and clutches, and here Mr. Leavitt employed hydraulic cylinders and accumulators. In some of the later hoisting engines, reversing engines were used in connection with the Whiting system.

While Mr. Leavitt was employed by the Calumet & Hecla Co. he was frequently engaged by other companies and municipalities, and found time to act as consulting engineer for Henry R. Worthington, The Dickson Mfg. Co. and the Bethlehem Steel Co.,—for the former company when they developed their high duty direct acting pumping engine, and for the latter when the plant at Bethlehem was being modernized and hydraulic forging introduced. For pumping water for the forging presses of the Bethlehem Co., he designed a 3-cylinder 3-crank simple non-condensing vertical beam engine to drive pumps designed and built by the company.

For the Dickson Mfg. Co. he designed a pair of remarkable 30 in. x 60 in. x 60 r.p.m. engines for the Washington Mills of the American Woolen Co. at Lawrence, Mass. These have been continuously in operation since the spring of 1887.

He designed the first engines used for the cable railway of the Brooklyn Bridge; engines, boilers and other machinery for the El Callao Mining Co. of Venezuela; three immense sewage pumping engines for the City of Boston, one being of 75 million gallons capacity in twenty-four hours; a pumping engine of 15 million gallons capacity for the Louisville Water Works which upon being tested for six days and six nights without stopping surpassed all previous records for economy in steam consumption; a large engine for the Cambridge Water Works;

two engines for the New Bedford Water Works; a large engine for the Boston Water Works, etc.

Mr. Leavitt was a strong advocate of the locomotive type boiler and used it almost exclusively, the diameter of the shell being usually 90 in. in diameter.

After 1888 he made frequent visits to Europe, where his fame had preceded him. He became well acquainted with the leading engineers in several countries; among these was Professor Riedler of Berlin, from whom he acquired the right to use the Riedler pump valve and gear in this country; the Boston engine mentioned above is equipped with this gear. He was in intimate relationship with the Krupps, and by their invitation was present on their yacht "Rona" at the opening of the Kiel Canal.

Mr. Leavitt was one of the thirty mechanical engineers who organized The American Society of Mechanical Engineers in 1880. Of his standing at that time the History of the Society by Prof. F. R. Hutton says:

"Mr. E. D. Leavitt was best known for his notable successes in the design of high duty compound pumping engines for city water works service; he was then (1880) on the point of completing the 'Superior,' the great engine for the Calumet & Hecla Copper Mining Company. He stood for high economy in slow speed engines and with an elaborated valve gear, just as Mr. Charles T. Porter stood for economy in the type operating at high rotative speeds with simple valve gear.

"He served as President of the Society during 1882-83, a very critical time in the life of the Society.

"Mr. Leavitt's first meeting (over which he presided) was the very successful Cleveland meeting, at which for the first time the papers to be read were furnished to members, and particularly to the technical press on printer's galleys.

"He positively declined a second term as President on the principle . . . that the honor of office should be widely conferred, even at a loss of the possible greater effectiveness which might be secured by longer service."

Mr. Leavitt was on intimate terms with the most prominent American engineers of his active days, including James B. Francis, John Fritz, Charles T. Porter, Alexander L. Holley, Henry R. Worthington, Washington Jones, John E. Sweet, Robert H. Thurston, S. B. Whiting, John C. Hoadley, W. E. Worthen, James P. Kirkwood, Joseph P. Davis, Alphons Fteley, Charles Hermany, John A. Roebling, William Sellers, Coleman Sellers, Samuel T. Wellman, and George W. Melville.

He was of a very modest and retiring nature, and his acquaintance with the younger members of the Society was not extensive and many of them probably never saw him. In later years he did not attend the meetings frequently, and when he did he sought the companionship of the older men.

Of Mr.Leavitt as a designer, it can be said that he did more than any other engineer in this country to establish sound principles and propriety of design. He appreciated the importance of directness and the absence of ornamentation in strictly utilitarian designs, and he firmly believed that beauty in machine design came from propriety. He bore the same relation to good taste in the design of heavy machinery that William Sellers did in the design of machine tools.

He was a very strong advocate of good materials and good workmanship, and had a singular appreciation of what gave stability and permanence to machinery. He was among the very first engineers in this country to appreciate the importance of weight in machinery, and while many Americans were advocates of light weight, Mr. Leavitt's view has amply been vindicated by the present status and tendency of design in this country.

In his Calumet and Hecla machinery he held the view that the best was none too good, and that it was of the utmost importance to have machinery which could be depended upon to do its work, always of the severest kind, without interruption. The service was twenty-four hours a day, and interruption of production was very costly.

Mr. Leavitt received the degree of Doctor of Engineering from the Stevens Institute of Technology in 1884, and was the first recipient of this degree from the Institute. He was not only an original member of The American Society of Mechanical Engineers, but was made an Honorary Member on January 12, 1915; he served as a Vice-President in 1881-82 and as President in 1883. He was a member of the Institution of Mechanical Engineers of England for thirty-three years, and was made an Honorary Member on February 18, 1916. He was a member of the following societies: Institution of Civil Engineers of Great Britain; American Society of Civil Engineers; American Institute of Mining Engineers; Boston Society of Civil Engineers (Honorary, 1908); American Society of Naval Engineers (Honorary); British Association for the Advancement of Science (Life Member), The Franklin Institute, and the New England Water Works Association (Honorary, 1906). He was a Fellow of the American Academy of Arts and Sciences.

He was for many years on the Visiting Committee of the Engineering Department of Harvard University and of the Observatory.

In general business Mr. Leavitt did not make himself prominent, but he was a director for many years of the Harvard Trust Co. of Cambridge, and was very much interested in the Cambridge Young Men's Christian Association. He was also a member of the board having charge of the construction of the new West Boston Bridge between Boston and Cambridge.

Mr. Leavitt's health was never robust, and in consequence of this he worked under considerable disadvantage for much of the time.

CHARLES J. H. WOODBURY

By the death of Erasmus D. Leavitt on March 11 and of Charles J. H. Woodbury on March 20, the Society loses in the same month two of its original members, both of whom early held office and both of whom inaugurated important developments in the Society's work.

Charles J. H. Woodbury was born at Lynn, Mass., on May 4, 1851, and resided there during his life. He received his education in the public schools of Lynn, and from there he entered the Massachusetts Institute of Technology in the course of civil engineering, graduating in 1873.

He began the practice of his profession in the city engineer's office in Lynn during his vacations while at college, and was later superintendent of a mill at Rockport. He became engineer of the Boston Manufacturers' Mutual Fire Insurance Company in 1878, and later vice-president, and while with the company he made numerous investigations on fire hazards in mill construction, lubricating oils and electric lighting, and invented several improvements in automatic sprinklers. He also reorganized the company's methods of inspection and reports upon mill property. In 1894 he became assistant engineer of the American Bell Telephone Company, which position he held until the removal of the company to New York in 1907, when he took up private practice as a consulting engineer.

Dr. Woodbury was the author of Fire Protection in Mills, 1882, Telephone Line Engineering; The Telephone System, 1899, and Bibliography of Cotton Manufacture, 1909. Also,

he wrote numerous monographs and papers on fire protection, political economy and engineering, many of which are incorporated in the proceedings of the scientific and engineering societies.

He was the originator of a number of valuable inventions, and on three occasions received awards for them. The Société Industrielle de Mulhouse awarded him the Alsacian Medal in 1883, the city of Philadelphia conferred on him the John Scott Medal in 1885, and in 1910 he received the Association Medal from the National Association of Cotton Manufacturers. Further recognitions for his contributions to science and engineering came to him from Tufts College in 1893, when he received the honorary degree of Master of Arts from the college, and he was made an honorary Doctor of Science of Union College in 1906 and of Dartmouth College two years later.

Dr. Woodbury was a member of the American Society of Civil Engineers; the American Institute of Electrical Engineers; the National Association of Cotton Manufacturers, of which he was secretary and treasurer since 1894; the Society of Arts, and the Sons of the American Revolution. He was a fellow of the American Academy for the Advancement of Science, and an honorary member of the New York Telephone Club. He was a non-resident lecturer at the Massachusetts Institute of Technology and also at Cornell University. From 1886 to 1895 he was chairman of the Lynn School Committee.

Dr. Woodbury was elected to membership in our Society in 1880, and he served as Vice-President from 1887 to 1889.

To him is due the initiation of our Library. At the meeting of the Council on February 15, 1883, he moved that the Secretary be instructed to request from members circulars of manufacturing establishments and reports of engineering operations, with a view to making a catalogue of contemporaneous engineering work, to be filed properly and placed at the service of members. The motion was carried and put into effect, and the response was prompt and liberal, many of the technical periodicals contributing copies of their publications, and some sending complete bound files of their back numbers. As the outcome a standing committee on the library was appointed, which recommended the definite organization of the Library.

The President appointed the following as Honorary Vice-Presidents to represent the Society at Dr. Woodbury's funeral: G. I. Alden, Gardner C. Anthony, H. S. Baldwin, Albert G. Duncan, C. H. Fish, W. A. Hall, Franklin W. Hobbs, W. R. Park, George F. Swain, J. A. Tilden, A. C. Walworth, A. K. Warren, H. S. Baldwin, G. H. Barrus, John A. Stevens, Richard H. Rice, C. T. Plunkett, E. F. Greene, E. W. Thomas, C. T. Main.

JOHN W. HILL

John W. Hill was born in Liverpool, England, on July 12, 1865, and received his early education there. From 1880 to 1884 he served an apprenticeship as machinist with Daniel Adamson & Co. From 1890-1899 Mr. Hill was at the Watervliet Arsenal, with E. D. Leavitt of Cambridge, Mass., and the General Electric Company as draftsman and designer. After leaving the General Electric Company, he was superintendent of the Steamobile Company at Keene, N. H., and also superintendent of the Roller Bearings Company. He was later employed with the Maxwell Brisco Company in charge of the department of tooling up machines for rapid jig construction of automobiles.

In 1911 he entered the employ of the Bantam Anti-Friction Company as mechanical and sales engineer in charge of the Detroit office and the northwestern territory.

Mr. Hill was a member of the Society of Automobile Engineers, and a member of this Society since 1899. He died at his home in Detroit on February 12.

FREDRIK V. MATTON

Fredrik V. Matton was born in Stockholm, Sweden, on June 6, 1856. He received his technical training at Stats College and served his apprenticeship as a machinist in his native country. He came to this country early in 1882, first securing employment at Altoona and later at the Harrison Sugar Refinery at Philadelphia. While there he had charge of the repairs and construction of general machinery.

In June, 1885, Mr. Matton became employed at the Camden Iron Works in Camden, N. J., as chief engineer, which position he held until his last illness.

Mr. Matton became a member of the Society in 1892. He died at Atlantic City on December 3, 1915.

DAVID THOMPSON

David Thompson was born at Castlemaine, Victoria, Australia, on December 5, 1865. He received his early education in the state and public schools and in the School of Mines. He served an apprenticeship in the Castlemaine Foundry of the Thompson Company, manufacturers of mining and general machinery, which was founded by his father. From 1882 to 1887, he was engaged in making detail drawings for all classes of mining machinery, engine boilers and pumping gears, and in 1887 became assistant works manager at the Castlemaine Foundry. Since 1891 he has been managing partner of the Foundry, which are at the present time the largest privately owned ironworks in Australia.

Mr. Thompson was very much interested in the welfare of the working classes and sat on all wage boards in Melbourne in connection with the iron trade and was largely instrumental in fixing the rates of wages. He was also a member of the Chamber of Manufacturers and acted on various committees associated with that Chamber.

Mr. Thompson became a member of the Society in 1905. His death, which was the result of an accident in the works at Castlemaine, occurred on February 6, 1916.

WILLIAM ALFRED PERRY

William Alfred Perry was born in Brooklyn on April 22, 1835. He received his early education at Mr. Howard's Day School in Brooklyn and graduated from Columbia College in 1855. The following year he became a clerk in the firm of Henry R. Worthington, and 13 years later became first a partner and later vice-president of the same firm. He was also a director in the Union Ferry Company.

The first propeller ferry boat with guards that ran in New York Bay was built under his direction by the firm of Pusey Jones & Company of Philadelphia in 1867.

Mr. Perry was a member of the University, Century and Engineers' Club. He became a member of this Society in 1880. He died at his home in New York City on February 16, 1916.

HARRY SHAFER PELL

Harry Shafer Pell was born in Lykens, Dauphin County, Pa., on July 23, 1846. He received his early education in the public schools and in 1860 entered the employ of the Lykens Valley Railroad Company as an apprentice machinist and blacksmith. From 1871 until 1873 he was master mechanic and later engineer for the Vulcan Iron Works. From 1873 until 1881 he was shop foreman for Tolten and Company of

Pittsburgh. He was also engineer for St. Louis Ore and Steel Company, in the machinery and foundry business at Minneapolis, superintendent in charge of the shops and all construction work for Jas. P. Witherow of New Castle, Pa., and engineer and superintendent for The Stirling Company of Barberton, Ohio, manufacturers of the Stirling boilers. While there he had charge of the engineering department, shops and erection, as well as all of the purchasing of materials. For the past few years Mr. Pell has been chief engineer of the water tube boiler department of the Erie City Iron Works.

Mr. Pell died at his home in Erie, Pa., on March 1, 1916.

SOCIETY MEETINGS

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

PHILADELPHIA, FEBRUARY 3

On February 3 a joint meeting of the Philadelphia Section of the Society was held with The Franklin Institute, at which Charles Day of The Franklin Institute and Professor Fernald of the Am.Soc.M.E. presided. The paper presented was on The Development of the Pumping Engine, by Arthur M. Greene, Jr., Mem.Am.Soc.M.E., professor of mechanical engineering at Rensselaer Polytechnic Institute.

WORCESTER, FEBRUARY 16

At a meeting of the Worcester Section of the Society held on February 16, Dr. Ira N. Hollis, president of the Worcester Polytechnic Institute, spoke on What Constitutes a Well Rounded Fleet. The conclusion that Dr. Hollis came to was that in any program of building up a fleet due consideration must be given to the different units of a fleet in order to make its fleet action effective. Battleships without the necessary auxiliaries seriously handicap their full use.

PROVIDENCE, FEBRUARY 23

A meeting of the Providence Association of Mechanical Engineers was held on February 23, at which Prof. James A. Hall, Mem.Am.Soc.M.E., addressed the meeting on The Handling of Steam Coal from the Mine to the Consumer.

CINCINNATI, FEBRUARY 24

A joint meeting of the Engineers' Club of Cincinnati and the Cincinnati Section of the Society was held on February 24, at which Morse W. Rew, assistant engineer of the Board of Rapid Transit Commissioners, gave an illustrated lecture on a Rapid Transit System and Interurban Facilities for the City of Cincinnati. The fact that the people of Cincinnati will be called upon to vote for or against a proposed issue of $6,000,000 for this rapid transit scheme on April 25, 1916, made the lecture even more interesting. Mr. Rew discussed the needs of such a system in Cincinnati, advantages accruing to the individual and to the business man, as well as to the community as a whole. He told what that city might expect from the Rapid Transit System as an aid to suburban development, and gave statistics of what has resulted in the various cities which now have subways. He also gave statistics disproving the popular idea that subway travel is more dangerous than surface, elevated and other methods of transportation.

The question of who would operate the proposed system was touched upon, and Mr. Rew stated that if the bond issue of $6,000,000 is approved by vote of the people, the Rapid Transit Commission proposes to lease the system on the best terms possible to an operating company, subject to the approval of the people, such approval being asked at a special election to be held prior to letting any contracts for construction work. He closed his address with a brief engineering description of the route and of the different types of construction that will be used on the proposed system.

BUFFALO, MARCH 1

At a meeting of the Buffalo Engineering Society on March 1, T. Kennard Thomson, Mem.Am.Soc.M.E. and consulting engineer of New York City, spoke on The Problems of a Consulting Engineer. Mr. Thomson outlined his plan for the extension of Buffalo by a development of the submerged land along the water front, consisting of about seven square miles, which could be used in developing industrial and recreation facilities. He proposed to use a part of this new filled-in land for the freight and passenger terminals of the railroads and boat lines, and stated that the cost of this work could be financed with the proceeds of sale of the new land. Mr. Thomson, together with Peter A. Porter of Niagara Falls, had also plans for the construction of a new electric power plant. They proposed to use the natural drop of 102 ft. in the river between the Falls and Lewiston by the construction of an enormous dam. It would then be possible, the speaker stated, to create 2,000,000 h.p. as compared to the 1,000,000 h.p. now being obtained from the power plants at the Falls.

Dr. Thomson, who is consulting engineer of the American Commission for the celebration of 100 years peace between Great Britain and the United States, described the plans for the proposed peace bridge across the Niagara River at Ferry Street. Specifications call for a bridge one mile in length and 100 ft. wide, with six main spans of 300 ft. each. The spans would be the widest of the kind in existence.

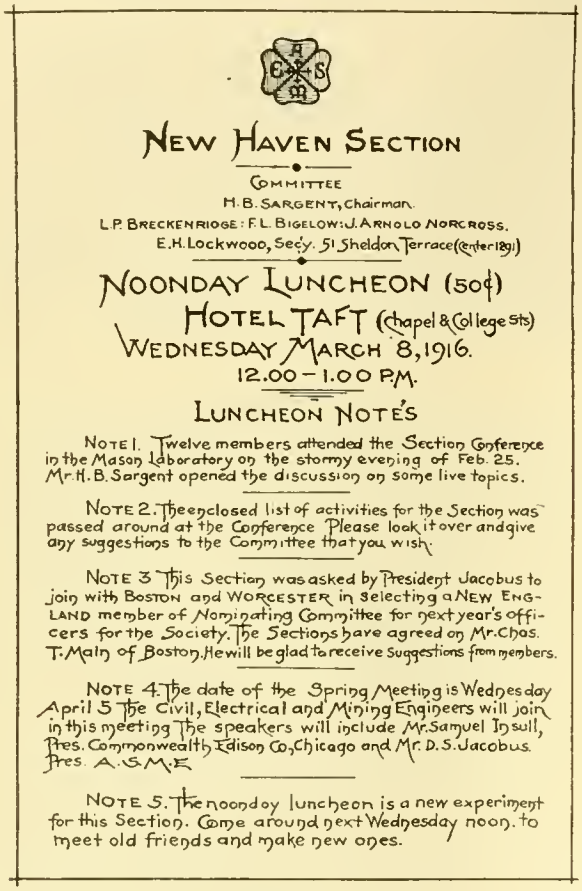
BIRMINGHAM, MARCH 2

A business meeting of the Birmingham Section of the Society was held on March 2 at which 16 members were present. The new Constitution and By-Laws were adopted and other routine business matters cared for. The greater part of the discussion, however, was devoted to the coming visit of the Society to Birmingham on April 10. The Section is anxious to see a large number of members in Birmingham on

the 10th and is making extensive plans to give everyone a good time.

NEW HAVEN, MARCH 8

A second informal meeting of the New Haven Section was held on March 8 and was followed by a noon-day luncheon. Social meetings of the New Haven Section have now become a regular feature, but will not interfere with the large meetings held twice a year for reading of papers. Fig. 1 shows the program which was distributed at the luncheon, upon which appears general notes which are of immediate interest to the New Haven members. The first of these informal meetings was held on February 25 and it was devoted principally to promoting mutual acquaintance and to a discussion of the interests of the New Haven Section. At this meeting there were distributed sheets on which appeared possible procedures that the New Haven Section might follow in promoting the welfare of the Society and the local members, and also several suggestions which had been sent in by a member.



NEW HAVEN SECTION

COMMITTEE

H. B. SARGENT, Chairman.

L. P. BRECKENRIDGE: F. L. BIGELOW: J. ARNOLD NORCROSS.

E. H. Lockwood, Sec'y. 51 Sheldon Terrace (Center 1891)

NOONDAY LUNCHEON (50¢)

HOTEL TAFT (Chapel & College Sts)

WEDNESDAY MARCH 8, 1916.

12.00 – 1.00 P.M.

LUNCHEON NOTES

NOTE 1. Twelve members attended the Section Conference in the Mason Laboratory on the stormy evening of Feb. 25. Mr. H. B. Sargent opened the discussion on some live topics.

NOTE 2. The enclosed list of activities for the Section was passed around at the Conference Please look it over and give any suggestions to the Committee that you wish.

NOTE 3 This Section was asked by President Jacobus to join with BOSTON and WORCESTER in selecting a NEW ENGLAND member of Nominating Committee for next year's officers for the Society. The Sections have agreed on Mr. Chas. T. Main of Boston. He will be glad to receive Suggestions from members.

NOTE 4. The date of the Spring Meeting is Wednesday April 5 The Civil, Electrical and Mining Engineers will join in this meeting The speakers will include Mr. Samuel Insull, Pres. Commonwealth Edison Co, Chicago and Mr. D. S. Jacobus. Pres. A.S.M.E

NOTE 5. The noonday luncheon is a new experiment for this Section. Come around next Wednesday noon, to meet old friends and make new ones.

Fig. 1 Attractive Program of Noon-Day Luncheon at New Haven

MINNESOTA, MARCH 9

The regular March meeting of the Minnesota Section of the Society was held on March 9 at the offices of the St. Paul Gas Light Company in St. Paul. Following the business session, Herman F. Mueller presented a paper on the Uniflow Engine. It consisted mainly of a description, the origin of the Uniflow engine in Germany, together with its manufacture, auxiliaries used in its operation, efficiency, etc. A general comparison was also made with other steam units in general use in this country.

BOSTON, MARCH 14

The Boston Section of the Society held a meeting on March 14 at which George H. Clarke of the mechanical engineering staff of the Massachusetts Institute of Technology presented an illustrated lecture on Safety Valves. Mr. Clarke has spent much time in investigations and tests of safety valves and has brought out some new and valuable principles of construction. The speaker covered his subject under the following topics:

a. Present state of the art and the available theory for design.

b. Absolute and imperative need of valves of higher discharge capacities.

c. The limiting possibilities of the spring loaded type and the portion attained by standard valves.

d. Reasons why the standard valves cannot be designed for increased capacities.

e. Theoretical considerations which should govern the design and do govern the action of all safety valves.

f. Description of a new type, its theory, the results attained on test and the advantages of the design.

A lengthy discussion followed the presentation of the paper on which the following gentlemen participated: Prof. Edward F. Miller, Mem. Am.Soc.M.E. and of the Massachusetts Institute of Technology; George H. Musgrave of the Star Brass Manufacturing Company, Mr. Pirie of the Crosby Steam Gage and Valve Company, John A. Stevens, Mem. Am.Soc.M.E. and consulting engineer of Lowell, Mass.; A. B. Carhart, Mem.Am.Soc.M.E. and of the Crosby Steam Gage & Valve Company; Mr. Edwards of the Wentworth Institute, Frank E. Fairbanks, Mem.Am.Soc.M.E. and of the Quincy Market Cold Storage Company, and F. W. Dean, Mem. Am.Soc.M.E. and consulting engineer of Boston.

NEW YORK, MARCH 14

The March meeting of the New York Local Section was a joint meeting of the Section and of the New York Section of the Illuminating Engineering Society to discuss the Code of Lighting for Factories, Mills and Other Work, prepared by committees of the latter Society. Prof. C. E. Clewell, Assistant Professor of Electrical Engineering, University of Pennsylvania, who assisted in the preparation of the code, opened the discussion by analyzing the causes which have led to greater attention on the part of factory owners and employers to the conditions under which their employees work, giving the reasons for the preparation of the code, discussing its probable field of usefulness and explaining points most likely to advance the status of factory lighting and raise the standards of quantity and quality of light for industrial purposes. Professor Clewell illustrated his remarks by a number of lantern slides.

L. P. Alford opened the discussion for the Society, and took up in detail the phraseology of the code. Following this, the code was discussed by several members of the Society and of the Illuminating Engineering Society, and a vote of thanks was extended to those who had taken part in the preparation of the code and in the discussion of the evening.

The meeting was preceded by an informal dinner at which members of both societies were present.

BUFFALO, MARCH 15

On March 15, at a meeting of the Buffalo Engineering Society, Prof. Arthur M. Greene, Jr., of the Rensselaer Poly-

technic Institute, gave an address illustrated with a large number of slides on the History of Pumping Stations. The slides showed the progress that had been made from the days of the "shadouf," as used by the Egyptians for irrigation purposes, to the modern large pumping stations. The works of Savery, Newcomen, Watt, Bull, Worthington, Reynolds, Gaskill and d'Auria were illustrated to show their contributions to this development.

There were about 150 members present at the meeting.

CINCINNATI, MARCH 16

The March meeting of the Cincinnati Section of the Society, which was a joint meeting with the Engineers' Club of Cincinnati, was held on March 16. The attendance at the afternoon session was about 75 and at the evening session about 100. The total number of persons who attended one session or another was probably 125. There were present at the meeting thirty members of the Am.Soc.M.E., which is the largest number of members that has ever attended a meeting in Cincinnati. Visitors were present from Akron, Dayton and Hamilton, Ohio.

There were two papers presented at the afternoon session: The Sales Engineer in His Relation to Production and Machine Design, by A. J. M. Baker, Mem.Am.Soc.M.E., and Recent Developments in the Recovery of Casing-head Gasoline, by Paul Diserens, Mem.Am.Soc.M.E. Both of these papers were illustrated.

There were also two papers presented at the evening session, one by W. G. Franz, Mem.Am.Soc.M.E., on Why Is an Engineer? and the other by A. M. Sosa, Mem. Am.Soc.M.E,. on Probable Future Requirements in Machine Tools.

CHICAGO, MARCH 17

The third meeting this year of the Chicago Local Section was held at the Hotel LaSalle on March 17, Chairman H. M. Montgomery presiding. This meeting was attended by 202 members and guests. The subject of the nomination of officers was discussed by the membership, and it was decided to follow the practice of the past and have the nominating committee nominate the full committee without any restrictions as regards rotation. The paper of the evening was prepared by S. B. Daugherty, International Steam Pump Company, Buffalo, N. Y., and was read by H. C. Lehn of the same company, as it was impossible for Mr. Daugherty to attend the meeting.

The subject of the paper was Oil Engines, and the author described in some detail both Diesel and low compression engines and gave figures of their reliability and economy. He also considered fuel and lubrication, and other vital factors. The discussion of the paper was active and interesting, many points being brought out regarding the potentialities of this type of prime mover.

PROVIDENCE, MARCH 22

The March meeting of the Providence Association of Mechanical Engineers was held on March 22. The prime matter of discussion was the enlargement of the scope of the Association and the committee which had been appointed to consider that project reported their suggestions as to changes in the present constitution to meet the new requirements. The resolutions presented are to come up for action at the April meeting of the Association.

Following the business meeting, the Association was addressed by J. W. Hook, general manager of the C. A. Dunham Co., of Marshalltown, Iowa, on Vacuum Steam Heating.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

An open meeting of the Student Branch of the Armour Institute of Technology was held during school hours on February 18. The speaker, Osburn Monnett, former smoke inspector of the city of Chicago, gave an illustrated talk on The Engineering Phases of Smoke Abatement Work. The substance of his lecture was the damage and expense incurred by smoke and his methods of remedying the smoke nuisance. He said that the soft coal smoke deposits a hard crust on buildings and that skilled labor is required to remove it; scrubbing and sand blasts have to be used in some cases. He said that the owners of the Railway Exchange Building spend $1500 yearly for this work.

Mr. Monnett said that at the beginning of this smoke work the return tubular boiler gave the greatest trouble as it made about 90 per cent of the smoke, and that his chief work was to find means of improving this boiler so that it would not smoke. He illustrated how the Ringlemann smoke chart is used to determine whether the smoke has a density of 20, 40, 60, 80 or 100 per cent. He closed his lecture by saying that abatement of smoke means city beautiful, health, more sunlight, better vegetation, clean homes, happier people.

BUCKNELL UNIVERSITY

A meeting of the Bucknell University Student Branch was held on March 6, at which O. C. Hartman, '16, gave a talk on Superheaters on Railroad Engines. The discussion covered the reasons for superheating, together with the conditions which must be met in design of locomotives of this type. The various methods of superheating used were explained by means of drawings and blueprints of the different types of locomotives and their advantages and disadvantages were brought out. A comparison was made between the superheater type of locomotive and the locomotive which uses only saturated steam.

CASE SCHOOL OF APPLIED SCIENCE

At the February meeting of the Case School of Applied Science Student Branch, held on February 2, R. R. Abbott, who is associated with the Peerless Motor Car Company as metallurgist, gave a talk on the Theory of Heat Treatment Practically Explained. The speaker gave a systematic explanation of the ferrite and pearlite compositions of steel, with the relative strength and toughness of each, and explained that alloys in the steels were used merely to change the physical properties of the steels either by increasing the strength of the ferrite or of the pearlite. Similarly he brought out the effects of heat treatment and its control on the physical properties of the various steels.

At a meeting of the branch on March 1, Prof. K. F. Adamson, Mem.Am.Soc.M.E., of the Mechanical Department, spoke on the Buckeyemobile and Uniflow Engine and showed why these types of reciprocating engines can compete with the smaller turbine units of the present time. He described in detail the Buckeyemobile, which consists of a unit of engine and boiler combined, and with the aid of data compiled by him showed the comparison of the efficiencies, economies and cost of power between this type and the modern large turbine units. His figures showed that only 1.25 to 1.5 lb. of coal per b.h.p. per hr. are used by the Buckeyemobile, which is in reality a copy of the German locomobile engine. Mr. Adamson then described in detail, using slides as illustrations, the American uniflow engine, and from typical indicator cards showed how closely the card taken from an engine of this type approaches the theoretical card: hence its high efficiency. The valve gearing, including bleeding valves, was thoroughly discussed.

COLORADO AGRICULTURAL COLLEGE

A meeting of the Colorado Agricultural College Student Branch was held on February 14, at which Mr. Gorton gave a talk on the first U. S. Government built Diesel engine. He described in close detail the engine as a whole and also the cylinders, pistons, the bed and all details of auxiliary air com-

pressors and fuel pumps. He explained the operation of the engine, the cooling system and the mounting of all parts.

Following Mr. Gorton's talk, Mr. Hoffman reviewed the paper by Robert Cramer on Higher Steam Pressures, which was published in the January 1916 issue of The Journal.

KANSAS STATE AGRICULTURAL COLLEGE

A meeting of the Kansas State Agricultural College was held on March 2, at which Prof. Walter W. Carlson, Mem. Am.Soc.M.E., gave a paper on the Composition and Use of Thermit. He gave the reactions of the compound and the results of these reactions. The action is so fast that a large amount of heat is generated which goes to melt the iron filings and makes the weld. The composition of the compound is $Fe_2O_3 + 2Al$ and by applying a source of heat to kindle the aluminum the equation $Fe_2O_3 + 2Al = 2Fe + Al_2O_3$ is derived. The aluminum has a great affinity for oxygen and is therefore used to take up the oxygen in Fe_2O_3. Thermit is used for welding metal and is also added to ladles of molten metal in the foundry to make the iron hotter and thus make it finer grain.

A second paper was presented by Mr. Slusher of Kansas City on Oxy-acetylene Welding. Mr. Slusher gave a comparison between the old and the new methods of welding and the saving that is brought about by the use of oxy-acetylene welding machinery.

The modern oxy-acetylene generator is very much improved over the old type and has reduced the danger and also the cost of the use of the machine. The oxygen and acetylene are put up in steel bottles, which reduces the danger in handling and using the gases. The torches of today are also a great improvement over the ones of five or six years ago; they are much lighter and the flame is much hotter. In the up-to-date torches the gases are mixed more thoroughly and there is less danger of back firing.

LEHIGH UNIVERSITY

A meeting of the Student Branch of Lehigh University was held on March 2. The first speaker was F. W. Ryder, '16, who read a paper on the Operation of Electric Mine Locomotives. He said that the transportation of material is a very important factor in the coal mining industry on account of the magnitude of the coal mined, which in 1910 reached the net total of 500 millions of tons.

The use of electricity in coal mines has been in vogue for many years, and the advantages of the electric locomotive over the steam locomotive have been fully demonstrated. The electric locomotive is good on grades, is superior to the steam locomotive in simplicity of construction and has a more compact form. Besides, the use of steam is difficult and costly, and diminishes the factor of safety. The gasolene type is undesirable because it develops a low efficiency. The first electric locomotive was built in 1899 and is still in daily operation.

In modern coal mines there are the straight haulage, cable reel and combination or crab types of locomotives in use. As regards the positions of the motors, there are two types: Two motors, one geared to each axle, or one motor connected to both axles. The total height is 27 in., which is smaller than any steam locomotive ever built.

The construction of the frames has undergone some important changes which have tended to increase the efficiency considerably. Formerly cast iron was used almost entirely for the frames, but now the plate steel construction has proved to be a great improvement over cast iron. Plate steel frames have decreased the weight and are much more desirable.

The bar steel frame, invented by The Baldwin Locomotive Works, is very flexible, is easily inspected and is practically proof against injury. The bodies may be either tandem hung, central hung, or low hung.

In the performance of the locomotive all the wheels must revolve at the same speed, with equal distribution of the drivers on the track. The maximum draw-bar pull is proportional to the weight of the locomotive.

The speaker also gave a description of the mechanical construction, and an elementary outline of the theory of the motor and locomotive.

The second speaker was C. C. Behney, '08, Mem.Am.Soc. M.E., who discussed Pitot Tubes and Measurements. Mr. Behney explained the principal features of the various Pitot tubes in present use, illustrating his talk by blackboard sketches. The following principal conditions of construction are necessary: Tubes must be built to measure the flow in pipes of liquids and gases; to measure low as well as high velocities; to measure the flow in the open channel as well as in pipes, and they should be compact, light and strong, and easy to manipulate. The method of finding the pipe coefficient, the use of a recorder, and the float idea for measuring the flow of water, were explained. The speaker closed his lecture by a discussion of various types of meters for measuring water.

LELAND STANFORD JR. UNIVERSITY

At a meeting of the Leland Stanford Jr. University Student Branch on February 9, two papers were read. The first paper was presented by E. O. Bennett on The Gyroscopic Effect of Rotary Motors on Aeroplanes. The speaker first gave a description and explanation of the several different types of rotary motors, then a mathematical analysis of the forces which come into action and the methods of calculating rudder areas sufficient to overcome the gyroscopic forces. In the discussion, the disadvantages of a rotary motor were brought out which showed the reasons why the practice of using automobile type of motors is now becoming common.

The other paper was by F. P. Andrews on the Use of Developments in Long Distance Wireless Telegraphy. Mr. Andrews gave a description of the modern wireless apparatus and then discussed the methods which have made possible communication over increased distances. The apparatus used in wireless telephony was also discussed and its present limitations pointed out.

LOUISIANA STATE UNIVERSITY

The first regular meeting of the Student Branch of Louisiana State University was held on March 9, at which the constitution which had been drafted by a special committee was presented and accepted.

On March 10, a special meeting was held at which J. J. Munson delivered a lecture on Water Power and Pelton Water Wheels. Mr. Munson gave a few brief historical notes on the development of water power and described the resources of water power in the United States in comparison with the resources in other countries.

PENNSYLVANIA STATE COLLEGE

At a meeting of the Pennsylvania State College Student Branch on February 23, Dean R. L. Sackett, Mem.Am.Soc. M.E. and of the School of Engineering, gave a very interesting and instructive talk on Factors Governing the Revision of Factory Systems, and discussed fully the problems which arise in this work.

POLYTECHNIC INSTITUTE OF BROOKLYN

A meeting of the Polytechnic Institute of Brooklyn Student Branch was held on March 4, at which a talk on The Army Rifle was given by Leon Eben and Abbott Obendorfer, illustrated by pictures and slides showing camp life at Plattsburg camp last summer. They said that the "Springfield 1903" model rifle in general use in the U. S. Army and National Guard is an improvement on the Krag-Jorgensen rifle in that it is more accurate, more powerful and weighs only nine pounds. Its muzzle velocity is 2700 ft. per sec. and when the shell is fired, it exerts a pressure of 6500 lb. per sq. in. The rifling or grooving of the barrel, which gives the projectile a rotary motion and a high muzzle velocity, is a spiral of 10 in. pitch. The barrel is 24 in. in length and has therefore 2.4 turns throughout its length. The bayonet for this model weighs one pound, is 16 in. long, and can be locked into place, thus preventing its loss.

STATE UNIVERSITY OF IOWA

A meeting of the State University of Iowa Student Branch was held on February 19, at which an illustrated lecture on West Point was given by Prof. F. G. Higbee, head of the

Department of Descriptive Geometry and Drawing. Prof. Higbee began with a brief history of West Point from the time of its founding as a fort for defense up to the present time. With the aid of lantern slides, he gave a detailed account of the methods of instruction and discipline at the Academy. Much emphasis is laid on the classroom work; a record is kept of each student's recitation in every subject every day, and the average of the week's work determines the standing of each man for the following week. This method of grading is necessary as the positions awarded after graduation are based largely on the standing of the men in their class and military work as undergraduates. Prof. Higbee explained the system by which the work is interchanged with recreation and pointed out that the life of a cadet is not the grind and drudgery it is generally thought to be.

SYRACUSE UNIVERSITY

At a meeting of the Syracuse University Student Branch, F. M. Williams, '97, state engineer and surveyor for New York, gave an interesting history of the barge canal, illustrated by stereopticon views and moving pictures. Mr. Williams stated that the barge canal is the most extensive engineering feat ever attempted by an individual state. The Erie Canal was opened in 1825 and proved so successful that an immediate enlargement was proposed. At various times extensions have been made and when it is finally completed the Erie Canal will have a total length of 341 miles, including 161 miles of natural river bed, 157 miles of channelized river, and 22.6 miles of lake system.

The problem of rebuilding 280 bridges is the greatest obstacle which has arisen in the present work. Eighty of these are railroad bridges and a great deal of trouble has come up between the state and the railway companies. The work on the entrance to the harbor at Syracuse on Onondaga Lake has been hindered because of such difficulties.

Although the work was begun in 1905, there still remain serious obstacles. The harbors at Syracuse, Rochester and Tonawanda present some of the greatest difficulties yet met with. Machinery valued at $40,000,000 is in use on the canal and there is a greater variety of machinery than in any other engineering project today, not even omitting the Panama Canal. There are two methods of excavating rock under water; by means of the drill and derrick boat, and by a rock dredger. The latter performs its work by smashing the rock with a heavy hammer and then dredging it out. The hydraulic dredge has proved the most successful on the barge canal and less costly. This dredge excavates about 400,000 cubic yards per month. The work on the canal between Buffalo and Rochester had to be done in winter to avoid blocking navigation as the present course and the old one are very close together.

The syphon lock at Oswego is the only one of its kind in America and the largest in the world. A model of this lock won the grand prize at the World's Fair. The rise from the level of the Hudson to the Mohawk, a height of 169 ft., has been accomplished by means of five locks, extending over a distance of one and one-half miles. These locks are unequaled in the world.

The stereopticon and moving picture views showed the various workings of the canal. Among the features of interest shown by the pictures were the Lockport locks, Crescent dam on the Mohawk, the Syphon lock at Oswego, a large hydraulic dredge in operation, and a ladder dredge. The last film exhibited showed views taken by the Pathé Company to be used in their picture "Seeing America First."

THROOP COLLEGE OF TECHNOLOGY

A meeting of the Student Branch of Throop College of Technology was held on February 11, at which Ford W. Harris, Mem.Am.Soc.M.E., spoke on Patents. He explained the fundamental idea of a patent, which is a contract between the Government and a person by which the Government gives that person the sole right to make, use, and sell his article or process, in consideration for which the person makes known a new invention or process. Mr. Harris explained the patent laws of this country and compared them with those of foreign countries.

UNIVERSITY OF ARKANSAS

On February 29, the University of Arkansas Student Branch of the Am.Soc.M.E. and of the A.I.E.E. held a joint meeting, at which Prof. B. N. Wilson, Mem.Am.Soc.M.E., presented an address on Scientific Management. He gave a brief history of scientific management and illustrated by several examples that it could be applied to almost every kind of industry. Professor Wilson pointed out that although the installation of such a system costs a great deal, it is cheaper in the end.

Prof. H. A. Brown of the electrical engineering department gave a demonstration of the wireless telegraph and explained by blackboard sketches its theory and working principles.

UNIVERSITY OF CALIFORNIA

The University of California Student Branch held its second meeting of the semester on February 22. H. S. Bean presented a paper entitled Rate Setting in Machine Shops, C. Sebastian discussed his thesis on Tests of the Starrett Compressed Air Pump, and E. Eichler gave a paper on High Explosive and Shrapnel Shell Manufacture.

At a meeting of the Branch on March 7, H. Crow presented a paper on The Gas Turbine. He discussed both the theoretical and practical phases of the subject and supplemented his discussion with slides showing various types of gas turbines. Prof. R. S. Tour discussed the "Relativity Theory" and touched upon some of the many deductions which may be made by the application of this theory. The subject of Oxy-Acetylene Welding was presented by C. V. Foulds, who reviewed the various methods employed and the application of this form of welding, and concluded by giving a practical demonstration of welding.

UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch on February 3, A. J. Baker, Mem.Am.Soc.M.E., spoke on The Opportunities and Field of the Engineer. Mr. Baker said that there is no profession which does more in the service of humanity or that demands that a man know his business thoroughly and be honest than the engineering profession, yet most people know very little about the engineer's work. It is the duty of every engineer to strive to correct the poor conception of the people and to endeavor to establish a higher plane for the profession, by widening the field of activity and developing the fields already entered.

The speaker mentioned some of the new fields to which the engineer might well direct his energies, among them the wind motor, the use of machinery for harvesting, and the development of sun machinery. He also emphasized water power development, and said that the work of controlling floods, such as the floods in the Mississippi Valley, and keeping the surface land on the farms is a field of activity well worth the endeavor of the engineer.

In closing, Mr. Baker spoke of the growing demand for machines which require mental effort to operate, instead of the machines so generally built at the present time which are made as automatic as possible in order that they may be operated by anyone with little or no mental effort, and pointed out that in the development of machinery along more efficient lines lay another great field for the engineer.

A joint meeting of the Student Branch of the Am.Soc.M.E. and A.I.E.E. was held on March 2. Dr. J. D. Magee of the Department of Economics gave a short address on Engineering Economics. After the address, a social was held in charge of the Seniors of the electrical engineerig department.

UNIVERSITY OF COLORADO

The University of Colorado Student Branch held a meeting on February 17, at which Harold Worcester read a paper, illustrated by slides, prepared by C. H. Thomas of the Skinner Engine Company. The paper took up history and origin of the uniflow engine, its principle of operation, construction, and valve action; special attention being given to the effect of the auxiliary exhaust valve in reducing the final compression pressure and clearance volume, a result which has made

this type of engine practical for noncondensing, medium pressure work.

UNIVERSITY OF KENTUCKY

At the regular February meeting of the University of Kentucky Student Branch the paper on Analysis of the Cylinder Performance of Reciprocating Engines, by J. Paul Clayton, Mem. Am.Soc.M.E. and of the University of Illinois, was discussed. G. L. Cherry introduced the subject with a twenty minute talk which was followed by a mathematical treatment of the subject by J. Wolf. A theoretical discussion was then given by Prof. Cassidy and a practical discussion by Prof. Wilhoite.

The Branch plans to spend the week of March 20 in Chicago and vicinity, inspecting the various points of engineering interest there.

UNIVERSITY OF MINNESOTA

An open meeting of the Minnesota Student Branch was held on February 19. At this meeting, moving pictures were shown illustrating the process of Thermit Welding. G. A. Ek, president of the Branch, explained the details of this process of welding.

On February 24, the Branch held its second annual get-together in the Auditorium. The principal speaker was Paul Doty, Mem.Am.Soc.M.E. and vice-president and general manager of the St. Paul Gas Light Company, who spoke of the engineer and engineering of the present time. Short talks were given by Prof. J. J. Flather, head of the mechanical engineering department, and Prof. W. H. Kavanaugh, head of the experimental engineering department.

The regular monthly meeting of the Student Branch was held March 4, at which A. P. Mason, a member of the senior mechanical engineering class, read a paper on the History and Use of Milling Machines. He illustrated his article by slides furnished by the Brown and Sharpe Manufacturing Company.

UNIVERSITY OF MISSOURI

A meeting of the Student Branch of the University of Missouri was held on February 21. The first speaker was Prof. A. L. Westcott, Mem.Am.Soc.M.E. and formerly assistant professor of mechanical engineering in the university, now superintendent of buildings, who spoke on the Advantages to the Student of Membership in the A.S.M.E. Student Branch. He pointed out the benefits to be gained by the student through the regular meetings of the section, and the chances to hear and take part in the programs.

J. W. Haney, Mem.Am.Soc.M.E., addressed the students on The Operation of the Power Plant and Heating-Ventilating System of a Large Office Building. He based his remarks mostly on his own work as chief engineer of the Commerce Power Company in connection with the Commerce Building at Kansas City, Mo., and told of many interesting things which happened in the operation of the plant, especially in connection with the elevator service.

An election of officers for the second semester 1915-16 was held, the following men being elected: Fred P. Hutchison, president; L. Senter, corresponding secretary; R. B. Warren, secretary-treasurer; J. W. Haney, R. M. Loetz, F. Nelson Westcott, governing board.

WORCESTER POLYTECHNIC INSTITUTE

At a meeting of the Worcester Polytechnic Institute Student Branch on March 3, Frank H. Trego, chief engineer of the Knox Motor Company, Springfield, Mass., and formerly research engineer for the Packard Company, gave an interesting talk on Automobile Engineering, dealing particularly with the details of construction and design, and explaining many problems which have arisen in the manufacture of motors. The speaker first considered the crank case or foundation of the motor, mentioning the advantages which aluminum possesses because of its light weight, and the disadvantages of excessive warping. A lengthy discussion was given regarding the advantages and disadvantages of two, three, four, and seven bearing crank shafts, particular emphasis being placed on the necessity for proper lubrication of these bearings. In explaining the importance of quiet running of automobile mechanism, Mr. Trego said that most purchasers care more about the details of appearance, quiet running and body construction than about the performance of the motor. He then discussed some of the causes for noise in gear trains, such as interference, poor alignment, improper material and poor lubrication, and their remedies, also the construction of the connecting rod and the broaching of bearing holes, and mentioned the offset piston pin and the elimination by this means of "piston slap." Mr. Trego showed several photographs of a modern aeroplane motor and explained its construction.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices now appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.

69 Technical Graduate to take charge of mechanical department of company building oil well machinery, employing about seventy-five men in thoroughly well-equipped and up-to-date plant. Salary $1800 to $2500 with good opportunity for advancement for progressive man. Location Texas.

116 Superintendent or Overseer to take charge of the mechanical side of manufacture of special line of chemicals used in fabric manufacturing concern. Location, New England.

120 Instructors for large Eastern college. Three instructors to combine teaching of shop work with practice of applied principles of scientific management. Instructor (a) wood-working; (b) forging; (c) machine shop and partly on thesis and factory layout work. Applicants must be graduates of an engineering college, and must be willing to adapt themselves to prescribed methods and begin at as low a salary as $1000 to $1100.

122 Heating and Ventilating Engineer, young technical graduate, with three or four years experience in this line of work. Location, Ohio.

124 Assistant to Plant Engineer young technical graduate, with about one year of practical experience, for work in plant maintenance, to include design, drafting, testing and investigations. Salary $65 to $75 a month with good opportunity for advancement.

125 Tool Designers, American or English. Location, Pennsylvania.

130 Textile Plant Engineer, one capable of studying textile operations with view to making improvements in machines or processes; who has had experience in similar lines, or a practical designer in connection with textile machinery. Salary $2000 to $3000, dependent upon ability and experience. Location, New England.

135 Draftsman, construction and equipment of sugar factories. Location, New York.

137 Manager, experienced in machine shop engine business; preferably one who can make investment and thus secure greater interest in business, for New Jersey concern, manufacturing steam and gas engines.

138 Research Assistant, young engineer to work principally along line of tests. Location, New Jersey.

139 Young Engineer Designer, with technical education and special training in the design of automatic machinery for the manufacture of small interchangeable parts; excellent chance for advancement to one who displays ability and application. Location, Chicago.

141 Assistant Superintendent with practical pattern shop, foundry and machine shop experience; technically educated man is preferred, who is ingenious and resourceful enough to handle the details of developing manufacturing methods in a shop turning out a large variety of machines in comparatively small numbers. Location, Middle West. Apply by letter.

146 Mechanical Engineer, splendid opening for young graduate of technical school, specialist in machine tool work; should be able to negotiate with manufacturers for agencies and demonstrate their products. Includes six to nine months' travel each year in Europe. In replying, state age, experience, salary expected, when at liberty, etc.

147 Assistant to Chief Engineer; all-around mechanical engineer wanted for assistant to chief engineer of firm doing large foreign business; would be in charge when chief is in Europe. Good opportunity for well educated technical graduate with right experience. State age, salary expected, previous experience, and when at liberty. Location, Massachusetts.

149 Chief Engineer with experience in chemical industries, for important new branch of established dye stuff factory. Location, Eastern States. Apply by letter giving details of experience and salary expected.

151 Manufacturing Executive to develop manufacture of addressing, folding and wrapping machines for newspapers and books. Must know paper handling and paper folding machinery and be able to design practical tools and jigs for manufacturing this particular product; should be thoroughly familiar with purchasing, clerical and accounting work in connection with factory, including stock-keeping, inventory taking, production ordering, etc. Growing opportunity; salary to start about $2500. Location, Middle West.

156 Sales Engineer thoroughly versed in the industrial hydraulic machinery line, competent to look after local interests of company. Location Middle West.

157 Designer and Draftsman as Assistant to engineer of concern manufacturing industrial hydraulic machinery. Location Middle West.

159 Production Engineer: A plant in Central New York State, manufacturing small arms, both sporting and military, of high reputation, requires a young mechanical engineer to standardize product and manufacturing processes for economical production of accurately interchangeable parts; must have high grade machine shop experience with arrangement of equipment, manufacturing operations, means for handling and storing materials, and in making operation studies to set production rates. Salary dependent on qualifications.

160 Production Engineer: A plant in Western Pennsylvania, making automobile frames and drop forgings for automobile parts and machining the latter, requires the services of a young mechanical engineer, familiar with similar work, to take charge of routing and scheduling work throughout the plant. Salary dependent on qualifications.

165 Chief Inspector, for a plant in Central New York State manufacturing small arms, both sporting and military, of high reputation. Must be mature man with experience on high grade machine work.

172 Superintendent, unusual opportunity with well established growing machine building concern; high-class executive up-to-date in shop practice. Location Brooklyn. State experience, age, and salary.

173 Instructor in Mechanical Engineering for university in California; to assist in steam, hydraulics and testing materials laboratories, and possible charge of a section of applied mechanics. Salary $1000 or less depending on man; young man with one or two years experience either in teaching or practical work.

174 Assistant Superintendent in forge department; general requirements are knowledge of oil furnaces and some experience in hydraulic forge work. Salary approximately $150 a month.

175 Draftsman for Connecticut concern of manufacturing chemists. Salary $20 to $30.

178 Chief Draftsman on oil well machinery; good opportunity for right man; would eventually require residence in Texas.

179 Draftsman experienced in elevating and conveying machinery and light structural work; preference given to man who would develop into salesman. Salary $1500 to $1700. Apply by letter with object of personal interview. Location New York State.

MEN AVAILABLE

The published notices of "men available" are made up only from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

D-118 Student Member, one year's experience, record good, reference upon application. Graduate in mechanical engineering course in June, desires opportunity for advancement with manufacturing concern.

D-119 Member; age 31. M.I.T. Has had diversified engineering training, also five years selling experience. Experienced in the design and application of mechanical conveyors for industrial plants. Wants position preferably with automobile manufacturer. Salary $2500. Answer through the Society.

D-120 Assistant to Executive Officer, large manufacturing corporation to promote unity of organization, economy and efficiency. Object, establishment of a permanent connection leading to greater responsibility and remuneration through years of service. Technical graduate, 31, experience in economy and efficiency work as member of staff of noted efficiency engineer, as assistant to comptroller, as manager of manufacturing plant, and as investigator of costs and statistics for one of largest industrial corporations in this country.

D-121 Efficiency or Factory Manager, technical graduate, M.E., age 30, ten years experience in costs, statistics, production work, office and factory management, references to several successful concerns for ability and results obtained as an organizer.

D-122 District Office Manager or Assistant to general sales manager, or manufacturer's representative handling several non-conflicting lines; would consider partnership in established selling or equipment company. Experience in selling and engineering work in eastern territory, graduate mechanical engineer, age 35, married, experience covering a wide range of industries; highest references as to character and ability.

D-123 Publicity and Sales Engineer, 20 years experience, bookkeeper, accountant, salesman, department manager, assistant factory manager, advertising manager, assistant sales manager, knowledge of the country from Maine to Cuba and from Atlantic to the western coast. Accustomed to large production and sales problems.

D-124 Chief Draftsman or Assistant Mechanical Engineer, college graduate, experienced designer, machinery, structural iron and small automatic machines.

D-125 Power Plant Engineer, experienced in design, heating and ventilating, industrial plants; selling experience; wishes responsible position. Has had charge of men and shown executive ability.

D-126 Superintendent and Mechanical Engineer, ten years experience on construction work, in charge of design, erection and operation of equipment, buildings and power plants for firm of consulting engineers. Twelve years previous experience in machine shops and in charge of steam plants; desires position with construction or manufacturing firm.

D-127 Mechanical or Chief Engineer, age 31, four years experience as superintendent of erection and chief operating engineer of large power and industrial plants; four years in charge of design and detailing of power plants; good executive ability, capable of assuming any responsibility in power plant lines and getting results from factory organization. Location preferred in U. S. A. Salary $2500.

D-128 Superintendent or Master Mechanic, American, age 33, practical tool-maker and machinist, at present employed as master mechanic in factory employing about 600 hands, experienced in sheet metal stamping and automatic machinery on interchangeable manufacturing, estimating, design of machinery and tools, an all-around production man of experience who can effect results. Answers to this notice treated confidentially.

D-129 Steel Engineer, member, technical graduate, age 30, ten years experience in treating, testing and micro-structure of steel; practical knowledge of the treatment of steels to obtain best physical and machining properties; capable of eliminating all troubles in the working of steel and manufacture of steel products.

D-130 Electrical and Mechanical Engineer, Cornell graduate with extensive experience designing, constructing, operating, maintaining, purchasing, managing and office engineering, desires position where such experience would be required. Now chief electrical and mechanical engineer, constructing and operating an explosive plant. Engineering work of operation of minor importance reason for change.

D-131 Manager, Mechanical and Marine Engineer, designer; associate member, college graduate, age 36, married, American citizen, speaks English, French, Italian, Spanish, some knowledge of German. Three years practical experience as a marine engineer. Six years a district manager of an electric illuminating and manufacturing company. Six years experience in mechanical design of electrical machines with two leading American manufacturing concerns; expert calculating engineer. At present employed; four years in present position; open for engagement in U. S. or abroad. New York City preferred.

D-132 Superintendent of Power desires change. Chief engineer of power two years in large mining and smelting works in South America. Worked as erector in smelters of Arizona installing engines and blowers. Superintendent of electric light and water for municipality. Consulting engineer own office in Texas two years; engineering construction in Mexico at time of Madero's overthrow; past two years and at present doing engineering sales work power plant and pumping machinery. Member A.M.S.E. and Louisiana Engineering Society.

D-133 Plant Engineer or Master Mechanic, age 36, complete mechanical, electrical, buildings equipment; land or water front properties; maintenance and extensions; extensive practical and office experience. Desires change; connection with industrial or engineering concern.

D-134 Chief, Mechanical or Consulting Engineer. Associate; technical education; fourteen years experience, familiar with designing industrial plants, mill buildings, ore roasting furnaces, coal washing, screening, elevating and conveying machinery, having held positions as chief draftsman, engineer or construction and chief engineer for large concerns.

D-135 Chief Draftsman or Assistant Chief Engineer, Cornell graduate, 15 years varied experience with engineers and contractors and industrial concerns doing their own plant engineering and with manufacturing concerns. Experience principally in drafting room and engineering office.

D-136 Mechanical and Electrical Engineer, Cornell gradute, age 31, with nine years experience in the design, construction, operation and testing of steam and electric power and pumping stations, also sewage disposal works, desires position with consulting engineer, manufacturer of power plant apparatus, construction, or operating company.

D-137 Safety Engineer or Inspector. Junior member, age 26, single; 2½ years experience in safety work, 1 year as assistant safety engineer in a large metallurgical plant employing over 5000 men. Experience in first-aid instruction and organization of safety committees. Over 4 years experience in general drafting. Location immaterial. At present employed, but available on short notice.

D-138 Instructor in Mechanical Engineering. Junior member, technical graduate, age twenty-six, married; experience as assistant superintendent of manufacturing, with illuminating gas company in charge of labor and mechanical equipment; six months in a drafting room; two years successful teaching experience; employed until July first; desires position with a college or university beginning in September, 1916.

D-139 Student member of University of Kentucky; mechanical and electrical engineering department; would like opportunity to go to South or Central America on graduation in June. References.

D-140 Manager or Superintendent. Mechanical engineer, technical graduate, ten years experience, design and construction centrifugal pumps and pumping engines. Employed but available on short notice.

D-141 Tool or Special Machine Designer; associate member, graduate in machine design, age 32, married; 5 years experience as chief draftsman, desires opportunity at tool design or special machinery design; immediately available. Location New York.

D-142 Chief Engineer or Superintendent of power plant, with 12 years experience in present power plant practice, refrigeration, steam heating and gas, desires position with large corporation or power company with an opportunity to show results. Salary to start $2400. At present employed.

D-143 Assistant to Consulting or Mechanical Engineer. Graduate M.E., age 26, experience in responsible charge of installation, and plans for factory machinery layouts, power transmission systems, foundations and piping layouts for power plant equipment and accessories, mechanical equipment of buildings. Location in central states preferred. At present employed.

D-144 Executive wishes to make permanent connection with manufacturer of electrical machinery. Practical experience of sixteen years includes drafting, testing, designing and manufacturing, also sales and general management; responsible charge of entire business for considerable time. Would take charge of branch office, but preference given to factory position.

D-145 Instructor or Assistant Professor; young engineer, at present in charge of the courses in engineering laboratory in prominent eastern university, seven years widely varying experience teaching nearly all branches of mechanical engineering, and about four years practical experience in drafting room and shop, desires position in a college receiving state support, east or middle west preferred. Will furnish best of references and adequate reasons for desiring change.

D-146 Wood-Working. Junior member wishes a position in a wood-working shop.

D-147 Production Engineer. Associate member, 32, specialist in interchangeable manufacturing. Broad experience in

machine shop, foundry, stamping, shaping, plating and finishing. Record for stability and successful manufacturing. Past four years works manager. Vicinity New York. Salary $3800. Highest credentials.

D-148 Designer, Test Engineer or Assistant to Consulting Engineer in industrial or power plant work. Mechanical engineer, age 27, three years machine shop experience, two years power plant design, two years power plant testing.

D-149 Estimator desires executive position, several years varied experience, can present best testimonials; 30 years old, speaks foreign languages.

D-150 Superintendent and Mechanical Engineer, technical graduate, fifteen years experience as executive in charge of building and power plant construction, including layouts, purchase, installation and operation of complete mechanical equipments. At present employed by large corporation as engineer in charge, desires similar position.

D-151 Manufacturing Executive. Associate member, technical graduate, six years manufacturing and designing experience.

D-152 Student member, age 23, desires employment at a moderate salary, where advancement is possible. Will graduate from university in June.

D-153 Sales Engineer, Chief Engineer, Manager, Superintendent: Cornell graduate in mechanical engineering, age 36. Broad experience in general engineering both from a technical and practical standpoint. Particularly familiar with the design, manufacture, erection, operation and development of hoisting, conveying and handling machinery and plants. Experienced in structural design. Employed for the past ten years by a leading concern but seeks opening for advancement.

D-154 Mechanical and Combustion Engineer, Junior member, age 25, married, technical graduate, four years power plant experience, including design, tests, and operation, specializing on fuel and power plant economies. At present employed, desires position along above lines offering attractive opportunity for the future.

D-155 Manager of Sales, 42, aggressive and efficient; desires to make connection with concern wishing to develop its business along broad lines; now vice-president and general manager of an engineering concern; desires change for reasons satisfactorily explained; technical and practical training, with broad experience in selling in the field. Successful record with ability to produce results. Valuable acquaintance with consulting and operating engineers and industrial concerns.

D-156 Hydraulic and Mechanical Engineer; technical graduate, speaks and corresponds fluently in three languages. Fifteen years experience in designing, manufacturing and operating hydraulic turbines, centrifugal pumps, hydro-electric power plants; also mechanical equipments for mines. Well acquainted with leading business institutions and consulting engineers in Canada, United States and Mexico also first class foreign relations in Britain and European Continent. At present employed in executive capacity but desires change. Can furnish high class references.

D-157 Teacher, technical graduate with ten years experience, including practical work and teaching, desires a position in the mechanical engineering department of a university or technical school.

D-158 Chief Engineer, Superintendent or Equipment Engineer of manufacturing methods, exceptionally well educated, trained and experienced, technical graduate 1904; varied experience as machinist, tool and die maker, tool department sub-foreman, foreman, tool and machine designer and inspector, acting equipment engineer, production superintendent. Acquired skill and the reputation of an expert, speaks several languages, thoroughly able to handle and teach men. Excellent references.

D-159 Engineer, with private firm or consulting engineer, technical graduate, age 34, twelve years experience in design, testing, supervision and reports on light, heat and power plants; specialized in economical power production.

D-160 Engineer Assistant to Executive. Member, technical graduate, wide experience in management, sales, operating and executive work; at present engaged; desires position capable of being developed to broad future.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Society of Swedish Engineers. Bulletin vols. 8 and 9. *Brooklyn, 1914-15.* Gift of Society.

Association of Railway Electrical Engineers. Proceedings vol. 6, 1913. *Chicago, 1913.* Gift of Association.

Building Construction as Affecting Fire Risks, C. F. Wieland. *San Francisco, 1915.* Gift of author.

Carnegie Institution of Washington. Annual Report of the Director of the Department of Terrestrial Magnetism. Extract from Yearbook no. 14, 1915. Gift of Institution.

Coxe, Arthur Cleveland, Memorial. Class of 1897. Hobart College. Gift of Hobart College.

Detroit Board of Water Commissioners. 63rd. Annual Report. *Detroit, 1916.* Gift of Detroit Water Department.

Insuring the Coal Supply, Henry J. Edsall. Reprint Coal Age, Nov. 6, 1915. Gift of Link Belt Company, Chicago, Ill.

New York City Board of Water Supply. Information for bidders, for furnishing and delivering bronze gate valves for the City Tunnel of the Catskill Aqueduct. 1916. Contract 172.

——— Information for bidders for lining with brick masonry a portion of the Eastview Tunnel of the Catskill Aqueduct. 1916. Contract 169. Gift of Board of Water Supply, New York City.

New York State Engineer and Surveyor. Annual Report. Supplement. Vol. II, 1914. *Albany, 1915.* Gift of State Engineer and Surveyor.

North Dakota Society of Engineers. Proceedings vol. 2. 1915. *1915.* Gift of Society.

Russian Department of Agriculture. Bulletin of the Bureau of Farm Mechanics. Vol. VII, part IV. *1915.* Gift of Russian Department of Agriculture.

The Settlement of the Most Important Question of the Age: Is the Efficiency of a Thermodynamic Reversible Cycle Independent of the Working Medium? By Jacob T. Wainwright. *Chicago, 1915.* Gift of author.

Society for the Promotion of Engineering Education. Proceedings vol. XXII. *Pittsburg, 1915.* Gift of Society.

New Bedford. Water Board. Report, 1915. *New Bedford, 1916.* Gift of Water Board of New Bedford.

Society of Constructors of Federal Buildings. List of Members. *February, 1916.* Gift of Society.

Worcester, City of Prosperity. 16th Annual Convention National Metal Trades Association. April, 20-22, 1914, by Donald Tulloch. *Worcester, 1914.* Gift of P. E. Barbour.

GIFT OF HOWARD E. CORNELL

Letters Patent issued in 1841 to Ebenezer Beard, signed by Daniel Webster, "On Screw Propellers." Issued in 1853 to Ebenezer Beard, covering "Improvement in Propellers" and assignment of same to Messrs. Reaney, Neafie & Co.

TRADE CATALOGUES

Brown Hoisting Machinery Co. *Cleveland, O.* Catalogue D. Brownhoist Tramrail Systems Trolleys, Electric Hoists. *1915.*

Stephens-Adamson Mfg. Co. *Aurora, Ill.* Labor Saver. *Feb. 1916.*

Texas Company. *New York, N. Y.* Lubrication. *Feb. 1916.*

Valley Iron Works Co. *Appleton, Wis.* The Beater. *Jan.-Feb. 1916.*

Walworth Manufacturing Co. *Boston, Mass.* Catalogue No. 71. 486 pp. Walworth Log. *Feb. 1916.*

Wiedeke, Gustav & Co. *Dayton, Ohio.* Ideal Catalogue No. 48. Ideal Tube Expander and Cutter.

Warner Elevator Manufacturing Co. *Cincinnati, Ohio.* Bulletin 2701. "Type N" Freight Cars, Jan. 1916. Bulletin 2702, "Type M" Steel Freight Cars. Jan. 1916. Bulletin 2802, No. 11 Electric Elevator, Jan. 1916. How to Obtain the Best Service at the Least Cost.

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

Aeronautische Meteorologie, Franz Linke, part 1-2. Luftfahrzeugbau und Führung, Neumann, Band I, II. *Frankfort, 1911.*

Aëroplanes and Dirigibles of War, F. A. Talbot. *Philadelphia, 1915.*

American Army, W. H. Carter. *Indianapolis, 1915.*

Annals of a Fortress, E. Viollet-le Duc. Translated by Benjamin Bucknall. *London, 1875.*

Applied Thermodynamics for Engineers, W. D. Ennis. Ed. 4. *New York, 1915.*

Architects' and Builders' Pocket Book, by the late F. E. Kidder. ed. 16. *New York, J. Wiley & Sons, 1916.* Gift of Publisher. Price $5.00 net.

The book has been entirely revised, and is in many respects a new work, being entirely reset, in a smaller but clearer type. Much new matter has been added. The amount of information condensed into the 1800 pages is very great. W. P. C.

Armor and Ships, J. W. Gulick. *Fort Monroe, 1910.*

Attack of Fortified Places, Including Siege Works, Mining and Demolitions, James Mercur. *New York, 1914.*

Die Automobil-Betriebsstoffe, Ernst Jaenichen. *Berlin, 1915.*

Beihefte Zum Gesundheits Ingenieur, K. Brabee. Beiheft 8. *Munchen, 1915.*

Wie berechnet, konstruiert und baut man ein Flugzeug, O. L. Skopik. ed. 2. *Berlin, 1915.*

British Columbia Bureau of Mines. Preliminary review and estimate of Mineral Production, 1915. Bulletin No. 1, 1915. *Victoria, 1916.*

Building Estimator's Reference Book, F. R. Walker. *Chicago, 1915.*

Canada Department of Mines. Summary Report of the Mines Branch, 1914. *Ottawa, 1915.*

——— Production of Cement, Lime, Clay products, stone and other structural materials in Canada, 1914. *Ottawa, 1915.*

Canons of Classification, W. C. B. Sayers. *London, 1915-16. White Plains, N. Y.*

Carnegie Library of Pittsburgh. Road Dust Preventives, references to books and magazine articles. *Pittsburgh, 1916.*

Cold Storage and Ice Association. Proceedings vol. XII, 1915. *London, 1915.*

Colorado Industrial Plan, John D. Rockefeller, Jr. Including a copy of the plan of representation and agreement adopted at the coal and iron mines of the Colorado Fuel and Iron Co. *1916.* Gift of John D. Rockefeller, Jr.

Contributions to the Pre-Cambrian Geology of Northern Michigan and Wisconsin. Michigan Geological & Biological Survey. Publication 18. *Lansing, 1915.*

Cornell University. Librarian's Report, 1914-15. *Ithaca, 1915.*

Description of the Laboratories of the Mines Branch of the Department of Mines. Canada Mines Branch, Bulletin no. 13. *Ottawa, 1916.*

Designing, Heating and Ventilating Systems, Chas. A. Fuller. *New York, 1914.*

Digest of Workmen's Compensation Laws, 1913. *New York, 1913.* Gift of National Association of Manufacturers.

The Einasleigh Freehold Copper Mine, N. Q. Publication no. 246, Queensland Geological Survey. *Brisbane, 1914.*

Elementary Naval Tactics, Wm. Bainbridge-Hoff. *New York, 1907.*

Employers' Liability, Workmen's Compensation and Prevention of Work Accidents, F. C. Scherdtman. *1912.* Gift of National Association of Manufacturers.

Enzyklopadie der technischen Chemie, Fritz Ullmann. Band 3. *Berlin, 1916.*

Erlaeterungen zu Normalien fua isolierte Leitungen in Starkstromanlagen, den Normalien fur isolierte Leitungen in Fernmeldeanlagen sowie den Kupfernormalien, Richard Apt. *Berlin, 1915.*

Esplodenti e Modo di Fabbricarli, R. Molina. *Milano, 1916.*

Geology and Mineral Resources of the Stanthorpe, Ballandean and Wallangarra Districts, Southern Queensland, 1913. Publication no. 243, Queensland Geological Survey. *Brisbane, 1914.*

Graphics and Structural Design, H. D. Hess. ed. 2. *New York, J. Wiley & Sons, 1915.* Gift of publisher.

A number of changes have been made, including a more extended treatment of steel mill buildings and of reinforced concrete, modifications and explanations of the specifications, and other changes due to advances made in the subject. W. P. C.

Handbook for Light Artillery, A. B. Dyer. *New York, 1908.*

Handbook of Natural Gas, H. P. Westcott. ed. 2. *Erie, Pa., 1915.*

Handbook of Problems in Direct Flae, Jas. M. Ingalls. *New York, 1903.*

Handbuch der Eisen und Stahlgiesserei, C. Geiger. Band II. *Berlin, 1916.*

Handbuch der Mineralchemie, C. Doelter. Band II, pt. 9. *Dresden, 1915.*

Handbuch fur den Deutschen Braunkohlenbergbau, G. Klein. ed. 2. Textband and Tafelband. *Halle, 1915.*

Die Hebezeuge, Hugo Bethmann. ed. 3. *Braunschweig, 1915.*

Hydraulic Motor, I. P. Church. *New York, 1914.*

Industrial Betterment Activities. Gift of National Association of Manufacturers.

Institute of Radio Engineers. Year Book, 1916. *New York, 1916.*

International Engineering Congress, 1915. Transactions. vol. VI-Mechanical Engineering. *San Francisco, 1915.*

Inventions and Patents, P. E. Edelman. *New York, 1915.*

Investigation of a Reported Discovery of Phosphate in Alberta, Canada. Mines Dept. Bulletin no. 12. *Ottawa, 1916.*

Konstauktionsberechnungen von Kraftfahrzeugen und die Organisation des Konstruktionsburos, A. G. von Loewe. *Berlin, 1915.*

Lehrbuch der Elektrochemie von Svante Arrhenius. *Leipzig, 1915.*

Leitfaden der drahtlosen Telegraphie fur die Luftfahrt, Max Dieckmann. *München, 1913.*

Machinists and Founders Supplement to Thomas' Register of American Manufacturers and First Hands. *New York, 1915.* Gift of Thomas Publishing Co.

Market System for New York City and Open Markets Established in Manhattan, Marcus M. Marks. *1915.* Gift of Author.

McGraw Electrical Directoay. Railway Edition, February 1916. *New York, 1916.*

Metal Statistics, 1916. Ninth Annual Edition. *New York, American Metal Market Co., 1916.* Gift of publisher.

Mineral Resources of Michigan with statistical tables of production and value of mineral products for 1914 and prior years. Michigan Geological & Biological Survey. Publication 19. *Lansing, 1915.*

Moderne Seifenfabrikation, A. Ganswindt. *Leipzig, 1915.*

Motor and Carriage Painting, A. Bates. *London, 1915.*

New York Times Index, vol. IV, 1915. *New York, 1915.*

Die Nutzbaren Mineralien mit Ausnahme der Erze, Kalisalze, Kohlen und des Petroleums, Bruno Dammer und Oskar Tietze. Band II. *Stuttgart, 1914.*

Papierprufung, Wilhelm Herzberg. ed. 4. *Berlin, 1915.*

Pennsylvania. Mines Departmeut. Report, 1914. Part I—Anthracite. *Harrisburg, 1915.*

Pennsylvania Workmen's Compensation Board. Rules and Rulings. *Harrisburg, 1916.*

Power for Profit, R. P. Bolton. *New York, 1915.*

300 Practical Shop Kinks. Gift of American Machinist.

Preliminary Report on the Mineral Production of Canada, 1915. *Ottawa, 1916.*

Preliminary Statement on the Mineral Production in the Province of Quebec, 1915. *Quebec, 1916.*

Quarry Materials of New York—Granite, Gneiss, trap and marble. N. Y. State Museum. Bulletin no. 181. *Albany, 1916.*

Railway Maintenance Engineering, with notes on Construction, W. H. Sellew. *New York, 1915.*

Raw Materials for the Enamel Industry and their chemical technology, Julius Grünwald, translated by Herbert H. Hodgson. *London, 1914.*

Scherzer Rolling Lift Bridges, their inception, development and Use. *New York-Chicago.* Gift of Scherzer Rolling Lift Bridge Co.

Seile und Ketten, F. Peter. Die Maschineu der Berg und Hüttenwerke, pt. 2. *Halle, 1914.*

Shafting, Pulleys, Belting, and Rope Transmission. Compiled by H. E. Collins. *New York, 1908.*

Smokeless powder, nitro-cellulose and theory of the cellulose molecule, J. B. Bernadou. *New York, 1908.*

Societe Technique de L'Industrie du Gaz en France. Compte Rendu 41me Congrès. *Paris, 1914.* Gift of Geo. G. Ramsdell.

Special Libraries. Cumulative Index, vol. 1-6, 1910-15. *Reading, Mass.*

Statistics of the Mineral Production of Alabama for 1914. Bulletin no. 16, Geological Survey of Alabama. *University, 1915.*

Surveyors Institution. Professional notes from their commencement in 1886-1913 (vols. 1-19), with General Index to vols. 1-17, 1886-1911. *London, 1886-1913.*

——— Transactions, 1868-1914 (vols. 1-46), with general index to vols. 1-42. *London, 1868-1914.*

Text Book on Field Fortification, G. J. Fieberger. ed. 3. *New York, 1913.*

Toy Making. A practical guide to the making of a number of popular toys. *London-New York, 1915.*

U. S. National Museum. Report, 1915. *Washington, 1916.*

University of California. Annual Report of the President 1914-15. *Berkeley, 1915.*

Die Verwendung von Pressluft im Bergbaubetriebe, A. E. Liwehr. *Weimar, 1915.*
West Virginia Geological Survey. Reports of Lewis and Gilmer Counties with Maps. *Wheeling, 1916.*
World Almanac and Encyclopedia, 1916. *New York, 1916.*

GIFT OF AERONAUTICAL SOCIETY

Aeronautical Classics, edited for the council of the Aëronautical Society of Great Britain by J. O. B. Hubbard and J. H. Ledeboer. *London, 1910-11.*
Ashton, W. G. Model Flying Machines, their design and construction. *London.*
Brockett, Paul. Bibliography of Aeronautics. *Washington, 1910.*
Collins, F. A. Second Boy's Book of Model Aeroplanes. *New York, 1911.*
Davis, C. H. National Old Trails road, ocean to ocean highway. *Washington, 1914.*
Flying, the why and wherefore by Aero Amateur. *London.*
Hering, D. W. Essentials of Physics for college students. *New York, 1912.*
L'Institut Aerodynamique de Koutchino. Bulletin Fascicule I. ed. 2. *Moscow, 1912.*
Langley, S. P. Experiments in Aerodynamics. ed. 2. *Washington, 1902.*
Maxim, Hudson. Defenseless America. *New York, 1915.*
Müller, Bruno. Air sacs of the pigeon. *Washington, 1908.*
Peary, R. E. Northward over the "Great Ice." 2 vols. *New York, 1898.*
Petit, Robert. How to build an Aeroplane. *London, 1910.*
Richardson, H. C. Hydromechanic experiments with flying boat hulls. *Washington, 1914.*
Ritter, Wolfgang. Flying Apparatus of the Blow-fly. *Washington, 1911.*
Rotch, A. L. Charts of the atmosphere for aeronauts and aviators. *New York, 1911.*
——— Conquest of the air or the advent of aërial navigation. *New York, 1909.*
Royal Aero Club of the United Kingdom. Yearbook 1912. *London.*
Santos-Dumont, A. My air ships. *New York, 1904.*
U. S. Patent Office. Specifications of patents in Aëronautics. 5 vols. *Washington.*
Verrill, A. H. Gasoline engines, their operation, use and care. *New York, 1912.*
——— Harper's air craft book. *New York, 1913.*

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Aerial Age. vol. 1, nos. 1, 4, 6, 7, 9, 11, 12; vol. 2, nos. 1, 2.
Aero. vol. 2, nos. 6, 20, 22; vol. 3, nos. 1-7, 9-13, 17, 20, 24, 26; vol. 4, nos. 1-2, 5, 7, 10-13.
Aero (London). vol. 5, nos. 104, 105; vol. 6, nos. 106-108.
Aero and Hydro. vol. 4, nos. 14, 15, 17, 20; vol. 5, nos. 13, 22, 24, 26; vol. 6, nos. 1, 4, 6, 8-16, 18-23, 25-26; vol. 7, nos. 1-26; vol. 8, nos. 1-5, 7-17.
Aero Club of America. Bulletin vol. 1, no. 4.
Aeronautical Journal. vol. 12, no. 47.
Aëronautical Society of Great Britain. Report 1st.
Aeronautics. vol. 1, no. 5; vol. 13, complete.
Aeronautics (London). vol. 5, nos. 47, 49; vol. 9, nos. 114, 115.
Air Scout. vol. 1, nos. 1-5.
Aircraft. vol. 1, nos. 3, 6-12; vol. 2, nos. 1, 3-12; vol. 3, nos. 2-4; vol. 4, nos. 7, 10-11; vol. 5, nos. 7-12; vol. 6, nos. 1-7.
American Aeronaut. Jan.-June 1908; vol. 1, nos. 1, 3.
American Mathematical Society. List of officers and members 1915.
American Magazine of Aeronautics. vol. 1, no. 1.
L'Association Général Automobile Revue. vol. 8, no. 2, 1909.
Automobilia. vol. 5, no. 40.
Flight. vol. 3, nos. 45, 49; vol. 4, no. 27.
Fly. vol. 3, no. 12; vol. 4, nos. 1-3.
Mobile Era. vol. 2, no. 5, 1912.
Revue générale de L'aéronautique. October 1911.
Svensk Motortidning. nos. 20-22.
La Technique Aéronautique. nos. 44-45, 49.

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American Rolling Mill Company. Story of Armco iron defeating rust. *Middletown, Ohio.*
Asbestos Protected Metal Company. For roofing and siding. Bulletin 55. *Pittsburgh.*
Bower Roller Bearing Company. Roller bearings. *Detroit, Mich.*
Burgess Company and Curtis. Burgess hydro-aeroplane and school of aviation. *Marblehead, Mass.*
——— Burgess-Wright aeroplane. *Marblehead, Mass.*
Curtis Aeroplane Co. Curtis Aeroplanes. *Hammondsport, N. Y.*
Hess-Bright Manufacturing Company. Ball bearings in flour and feed milling machinery. *Philadelphia.*
——— Hess-Bright. *Philadelphia.*
National Corrugated Culvert Mfg. Co. Making of Armco iron.
New Departure Manufacturing Co. Bearing friction and its elimination. *Bristol, Conn.*
Roberts Motor Company. Roberts aviation motors. *Sandusky, O.*
Standard Co. Eagle Marine engines. *Torrington, Conn.*

GIFT OF CARL HERING

American Institute of Electrical Engineers. Report of the Standard Wiring Table Committee. Matthiessen's Standard of Resistance of Copper.
Ayrton, W. E. and Cooper, W. R. Variations in the Electromotive force of Clark Cells with temperature. From Royal Society Proceedings, vol. 59.
——— and Hayecraft, H. C. Students' Simple Apparatus for Determining the Mechanical Equivalent of Heat. From *Philosophical Magazine, Feb. 1895.*
——— and Mather, T. The Construction of Non-Inductive Resistances. From *Philosophical Magazine, Feb. 1892.*
——— Galvanometers. From *Philosophical Magazine, Nov. 1896.*
——— Electrostatic Reflecting Voltmeter.
——— and Sumpner, W. E. Galvanometers. From *Philosophical Magazine, July 1890.*
——— Alternate Current and Potential Difference. Analogies in the methods of measuring power. From *Philosophical Magazine, Aug. 1891.*
——— Measurement of the Power given by any electric current to any circuit. From Proceedings of the Royal Society, vol. 49.
——— J. Perry and W. E. Sumpner. Quadrant Electrometers. From Proceedings of the Royal Society, vol. 50.
——— and Perry, John. Laboratory Notes on Alternate Current Circuits. From Proceedings, Institute of Electrical Engineers, vol. xviii.
——— and Taylor, J. F. Proof of the generality of certain formulae published for a Special Case by Mr. Blakesley. From *Philosophical Magazine, April 1891.*
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——— L'Eclairage Public par les Lampes à arc. *Paris, 1895.*
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——— Kraftübertragung mittels Wechselströmen von verschiedener Phase Drehstrom. From *Electrotechniker, 1891*
Forbes, Geo. On the relation which ought to subsist between the strength of an electric current and the diameter of conductors, to prevent overheating. *1884.*
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Hopkinson, J. and Wilson, E. Propagation of magnetization of iron as affected by the electric currents in the iron. *London, 1895.*
Kallir, Ludwig. Ueber das Verhalten des Wehneltschen Unterbrechers im Wechselstromkreise. From *Zeitschrift für Elektrotechnik, 1899.*
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Notice sur l'inductomètre Miot.
Perry, J. and Sumpner, W. E. Quadrant electrometers. From *Philosophical Transactions of Royal Society of London,* vol. 182, A.
Puluj, J. Strahlende elektroden materie und der sogenannte vierte Aggregatzustand. *Wien, 1883.*
Reeves, J. H. Addition to the Wheatstone Bridge for the determination of low resistances. From Philosophical Magazine, *May 1896.*
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GIFT OF CARY T. HUTCHINSON

Science Abstracts. vol. 1-10 (Sect. A-B); vols. 11-13 (Sect. B); vols. 14-18 (Sect. A-B). *London, 1898-1915.*
U. S. Geological Survey. Water Supply papers nos. 1-288. *Washington, 1896-1912.*

GIFT OF BUREAU OF RAILWAY ECONOMICS

The Bureau of Railway Economics have donated various publications during the month to the library.

GIFT OF CARNEGIE STEEL COMPANY

The Company very kindly presented the Library with a complete set of their pamphlets and trade catalogues.

GIFT OF NATIONAL BOARD OF UNDERWRITERS

The Board of Fire Underwriters presented us with a good collection of their publications issued to date.

GIFT OF WESTINGHOUSE, CHURCH, KERR AND COMPANY

A good collection of text books were presented by this company, and are now in the Library.

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Supplee-Biddle Hardware Co. *Philadelphia, Pa.* Monel Metal. *January, February 1916.*
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——— 157. No. 0 Stationary Feed Grinder Cut no. 755.
——— 161. Air Separation.
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——— no. 13. Pony crushers and other miscellaneous roll crushers, not including the hinged hammer crushers and pulverizers.
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Clay Catalogue.
Coal Catalog.
Conglomerate Ore Bulletin no. 112.
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General Descriptive Catalogue. *1909.*
Improved High Grade Oil Mill Machinery. Price List.
Oil Cake Catalogue
Shredder Catalogue.
Stock Food Edition.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the February 1916 issue of The Journal.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

Arranged in the Order of their Appearance in the Survey.

Aerodynamics, Present State
Dry Blast
Correlation
Cast Iron, Tensile and Bending Strength
Metals, Behavior Under Alternating Stresses
Law of Fatigue
Copper Steel, Corrosion Resistance
Mortars, Waterproofing
Semi-steel
Pulverized Fuels for Locomotives
Fuel Economy
Furnace with Adjustable Grate Area
Charging Cars for Coke-ovens
Hydraulic Control Valve, Automatic
MaB Racing Engine
Rotary Conical Valves
Boiler Plates, Autogenous Welding
High Pressure Mains, Welding
Woodruff Keys and Keyways
Gas Cutting, Costs
Leather Belting, Transmitting Power
Concrete Beam Reinforcement
Moment Diagram and Concrete Beam Reinforcement
Boiler Explosions
Porat System of Firing
Peat Firing for Locomotives
Turbo-blowers and Compressors
Two-stage Air Refrigeration

THIS MONTH'S ARTICLES

Prof. L. Marchis's discussion of various methods for measuring air resistance is abstracted.

In the section on engineering materials are covered the matters of correlation between tensile and bending tests of cast iron, giving among other things an expression for the coefficient of correlation. In the same section is discussed in detail the behavior of metals under alternating stresses.

The corrosion resistance of copper steel forms the subject of an investigation by D. M. Buck and J. O. Handy who found that copper does increase the resistance of steel and iron to atmospheric corrosion.

Data obtained in a French government laboratory show that small amounts (about 3 per cent) of anthracene oil increase the water-proofness of mortars which the author, however, ascribes mainly to the lubricating action of the oil because of which the mortar compresses better under the trowel.

Two papers on semi-steel are reported, in one of which the author shows how to make good semi-steel and in the other the writer denies that there is such a thing as semi-steel.

A paper on pulverized fuel for locomotives is reported and illustrated by a figure showing various parts of a typical pulverized fuel locomotive equipment.

Electrically driven charging cars for coke ovens are described in an abstract taken from a German periodical. In the section hydraulics is given an article describing an automatic hydraulic control valve. The valve gear of the MaB engine with rotary conical valves is shown in detail.

Two articles are given on autogenous welding, one of boiler plates, and the other of high pressure mains. In the same section is given an article on the cost of gas cutting.

The transmitting power of leather belting forms the subject of an article by R. T. Kent, abstracted from the Iron Age. Boiler and steam vessel explosion in Switzerland, the new Wisconsin Boiler Code and flow of steam in pipes are some of the other subjects discussed in reports from various American and foreign periodicals.

Two stage air refrigeration for dry blast, standard numerals for the scale of measuring instruments, etc., are included under Varia.

Aeronautics

The Present State of Aerodynamics, Professor L. Marchis

Beginning of a series of articles on the present state of aerodynamics. The author is Professor of Aeronautics in the Faculty of Sciences of the University of Paris.

In the present article are discussed various methods for measuring the resistance of the air such as the method of free fall used in the Eiffel experiments and the various so-called "car" methods of which there are several modifications. The author in particular describes the car method used at the Aerodynamic Institute of the Saint-Cyr Military School where different cars are used for the study of planes and of propellers.

The car for the study of planes and complete aeroplanes has an electric traction, runs on standard gage rails, and weighs without equipment 5 tons. It can develop a maximum speed of 20 m (65.6 ft.) per second, and has special appliances which permit of registering the vertical component of resistance of the air, the horizontal component and the couple of rotation from which can be determined the direction of the resistance of the air. In order to make a correction for the wind, its strength and direction are registered at a certain fixed point along the line where the tests are made. A similar but more powerful car is used for the study of complete aeroplanes and another special car is used for the study of propellers. The power absorbed by the propeller is measured in two different manners, first by means of a wattmeter registering the electric power consumed by the motor and second by a transmission dynamometer registering the couple transmitted to the propeller.

At the aeronautical laboratory of Chalais-Meudon is used an open truck car running on a narrow gage railway. The power absorbed by the propeller is measured by a registering ammeter and voltmeter.

In the laboratory of the Duc de Guiche an automobile is used for carrying the apparatus under test through the air. In this laboratory great care is taken to establish that the automobile itself produces no influence which might cause errors in observation. Great care has been also taken to select the place for the experimentation in such a manner that the results should not be affected by local conditions.

An entirely different method is used at the laboratory for military aviation at Vincennes. There the principle of the method of measurement is as follows: Assume that a body is rigidly suspended on a wheel rolling down an inclined rectilinear cable. Assume further that the body possesses a plane of symmetry and that the cable is located in that plane. This body will then go down along a cable in such a manner that its plane of symmetry will move parallel to itself and the body will be subject at each instant: (1) to the action of gravity applied to its center of gravity, (2) to the resistance of the air and (3) to the force of inertia applied likewise to its center of gravity. These forces can be decomposed into forces parallel to the cable and perpendicular to it. The force of gravity is opposed to that of the resistance of the air and the force of inertia is parallel to it.

The magnitudes of the components parallel to the cable and perpendicular to it can be registered graphically. When the system is at rest the weight is acting alone, hence the method of registration permits of separating the effects of weight. Then the body is allowed to slide down the cable with the wheel forming a rigid part of the system. At a given moment the acceleration of the system is measured and the components of resistance of the air and force of inertia recorded. The article describes fully how this is carried out in practice, with the cable 155 m (508 ft.) long. (*L'État Actuel de L'Aerodynamique,* L. Marchis, *L'Aérophile,* vol. 24, no. 1-2, January 1-15, 1916, beginning of a series of articles.)

Engineering Materials

CORRELATION BETWEEN TENSILE AND BENDING TESTS OF CAST IRON, Winslow H. Herschel

The article discusses first the subject of correlation generally and then that of correlation between tensile and bending strength of cast iron.

As a basis of his investigation, the author uses the formula for the coefficient of correlation (that is, the degree to which variations in one variable depend on variations in another variable) given by W. I. King which is

$$Y = \frac{\Sigma d_x d_y}{N \sigma_x \sigma_y} = \frac{p}{\sigma_x \sigma_y}$$

where N is the number of pairs of related values of the variables X and Y. d_x and d_y are deviations from the mean while σ with suitable subscript is known as the "standard deviation" and should not be confused with the "mean deviation" which is the arithmetical mean of the deviations from the average taken without regard to either sign. In the case of the standard deviation the + and — signs are eliminated by squaring.

The author derives the average strength and average load from 13 tests of cupola iron and from these data derives first an expression for the standard deviation of tensile strength and then from that the coefficient of correlation; then with the same data he derives the correlation between tensile strength and maximum deflection, and finds that there is no certain indication of correlation.

The relation between tensile and bending tests of cast iron is construed with reference to the previous work of Nagle, Merriman and Burr. The last, by the way, stated that the modulus of rupture of cast iron is only an empirical quantity.

After investigating the relation between the tensile and the bending tests, the author determines the coefficient of correlation and proves that such a correlation does actually exist. The problem, however, could not be considered solved until there has been found a relation between a change in the value of one variable and the corresponding one in the other.

As shown in Fig. 1, the means M_x and M_y intersect at the point M and the lines RR and CC also pass through this point. These last two lines are called the lines of regression. A point from the line RR is obtained by plotting a value on Y against the average value of X, both taken from a table in the article. The values of line CC are similarly taken from a table. In the figure $\tan k\,Ml = b_1 = \frac{r\sigma_x}{\sigma_y}$ and this value is called the regression of X on Y, and it presents the deviation in X corresponding on the average to a united change in the value of Y. Similarly $\tan r\,Ms = b_2 = \frac{r\sigma_x}{\sigma_y}$ is called the regression of Y on X. From this the author derives equations for the line of regression. From these equations it follows that there is no constant

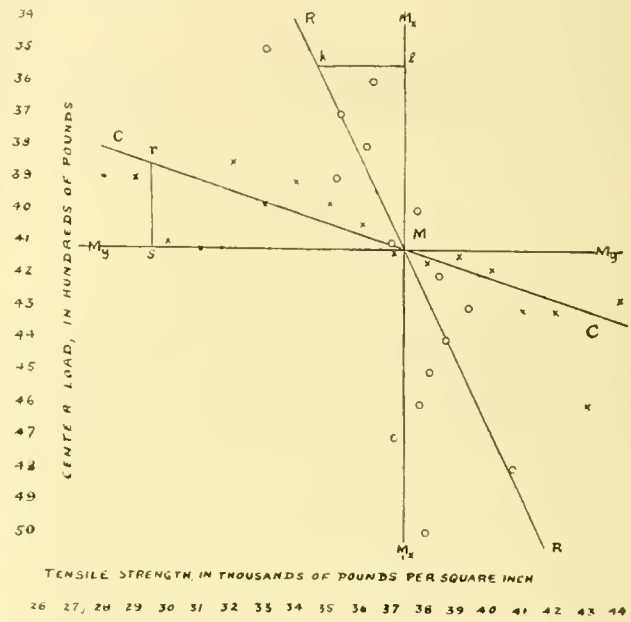


FIG. 1 DIAGRAM OF CORRELATION OF TWO MAGNITUDES, AND OF LINES OF REGRESSION

ratio between tensile strength and transverse breaking load as assumed by Nagle.

After describing the method of correlation, the author applies it to determining whether deflection or center load is the better criterion for tensile strength. (*The Technology Monthly and Harvard Engineering Journal,* vol. 2, nos. 7 and 8, pp. 5 and 15, February and March, 1916, 16 pp., 5 figs. *tm.*)

THE ENDURANCE OF METALS UNDER ALTERNATING STRESSES, B. Parker Haigh

The author draws a distinction between "proving tests" and "experimental research," the difference between the two being in the object of the experiment rather than in the manner in which it is carried out. Tests of the endurance of metals under alternating stresses have seldom been specified as "proving tests" and hardly seem likely ever to form part of the regular series of tests imposed by specifications, which is mainly due to the time which it takes to make fatigue tests.

With the knowledge at present available, it is impossible to anticipate the result of a fatigue test under alternating stress from the proved values of the alternate tensile or shear strength or Brinell hardness, but by the accumulation and analysis of additional data it may reasonably be hoped that a relation will eventually be found between the limiting range

of stress above which fatigue is liable to occur and the other physical properties of the metal, and one of the objects of this paper is to indicate the advances that have been made towards finding connections between the results of fatigue and other tests.

In the view of the writer the continued development of amorphous material with each repetition of stress is to be attributed to the fact that the great strength of the amorphous material is associated with the low modulus of elasticity, while the weaker original metal possesses a comparatively high modulus. A number of tests carried out by the writer have shown that the modulus of elasticity of a specimen of annealed iron or mild steel is always reduced by straining in tension, provided that the effects of hysteresis are eliminated either by allowing some time to elapse after straining before making the second determination of the modulus, or preferably by boiling the specimen in water for a few minutes.

Fig. 2 indicates the results of a typical series of experiments carried out in this manner. In this instance the specimen of annealed wrought iron was strained beyond the elas-

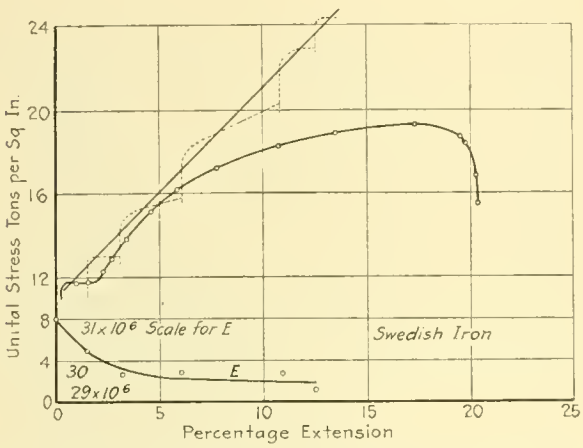


Fig. 2 Typical Behavior of a Metal Under the Action of Alternating Stresses

tic limit in five stages, reaching a total elongation of 12.5 per cent. After each extension the modulus of elasticity was measured after boiling and cooling. The value of the modulus is highest in the annealed metal, and falls quickly at the first strain and more slowly afterwards, the total reduction in the value of the modulus being approximately 6.5 per cent.

The author claims that when the range of alternating stress is maintained above the critical value at which the cleavage of ferrite begins, the material is in an unstable condition and is gradually converted to the amorphous condition. If the range of stress is only a little in excess of the limiting fatigue range, the conversion of the normal crystalline metal to the amorphous phase proceeds slowly, but if the excess is greater, conversion becomes general throughout the mass and the specimen becomes very warm owing to the loss of energy in friction between the constituent particles which shear to and fro relatively to one another during each cycle of stress.

From a number of tests on a sample of Bessemer steel, the author plotted several graphs in various ways. From these graphs he derives the following conclusions. While it may be doubted whether even the most prolonged tests would indicate an absolute fatigue limit, it is clear that for most practical purposes an approximate limit exists close to 35 tons per sq. in. The author writes Dr. Stromeyer's equation of a "law of fatigue" in the following manner:

$$S = F_1 + C\left(\frac{10^6}{N}\right)^n$$

Where S = half the range of stress producing fracture by fatigue, after N cycles of application of stress; F = one-half limiting fatigue range of stress under which fracture would occur, but only after an infinite number of repetitions of the stress; C = constant; n = index, both determined for each particular material by experiment.

It is probable that this simple law only holds for specimens tested in one particular manner, e.g., in direct tension or compression, bending, or rotary bending, and that the values of the constant C and the index n would have to be varied not only with the kind of stress applied to the specimen, but also according to the design of the particular testing machine used. It is always likely that the results of bending tests would depend on the finish of the specimen in greater degree than in the case of tests with direct stress. In tests carried out at University College, London, the endurance of bending specimens which had been turned in a lathe was found to be increased by grinding or polishing and to be reduced by scratching the surface slightly.

The author describes several types of testing machines for alternating stresses, among them the one devised by himself (for a detailed description see *Engineering*, November 22, 1912), in which an alternating current magnet is employed to generate the whole of the pull applied to the test piece without the agency of resonance. He also describes the method by which the intensity of the alternating stress is measured and the machine standardized.

From the experiments made it appears that the effect of a certain degree of extension is very much the same no matter whether that extension has been produced by a steady or by a pulsating pull. The only slight difference is that the metal strained by steady load is not quite so stable as when strained by pulsating stress, giving way slightly under pulsating stress but reaching the full stable condition corresponding to any particular degree of extension.

This last effect was found to be very marked in annealed copper wire. The larger alternating stress testing machine has been used in the engineering laboratory of the Royal Naval College, Greenwich, and also by the author in connection with several researches on steels and alloys, of which the paper presents data referring to the tests of naval brass and muntz metal. Tests were also made on specimens of Swedish wrought iron to ascertain to what degree the endurance of the metal was affected by cold working and by heat treatment, Swedish wrought iron being employed in order to isolate ferrite, the chief constituent of mild steel. Three series of tests were carried out in order to compare the effects of different treatments in each series, the stress being varied between equal intensities of tension and compression and the frequency maintained at 2000 cycles per minute. *First series,* no treatment, annealed metal. *Second series,* similar specimens strained by direct tension, the elongation being the same in all cases, 10 per cent. *Third series,* similar specimens strained in the same manner and subsequently boiled in water at 100 deg. cent. for 30 minutes to restore elasticity.

It was found that the results of each set were highly consistent among themselves, but that the fatigue limits indicated by the three differed appreciably. The endurance was considerably increased when the metal had been strained and was further increased when the strained metal had been boiled.

Several tests were made on structural steels, one a mild steel and the other a stronger Bessemer steel containing about

0.35 per cent carbon. It was found that the fatigue limits of the two metals were very nearly alike, although the tensile strength and yield strength differed quite widely. The values of the ratio between the fatigue limits and ultimate strength likewise vary widely, and it is probable that the effects of other elements than carbon present in the metal are important. The author believes that it is probable that impurities exert their harmful influence by dissolving in the ferrite and thereby increasing its hardness, at the same time changing the modulus of elasticity so that cleavage between ferrite and cementite occurs more readily under a given average stress. However, experiments made by the author show that the value of the modulus of elasticity cannot be employed as a criterion towards the fatigue limit even when measured with reliable apparatus.

The article also reports experiments on mild steel under combined alternating and steady stress, the results of which are expressed in diagrams and a formula. (*The Journal of the West of Scotland Iron and Steel Institute,* vol. 23, no. 1, p. 17, November 1915, 32 pp 26 figs. *etA.*)

Research on the Corrosion Resistance of Copper Steel, D. M. Buck and J. O. Handy

Report of tests made in order to obtain definite information as to the influence of the presence of varying amounts of copper and other elements when alloyed with steel, on the corrodability of the latter.

Previous experiments by the same authors were reported in the *Journal of Industrial and Engineering Chemistry*, 1913, page 447; *The Iron Age,* June 3, 1915, and *The Iron Trade Review,* June 10, 1915.

The tests were conducted on full size uncoated sheets under exact service conditions, extreme care being taken so to plan the work that those differences found in the various grades of steels used could be safely ascribed to the influence of the particular element which had been added. The tests covered additions of phosphorus, silicon, aluminum, roll-scale and finally the addition of cold steel to the metal ingots of the heat. The data of the tests are reported in tables, and to a certain extent in diagrams and illustrations (Cp. Fig. 3).

Open hearth and Bessemer steels were used in these tests.

As regards the reliability of tests on small pieces when made by determining the losses in weight on exposure, the authors point out that the results accord in a remarkable manner, and that the weight losses corresponded to the relative endurances of the large sheets. In these experiments, the writers adopted the practice of removing and cleaning one-half of the small test pieces after the lapse of several months, allowing others to remain exposed for a somewhat longer period. This was done in an effort to determine if there was any tendency of the rust film to behave differently on different sheets. It was thought that the sponge-like rust which is normally formed on non-copper steels might accelerate corrosion more than the dense adherent film on copper steels. This idea proved to be correct. The results are summarized by the writers in the following manner:

Sheet steel or iron containing copper shows greatly increased corrosion resistance when exposed to atmospheric conditions. The most effective amount of copper to be used for this purpose is approximately 0.25 per cent. Smaller amounts of copper down to as little as 0.04 per cent have a considerable influence in lessening corrosion, but the results are not as good as with the higher amount mentioned above. Work previously done by one of us has indicated that 0.15 per cent copper is in nearly all cases as efficient as 0.25 per cent. Higher amounts of copper, up to 2 per cent, give little or no added benefit.

Copper is as necessary in the so-called "pure irons" to insure corrosion resistence as it is in normal open-hearth and Bessemer steels. Phosphorus added to open-hearth steel slightly lowers the corrosion rate. Silicon, while probably without effect in the amounts normally present in open-hearth and Bessemer steels, accelerates corrosion when added in amounts from 0.10 to 0.30 per cent. The addition of small amounts of aluminum probably has little influence on corrosion; the above tests indicate it to be harmful rather than beneficial. The addition of sulphur to steel greatly increases the corrosion rate and when residually present in abnormal amounts, it is probably also detrimental from a corrosion standpoint. The addition of cold steel to molten steel does not lower the corrosion rate, but if it has any influence at all, it is to increase the corrosion.

Loss in weight determinations on small test pieces are found to be accurate and valuable when determining the relative corrosion resistance of various sheet metals. The

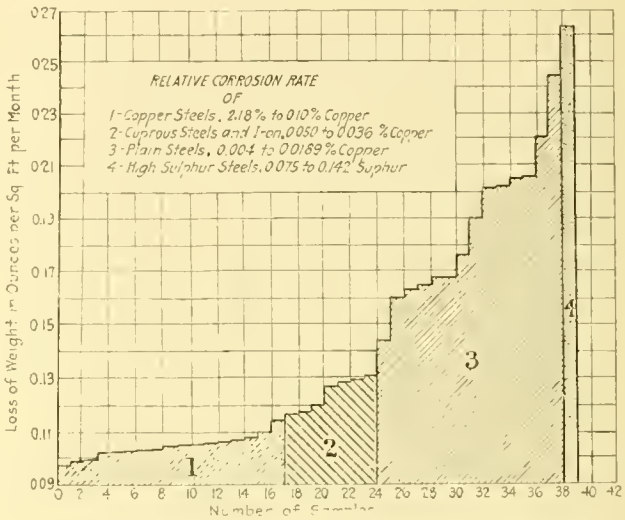


Fig. 3 Relative Corrosion Rates of Various Kinds of Copper Steel

method of cleaning such test pieces with ammoniacal ammonium citrate solution is found to be the most convenient and accurate thus far investigated.

CONCLUSIONS

I Copper increases the resistance of steel and iron to atmospheric corrosion:

1 Its influence is apparent when the copper content reaches only 0.03 per cent.

2 Its effect is almost at a maximum when the copper reaches 0.05 per cent.

3 The best amount of copper for commercial steel has been found to be 0.25 per cent.

II Steel containing 0.25 per cent copper outlasts "pure iron" containing 0.04 per cent copper.

III Steel containing 0.05 per cent copper lasts as long as "pure iron" containing 0.04 per cent copper.

IV Sulphur in steel accelerates corrosion very markedly.

V Sulphur oxides in the air accelerate the corrosion of steel.

VI Copper in steel counteracts or retards both the corroding influences noted in IV and V.

(*The Journal of Industrial and Engineering Chemistry,* vol. 8, no. 3, p. 209, March 1916, 8 pp., 9 figs. *eA.*)

Waterproofing of Mortars by Anthracene Oil, R. Feret

The article discusses the question of water-proofing of mortars by anthracene oil on the basis of experiments made by the author in the laboratory of the Ponts et Chaussées in Paris, France.

In the first group of tests a mortar was used consisting of one part of cement to three parts of sand with the weight of the water equal to 10.5 per cent of the solid matter. The tests were made on prisms 4 x 4 x 16 cent. (1.5 x 1.5 x 6 in.). These prisms after standing in the air for one week were kept under water for three weeks. In the first series of tests made it was found that two mortars with oil let through practically an equal amount of water, but considerably lower than that which penetrated through mortar without oil, so that the addition of oil was shown to have materially increased the water-proofness of the mortar.

In the second series, even though the mortars had been allowed to harden for a longer time before being subjected to the action of water under pressure, the permeability was under the same pressures in all cases greater than in the first series. In this series the difference in permeability between the mortar with oil and that without, was a good deal less than in the first case. In fact a mortar with 5 per cent of oil proved to be even a little more permeable to water than without oil. Curiously enough this difference changed in direction after a maximum pressure was attained, and remained in favor of the oil-treated mortars even after the pressures were reduced. This series of tests showed on the whole that anthracene oil has approximately the same action as far as water-proofing of mortar is concerned, as heavy petroleum oils, but it seems also to considerably reduce the strength of the mortar so that it does not appear advisable to use more than 5 per cent of the weight of the cement.

A further series of tests was then made with additions of from 3 to 5 per cent by weight of oil to the cement. In this series it was found that during a continuous test the mortar with 3 per cent of oil proved to be in the first period of the test the most permeable of all; then suddenly the 5 per cent mortar started to let through more water than the others which indicated that the water had found a passage between the mold and the mortar. On the whole, however, the mortars with oil let through less water than those without oil.

The author comes to the conclusion that mortars with 3 per cent of anthracene oil are less permeable to water than those without oil. The mortars with 5 per cent of water have given quite variable results. The addition of 3 per cent of oil did not materially affect either the resistance or the adherence of the mortar. The adherence to iron never decreased more than 26 per cent and sometimes even increased slightly. While it appears, therefore, that in most cases there is an advantage in incorporating into a mortar anthracene oil to the amount of approximately 3 per cent of the weight of cement, it is impossible to tell now in how much this addition will increase the water-proofness in a particular practical application when the conditions of filtration are quite different from those used experimentally in the laboratory.

It appears that such additions, however, are efficient only when the mortar is very compact in itself, that is when it consists of materials of proper granular structure. The maximum of compactness corresponds approximately to a mixture of two parts of sand of as large grain as possible with 1 part of fine grain (including cement). In addition to that the compactness of a mortar depends very largely on its strength and the conditions of operation and it is quite probable that the increase of water-proofness produced by quite small additions of oil is due less to the bottling of the pores than to its lubricating action because of which the mortar compresses better under the trowel. (*L'Imperméabilisation des Mortiers et L'Huile Anthracénique,* R. Feret, *Annales des Ponts et Chaussées,* partie technique, vol. 28 of series 9, no. 4, p. 51, July-August 1915, 20 pp. *e.*)

Semi-Steel, Y. A. Dyer and Richard Moldenke

Discussion of the question of what is semi-steel, how it should be made, and what is its practical value. The article consists of two papers, one by Y. A. Dyer, and the other by Dr. Richard Moldenke.

The first paper of Mr. Dyer takes the position that steel can mix homogeneously with pig iron and cast scrap under proper conditions. By proper mixing of from 10 to 40 per cent (even 50 and 60 per cent) of steel of low carbon preferably in the ordinary cupola along with pig iron of suitable homogeneity, or pig iron and selected cast scrap, a sound, tough, close-grain and easily machined casting of high tensile and transverse strength can be produced.

In the manufacture of semi-steel the pig iron to be used as a base metal should be under 0.60 per cent in phosphorus and over 1 per cent in manganese. The silicon in the pig for work requiring close-grain and high strength should be from 2.25 to 2.45 per cent. For small and comparatively thin castings the silicon in the pig should run from 2.50 to 2.80 per cent. The lower the sulphur the better. If low grade pig iron should be used with the above base metal, No. 3 or No. 4 foundry iron will suit; if scrap should be used, No. 1 machinery is best.

Low carbon steel is preferable in the mixture, such as croppings from angle bars and structural material, concrete bars, cast steel shafting, pipe, rails and boiler plate, all of which will range approximately as follows in analysis: Silicon, 0.03 to 0.35 per cent, sulphur, 0.05 per cent or under, phosphorus, 0.01 to 0.10 per cent, manganese, 0.40 to 0.80 per cent. The manganese should be watched closely in the mixture and ranged from 0.40 to 0.75 per cent in the casting. Manganese in the pig iron and other material used will more uniformly mix in the bath than if it should have to be supplied in the form of ferro manganese. If ferro manganese should have to be used, lump form charged in the cupola will give better results. Proper charging of the material and correct cupola practice are highly important elements of success.

The article reports data of tests of horizontal bars 1 in. square. The horizontal bars showed a strength from 35,000 to 37,000 lb. in tension, and about 3600 to 3700 lb. under transverse stress. The vertical cast bars broke at stresses from about 5500 to 7500 lb. per sq. in.

Dr. Richard Moldenke in his paper objects to the use of the term "semi-steel." The name was introduced in good faith at a time when little was known of the metallurgy of cast iron, but it should not be used now with our present extended knowledge of the properties of materials and their metallurgical characteristics.

As regards the data in Mr. Dyer's paper the writer calls attention to the fact that cast iron with silicon contents from 1.45 to 1.65 will often show tensile strengths in 1 in. square bars of 33,000 to 37,000 lb. per sq. in. without the addition of any steel to the mixtures, hence there does not seem to have been any gain from the addition of steel.

Melting large percentages of steel scrap with gray iron

means quick setting metal particularly if only just the right amount of fuel has been used which is complicated by undue oxidation of the steel, before it melts and a not too high temperature of the metal from the spout. Hence molds as ordinarily gated will not allow a proper feeding of the casting and wherever the thinner sections about a heavy point may have set the liquid portions unable to draw in fresh metal will result in iron with heavy draws and even the sound portions will show very open interior structures Only some adaptation of the "top pour" permitting the descent of the molten metal in small streams straight to the bottom and allowing the metal to remain quiet as the mold fills and draw from above to set sound, will give good results.

The author claims that the test bar will show up wonderful results and yet the casting may be quite below par. He believes further that when a customer buys castings made with steel scrap added to the mixture, he takes greater chances.

The writer has oftentimes run cupola heats of 100 per cent steel scrap and excess of fuel had to be used to get serviceable results but the product was cast iron just the same and nothing "steely" could be traced in the castings made. In fact, the author appears to believe that but for the propaganda of certain manufacturers, the term "semi-steel" would have been, as he expresses it, "decently buried and long forgotten," as it serves mainly to fool the foundrymen and consumers of castings. (*The Iron Age*, vol. 97, no. 9, p. 542, March 2, 1916, 3 pp. *cp.*)

Fuel

Pulverized Fuel for Locomotives, John E. Muhlfeld

Brief historical sketch of the development of the use of pulverized fuel for locomotives and data on the present state of the art.

The author believes that the development of means and methods for burning pulverized fuel in steam locomotives has now passed the experimental stage and commercial applications will be made as rapidly as the equipment can be produced.

Fig. 4 shows a typical application of pulverized fuel burning equipment to a consolidation type of steam locomotive indicating among other things the names of the parts.

From investigation to date any solid fuel which in a dry pulverized form will have two-thirds of its content combustible will be suitable for steam generating purposes. In tests with semi-bituminous coal from Brazil, S. A., the sulphur averaged from 3 to 9 per cent and the heating value from 10,900 to 8,800 B.t.u., and no difficulty was found in maintaining maximum boiler pressure on the locomotive.

To produce, however, the most effective results, pulverized fuel should contain not to exceed 1 per cent of moisture and should be of uniform fineness so that not less than 95 per cent of the total will pass through a 100-mesh and not less than 80 per cent of the total will pass through a 200-mesh screen. The total cost of preparing pulverized fuel properly in a suitably equipped drying and pulverizing plant will range from 15 to 45 cents per ton depending upon the capacity of the plant. (Paper presented before the *New York Railroad Club* on February 18, 1916, 10 pp., 3 figs. *dp.*)

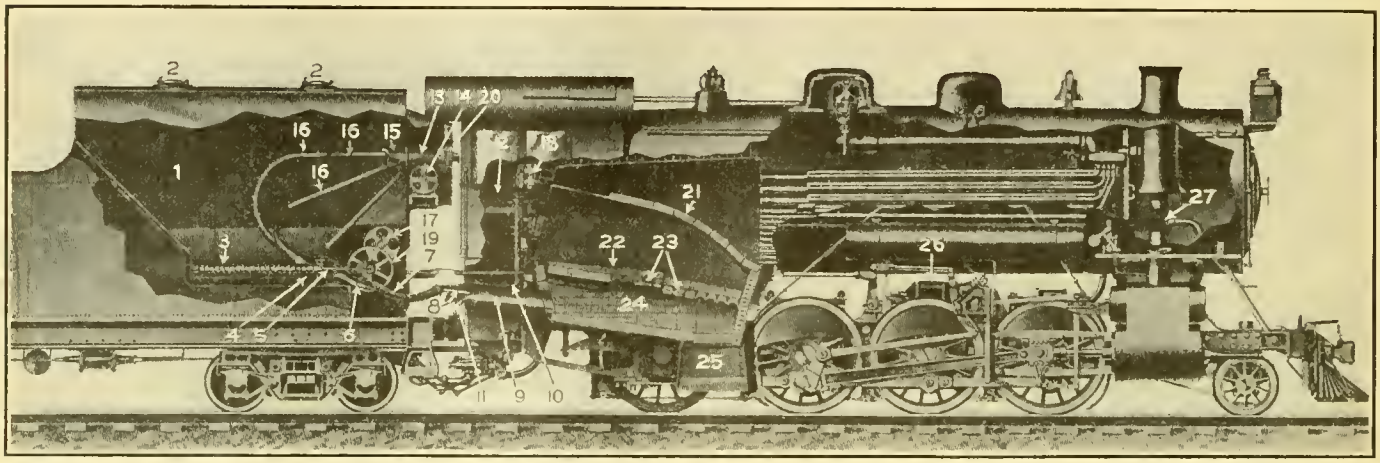


Fig. 4. Typical Pulverized Fuel Locomotive Furnace

1. Enclosed Fuel Container
2. Fuel Supply Inlets and Covers
3. Fuel Conveyor
4. Fuel and Pressure Air Feeder
5. Fuel and Pressure Air Commingler
6. Fuel and Pressure Air Outlet
7. Fuel and Pressure Air Flexible Conduit
8. Fuel and Pressure Air Nozzle
9. Fuel and Air Mixer
10. Firing up Opening
11. Induced Air Inlet Damper
12. Control for Induced Air Inlet Damper
13. Pressure Blower
14. Steam Turbine or Motor for Pressure Blower
15. Pressure Blower Manifold
16. Pressure Blower Conduits
17. Steam Turbine or Motor for Fuel Conveyor, Feeder and Commingler
18. Control for Steam Turbine or Motor for Fuel Conveyor, Feeder and Commingler
19. Operating Gear, Shaft and Clutches for Fuel Conveyor, Feeder and Commingler
20. Switchboard (when electrical equipment is specified)
21. Security Arch
22. Primary Arch
23. Auxiliary Air Inlets
24. Combustion Furnace
25. Self-Clearing Air Cooled Slag Pan
26. Turbo-Generator (when electrical equipment is specified)
27. Combination Engine and Turbo-Generator Exhaust Nozzle and Stack Blower

Fuel Economy, H. C. Woodbridge

Consideration of the general elements affecting fuel economy, especially from the point of view of proper organization of the firing service.

Among the main points to which the author calls attention is the necessity of proper training of firemen. In 1907, 300 firemen were specially trained by the officers of the Hamburg Society for the Prevention of Smoke. A report of this society shows a thermal efficiency with the regular or untrained firemen of 66.6 per cent, and a thermal efficiency of the same plant with trained firemen of 72.7 per cent. Similar experiments conducted in the Pennsylvania Railroad Company's laboratory at Altoona, under the direction of Professor Goss, have shown an efficiency of a locomotive boiler to be 73.2 per cent when fired by experienced men and 59.7 per cent when fired by inexperienced men. (*Railway Club of Pittsburgh*, vol. 10, no. 3, p. 64, January 28, 1916, 4 pp. *g.*)

Furnace with Adjustable Grate Area

The article describes a series of comparative tests on a 150 h.p. boiler in a building in New York City provided with an adjustable furnace. This furnace consists of a sliding bridge-wall operated back and forth by hand, through a worm gear rotating a cross shaft on which are maintained two pinions geared to racks secured to the underside of the movable bridge-wall framework. The wall is moved out over the grate bars sliding upon side supporting bars set alongside the furnace wall.

The rear of the bridge has an extension in the form of a cover which slides over a fixed frame secured to the brick-work of the bridge wall. The frame is made with recessed tray which is filled with sand so that a joint is maintained between the sliding bridge and the fixed frame, preventing the passage of air through the unused portion of the grate to the combustion chamber. On the return of the bridge, the rear edge scrapes a clean surface over the sand bed and renews the air joint in this manner.

The tests are made with a return tubular boiler. No data of tests are reported. (Novel Method of Adjusting Grate Area, *The Isolated Plant,* vol. 8, no. 3, p. 15, March 1916, 1 p. *d.*)

Electrically Driven Charging Cars for Coke-Ovens, K. Dobbelstein

Description of an installation at a German mine plant where the charging cars for coke-ovens are driven electrically.

Small manually driven cars were formerly used; then without changing the shape of the cars, two of them were interconnected and a motor installed in the angle between the hoppers. Fig. 5A shows how this was accomplished. The drive (Fig. B) is by means of a fully enclosed direct current motor *m* running on 110 or 220 volts and delivering from 5 to 6 h.p. The power is transmitted from the gear *z* through the chain *g* onto the axle of the car. Forward and reverse motion is obtained by the reversing controller *k*. A special mechanical arrangement maintains the switch lever in its proper position after the motor has been cut in. Simultaneously with the starting of the motor a mechanical brake *i* (or an equivalent magnetic brake) connected with the lever, is set into operation, in the first case by air and in the other by electric current. As shown in Fig. B, proper lighting is provided for night work. It has been found that the operation of the car requires little current; a car of 3 ton capacity running at 1.2 m (3.94 ft.) per second and using 220 volts, requires 15 amperes.

Fig. C shows the filling of the car from the coal tower. The operator brings the car right under the discharge opening of the tower, holding his hand all the time on the switch lever *a*. The wide lever *b* located in an inclined position in front of the operator opens and closes the discharge valve on the tower. There is also a third lever *c* visible in the rear but concealed in the front section of the figure by the body of the operator. This lever operates the jarring device used when discharging the coal. The operation of the car is so simple

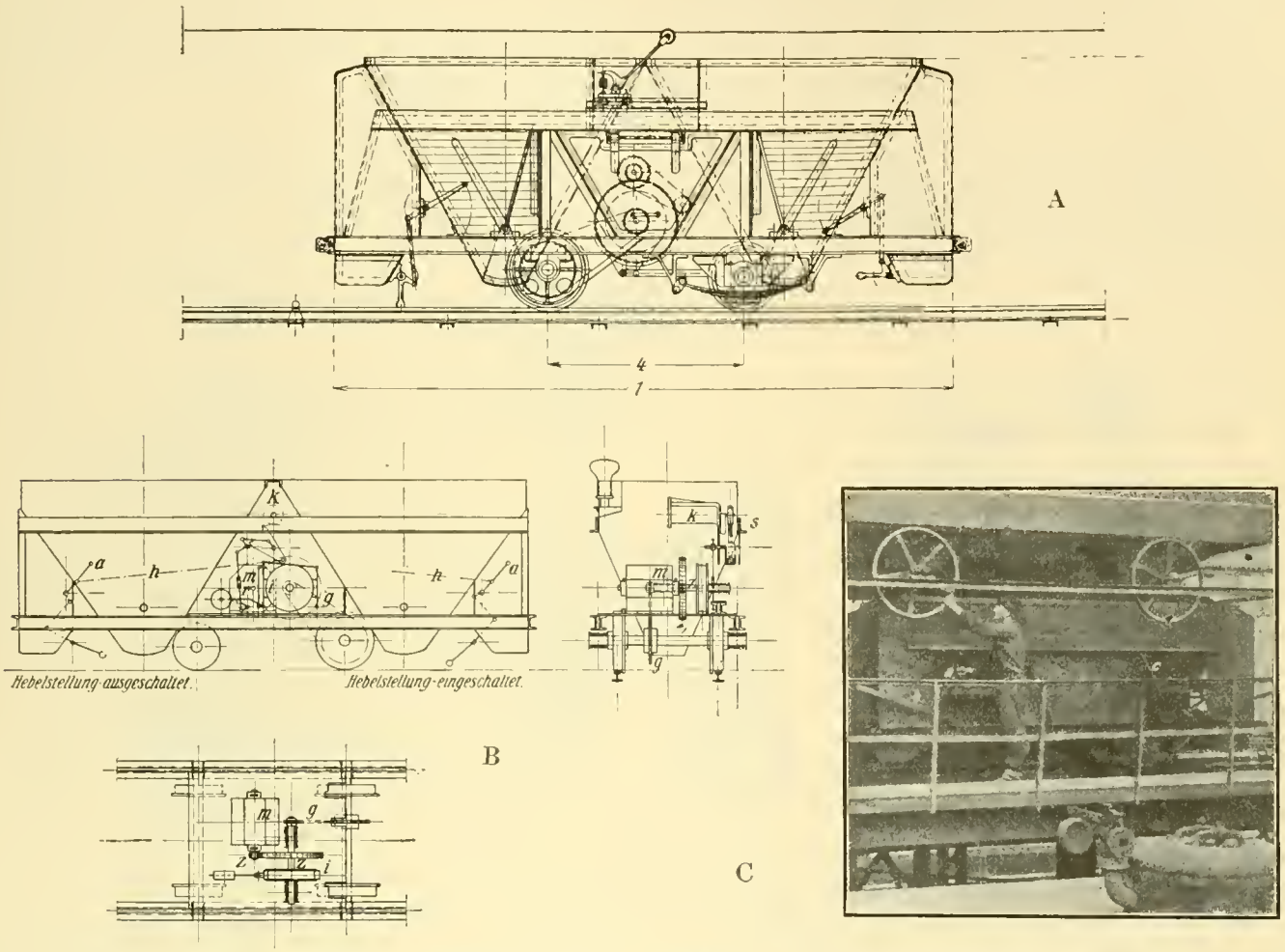


Fig. 5 Electrically Driven Charging Cars for Coke-Ovens

that a workman can manage it without any previous training. As soon as three cars have been filled from the tower and switched in one after another, two of them are sent forward without any operator on them direct to the proper oven, while the operator goes after in the third car. In this manner a battery of 60 to 80 ovens can be taken care of by a single man so that there is a large saving in attendance in addition to which the safety of operation is materially increased. (*Die Beschickung von Koksöfen mit kleinen, elektrisch betriebenen Fülltrichterwagen*, K. Dobbelstein, *Elektrische Kraftbetriebe u. Bahnen*, vol. 14, no. 5, p. 49, February 14, 1916, 3 pp., 6 figs. *d.*)

Hydraulics

Automatic Hydraulic Control-Valve

Description of an automatic hydraulic control-valve primarily designed to be placed in the pipe line connecting an accumulator in an outlying district with the mains of an hydraulic system.

To be of the greatest value such an accumulator must on the one hand be freely responsive to the pressures in the main, and on the other hand avoid the difficulty usual with the freely responsive accumulator in that it makes violent contacts with the stops at the top and bottom limits of the stroke. To meet this requirement the device described here consists of a combination of valves contained in one body. In Fig. 6*A* and *B* it is seen that the valve has a double headed piston *AB* working in a body having two ring ports *C* and *D*, with an annular space *E* between, connected to the outside of each port by a small by-pass *E'* fitted with the check valves *F* and *G*. The length and stroke of the piston are such that when in mid-position both ports are uncovered and there is, therefore, a clear passage through the valve in either direction. When the piston is moved over to either extremity of its stroke, it covers one of the ports blocking the passageway.

Now assuming the water to be flowing into the accumulator in the direction of arrow *H*, the ram will rise until it approaches the top of its stroke when the gear will move the valve piston in the direction of *H'* until port *C* is closed and the motion of the ram thus stopped.. If during the closing or closed period the pressure should at point *H* be reduced by a draught in the main, water passing through the by-pass *F* in the direction of the arrow *J* would cause the accumulator ram to descend and in so doing move the piston back to mid-stroke, thus restoring the full area through the valve passage. On the descent of the accumulator to the bottom position the movement of the piston and water will be similarly affected.

C and *D* show the arrangement of the control valve and the application of the operating gear. The control valve is placed at *K* in the pipe connecting the hydraulic main with the accumulator, the accumulator casing being provided with the contact brackets *L* and *R* through which passes the tappet rod *V*. In figure C the valve is in mid-position and the accumulator is shown approaching the bottom resting blocks at the point when the bracket *R* commences contact with the tappet *S*, thus depressing the lever *W* and gradually closing the valve through the spindle at *U*.

As the accumulator ascends, the weight *T* brings the lever back to mid-position. The same happens at the top of the stroke. As the accumulator descends the weight *M* again rests on the tappet *P* thus overhauling the weight *N* and bringing the lever *W* back to mid-position. The valve and gear remain in this position whilst the accumulator is moving between the bottom position shown in Fig. C and the top position when the bracket *L* lifts the weight *M* off the tappet at *P*. (*Engineering*, vol. 101, no. 2614, p. 102, February 4, 1916, 1 p., 4 figs. *d.*)

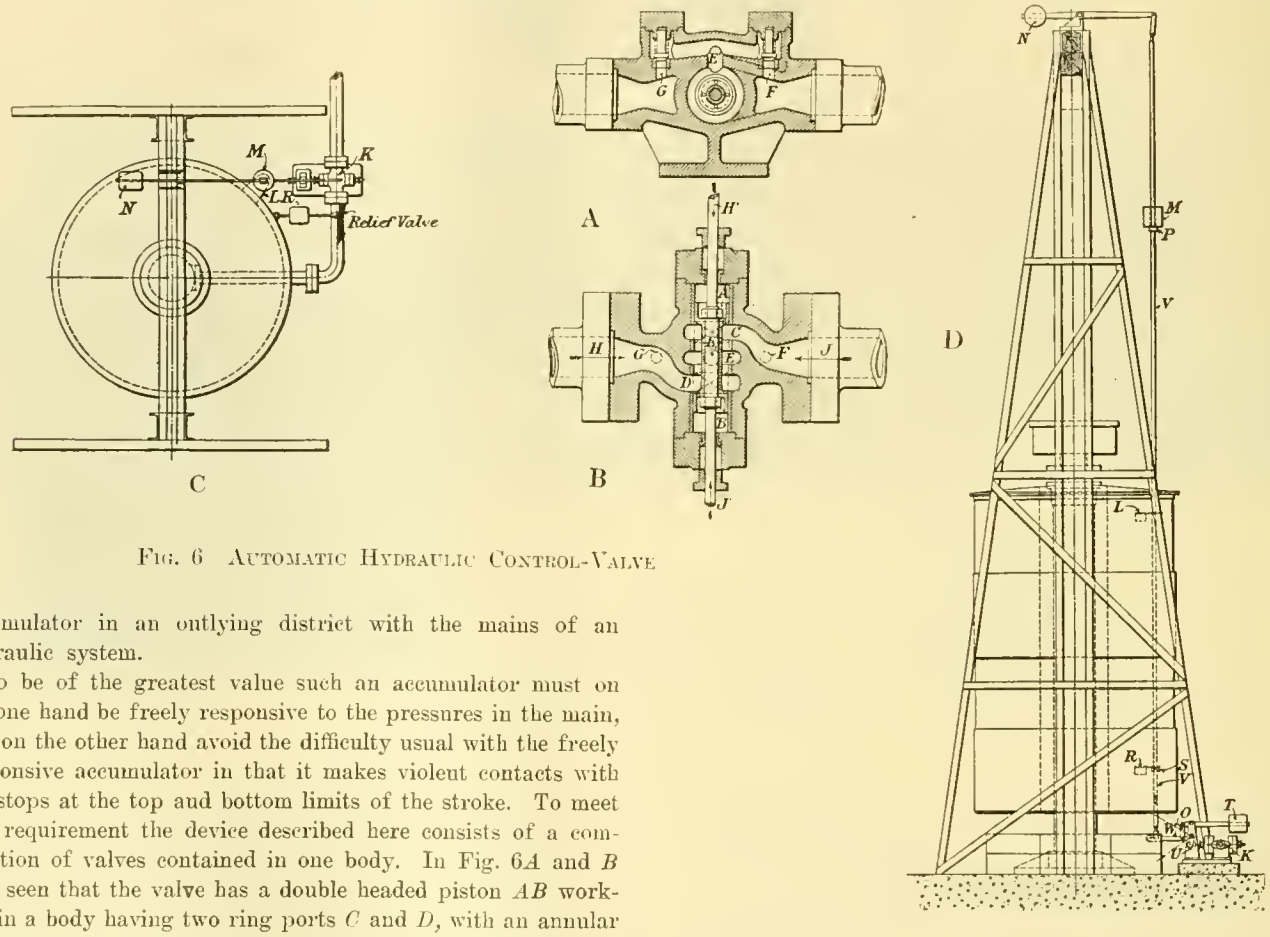


Fig. 6 Automatic Hydraulic Control-Valve

Internal Combustion Engineering

The MaB Racing Engine with Rotary Conical Valves

Description of the MaB racing engine used on an English cycle car. The most important points are the shape of the valve and the type of valve operation employed; the rotary valve employed permits of a continuous instead of an inter-

mittent movement so that it is possible to drive the valve direct from the crankshaft without the interposition of springs, cams, or any other variables which may in time affect the correct operation of the valves.

The valve itself is of conical formation as shown in Fig. 7A and its shape is said to be responsible for a very compact combustion chamber which allows of the full force of the explosion being expended upon the head of the piston. As seen in Fig. B the shape of the combustion chamber is such that the gases have a very easy path both from the carburetor and into the exhaust pipe. The construction of the driving gear looks somewhat complicated but this is due to the large number of ball bearings employed so that as much friction may be avoided as possible.

Under the influence of compression and explosion the rotary conical valve bears against the head of the cylinder but when no pressure is on the valve the weight is taken by the large ball thrust bearing seen just above the cylinder head. The coil spring on the upper part of the valve stem, Fig. B, is to keep the valve in close contact with the cylinder walls to prevent leaks. In addition this coil spring permits of a flexible connection between the valve and the cylinder which will allow the oil to be forced on the face of the valve from the force feed lubricator seen at the right hand side of the engine section.

The valve operating gear is as follows: (Fig. C) Mounted on the front of the crank shaft is a spiral gear which drives a vertical shaft at the same speed as itself. This vertical shaft measures with the horizontal shaft running the length of the cylinders. Mounted on this longitudinal shaft are four skew gears which mesh with gears mounted on each rotating valve having double the number of teeth and the valves, therefore, run at half crankshaft speed.

The engine has been constructed for purely racing purposes. (A Revolutionary Engine Design, *Gas Energy*, vol. 10, no. 2, p. 35, February 1916, 3 pp., 4 figs. *d.*)

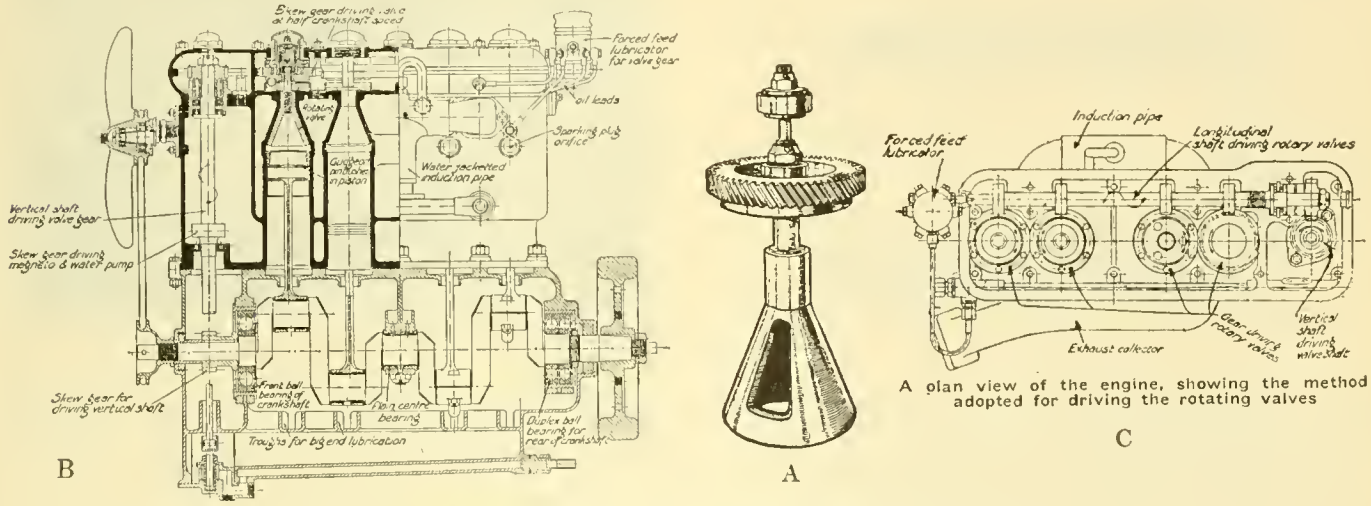


Fig. 7 The MaB Racing Engine and Its Rotary Conical Valve

Machine Shop

The Autogenous Welding of Boiler Plates

Abstract of a report issued by the Swiss Society of Steam Boiler Owners based on data collected by the Federal Laboratory for the testing of materials in Zurich.

It was found that the test pieces which broke at the weld had an average tensile strength of 76 per cent only and an elongation outside the fracture of 39 per cent, whilst the averages of those which broke outside the weld were respectively 87 and 66 per cent. In considering the tensile strength, however, it should be remembered that the welded pieces were annealed, a process which generally tends to decrease the tensile strength while increasing the elongation. Brinnel tests for the original plate gave an average hardness number of 115.6 and the average for 52 autogenous welded plates was 102.8 or 89 per cent of the hardness of the original plate measured outside the weld and 108.2 or 94 per cent of the hardness of the original plate measured at the weld. This decrease of 11 per cent in hardness represents approximately the influence of annealing.

The resilience of the metal as tested by impact bending tests on notched bars seems to have undergone a marked decrease owing to the welding conditions, a decrease larger than the decrease in tensile strength. An interesting fact is that the plates which in the tensile tests have given bad results gave satisfactory results in the impact bending tests, and it would appear that in regard to resistance to bending under impact the welds which lack in homogeneity and are fibrous, are superior to those which have greater uniformity and are more homogeneous. In general those plates on which the consumption of oxygen and gas were the highest gave better test results.

The tests did not afford any proof of the superiority of electric welding over autogenous welding. It must be said, however, that the tests were not carried out in a manner such as to establish an accurate comparison between the two processes. (*Engineering*, vol. 101, no. 2614, p. 95, February 4, 1916, 3 pp., 4 figs. *e.*)

Welding of High Pressure Mains at Springfield, Mass., A. S. Hall

Description of the welding of high pressure mains, presented in such a manner as to give information that may be used as the basis for estimating costs.

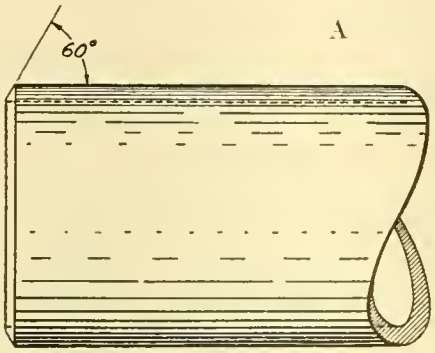
The welders on this job started as green men, recruited from the ranks of the regular street gangs of the company. As soon as one man became proficient, another man was broken in, until six capable welders were available. At first, however, because of their inexperience, the men were lavish in the use

of oxygen, acetylene, filler metal, etc., and the joints were slow in being made and often had to be rewelded. The detailed cost data are given in the article and show that the total cost of laying pressure main was nearly $15,000, while the cost per joint is estimated as follows:

Labor	$.6010
Oxygen	.2296
Acetylene	.2224
Filler Metal	.0522
Total cost per joint	$1.1052

It was found that the welding of double length pipe was the most economical method of laying high pressure mains. The cost data for another job are given in the same article, indicating a total cost per joint of $1.3016.

In ordering plain end pipe for a welded main such as has been described, an important feature is the bevel to which the ends of the pipe are cut. The writer has found from experience that the best angle for this bevel is 60 deg. to the horizontal, as shown in Fig. 8A.



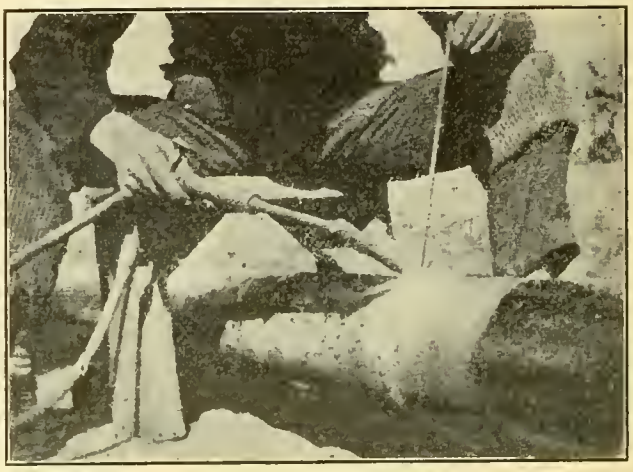


Fig. 8 A Best Angle for Bevel in Welding of High Pressure Main; B Best Position of the Welder

It is absolutely necessary, in order to make a tight joint, that the inner edges of the two pipes be fused together before any filler material is applied. There must be enough stock in the thin edges caused by the bevel to make this fusing possible. A bevel angle very much less than 60 deg. to the horizontal does not give this necessary amount of stock, so that a hole is frequently burned, through which molten metal runs to the inside of the pipe.

On the other hand, a bevel angle very much greater than 60 deg. to the horizontal not only leaves the inner pipe edges too thick to be easily fused, but it does not leave sufficient room in the groove for a proper amount of filler material.

It has been found more economical to weld together and test long sections of pipe before placing them in the ditch. Note in Fig. 8B, the position of the welder, sitting on a small wooden bench, with the arms resting on either knee. Such a position can be maintained for some time before becoming tiresome. No welder was allowed to light a torch without having on a proper pair of goggles.

In view of the extreme changes of temperature with the seasons in New England, an expansion joint was placed at intervals of about 1000 ft. to take care of the expansion and contraction of the mains. Extra heavy semi-steel screw end valves were used.

One of the great advantages of welding mains is the number and variety of bends and fittings which can be made on the job. In this case, all drip-pots, tees, and most of the bends were welded in this way. To facilitate this work, a number of sheet metal patterns were made, similar to those used in making stove pipe, to aid the welder in properly cutting the pipe.

The following data, as to the relative cost of welded high pressure mains as compared with threaded and coupled mains, are given: The writer's companies received the following data in answer to a recent inquiry as to the relative cost of plain end pipe and threaded and coupled pipe:

Size of Pipe	*Cost per Foot Threaded and Coupled Pipe*	*Cost per Foot Plain end Pipe*
2	$.09	$.085
4	.27	.26
6	.48	.46

If, for example, a 6-in. pipe is used, by using plain end pipe, a saving of $0.02 per ft. or $0.80 per double length is made before the pipe leaves the mill, which goes a long way toward paying for a joint. (*The Gas Age,* vol. 37, no. 5, p. 259, March 1, 1916, 6 pp., 21 figs. *d.*)

Woodruff Keys and Keyways

The article consists of two tables and a brief introduction. In Table 1 the dimensions of Woodruff keys and key-ways have been computed and tabulated for keys and key-ways suitable for shaft diameters from ½ to 2 in. inclusive, while Table 2 gives the dimensions of cutters of various sizes. The tables are very complete as every essential dimension is given in plain figures. (*Machinery,* vol. 22, no. 7, p. 586, March 1916, 2 pp. *p.*)

Cost of Gas Cutting, J. F. Springer

Data on cost of cutting steel by the oxy-hydrogen method, obtained partly by calculation and partly from a European source.

The data by calculation were obtained from a lot of miscellaneous work, in all 38 cuts, varying in area from 1.56 to 75.6 sq. in. From both sources it has been found that to cut 1/3 lineal foot, between 5.1 and 5.4 cu. ft. of oxygen are required. For work thicker than 1 in., the oxygen becomes a very decisive factor, it costs more per foot all the time and for heavier work the amount becomes rapidly greater relatively as the work increases in thickness. The article contains two tables, one on the cost of cutting steel plate and the other cost of cutting steel bars of circular section, both by the oxy-hydrogen process. The second table shows that 4.8 cu. ft. of oxygen is required to cut a 4-in. bar (area of cut 12.6 sq. in.)

Calculation shows that it takes approximately the same amount of oxygen to cut a given area in work of a given thickness whatever be the form of the cross section cut (in applying this rule it is necessary to take the maximum thickness as the basis). There is, however, a small advantage in favor of work of even thickness especially in the case of small work. With the given cutting torch there must be a certain pressure of oxygen which corresponds with the speed determined by the heating flame. A stronger pressure will be useless and occasions waste, and weaker pressure will require the forward speed to fall below its possibilities. (*Machinery*, vol. 22, no. 7, p. 581, March 1916, 1pp. *ep.*)

Mechanics

Transmitting Power by Leather Belting, R. T. Kent

A series of tables embodying the latest investigations showing tensions and horsepowers at which belts will give the best service and cost the least for maintenance and repairs. The purpose of these tables is mainly to provide an answer to each of the three following questions (assuming the pulley size to have been determined): what horsepower is to be transmitted; what size of belt should be used to transmit it; and under what tension should the belt be placed on the pulleys.

The writer gives the following determination of the more satisfactory belt drive: It is that one which will at all times transmit the necessary amount of power and at the same time cost the least for repairs and maintenance, and cause the least possible loss by machine shut-downs for the purpose of making belt repairs in working hours.

To have a satisfactory belt drive the following considerations must be taken into account when the drive is laid out: the conditions of use of the belt, whether it is readily accessible or not; the velocity at which the belt will travel; the arc of the pulley with which the belt is in contact; the tension per sq. in. of cross section under which it is first placed on the pulleys; the tension per square inch of cross section to which the belt may be allowed to fall in service before it is taken down and retightened.

The tables which accompany the article are based on the latest investigations of belting practice, viz. those of Carl G. Barth, and give horsepower and maximum and minimum tensions of leather belts per square inch of cross sectional area, cross sectional area of belts, arc of contact on smaller pulley, velocity of belts. The theory of belting practice is discussed on the basis of Mr. Barth's paper presented before The American Society of Mechanical Engineers in January. 1909 (Transactions, Vol. 31) (*The Iron Age*, vol. 97, no. 9, p. 527, March 2, 1916, 7 pp., 3 figs.)

The Moment Diagram and Its Relation to the Reinforcement of a Concrete Beam, S. C. Hollister

Discussion of methods for solving some of the problems relative to the proper placing of the steel reinforcements in the body of the beam. In the article extensive analytical methods have been resorted to and a series of graphic construction introduced to determine the relative position of the component parts of the reinforcing materials. A method is set forth for placing the reinforcements for both bending and shearing resistance entirely from the moment diagram.

The author starts with the statement that the difference in moment between any two points along a beam is equal to the product of the average shear over the distance between the points, and that distance (this law is not strictly true for loads concentrated at points along a beam). From this the author derives first an expression of the average shear in terms of the changing moment along a portion s of the beam resisted by the stirrup, and then determines the moment increment from zero to a certain value M_z and finds that this moment increment represents the value of the adopted stirrup to resist the vertical component of diagonal tension over the portion s of the beam and that for any given stirrup of area a_s and of fibre stress f_s, the moment M_1 varies directly with jd, a value dependent upon the characteristics of the beam which gives the following equation:

$$M_1 = a_s f_s jd$$

From this he obtains the following equation:

For vertical stirrups $M_1 = 1.5\, a_s f_s jd$

For stirrups inclined at an angle θ to the horizontal:

$$M_1 = \frac{1.5\, a_s f_s jd}{\sin \theta}$$

For stirrups inclied at an angle of 45 deg. for the horizontal:

$$M_1 = 2.1\, a_s f_s jd$$

These equations express the final working value of the resistance offered by single stirrups in terms of an increment of moment. The author gives a graph of the different equations when $j = 7/8$, a very common value in rectangular beam design, with instructions how to use this chart. He then gives in detail the design of a T-beam in accordance with the above described method. He shows how to place the steel in the beam and indicates the application of the method with two arrangements of the steel, one in which the bent up rods are intended to carry a portion of the shear and the other in which the stirrups are designed to carry all the shear. (*The Wisconsin Engineer*, vol. 20, No. 5, p. 206, February 1916, 11 pp., 6 figs. *t.*)

Steam Engineering

Boiler and Steam Vessel Explosion in Switzerland, E. Höhn

Description of what was found in an investigation of an explosion of a vertical inclined tube boiler in Switzerland (the boiler was built by a concern in Hesse, Germany).

The boiler had a welded-in fire-box with three inclined tubes and was tested after construction (in 1898) at an hydraulic pressue of 11 atmospheres and later on in 1911 by an inspector of the Swiss Association of Steam Boiler Owners, at 9 atmospheres.

The inspection after explosion showed that the arched crown of the fire-box separated from the fire-tube along a welded seam and was pressed downwards as indicated in the drawing (Fig. 9) just as if it were an elastic membrane. After this the force of the steam naturally penetrated into the fire-box and violently threw the boiler off its foundations.

A close investigation of the broken seam showed that it was welded just along one edge, in fact, poorly welded—and iron filings could be broken off without much trouble. In addition to that the smoke-tube before being inserted into the hole in the fire-box which was apparently too big, was enlarged as shown in the figure, which likewise cannot be considered good practice. A further constructive defect was the curving of the fire-box crown while the bottom of the boiler was flat. Since the jacket and the fire-box did not expand equally when heated, the difference in length had to be equalized somewhere, and it is flat bodies having an elastic action which are best able to take up such an equalization. As soon, however, as a curved body is introduced the elasticity suffers.

It must not be forgotten in this connection that the stress of the spring action in the header is taken up by the smoke-tube and the seams between the latter and the bottom of the boiler. This stress increases with the rigidity of the bottom.

hence with its curvature. Corrugated smoke-tubes, while technically possible, are not usable even though they have a certain amount of elastic action.

The article describes also another case of explosion, this time of a container used under pressure with steam for industrial purposes. Of interest is the discussion of the etching test.

In the present case one of the seams was found to have broken at the flange and the author points out that such a wrong application of welding is found oftener than one would think. In this connection the author calls attention to the fact that with arched headers the maximum stress occurs at the flange as has been previously shown by the investigation of C. Bach.

As regards the comparative value of riveting and welding in boilers, the author repeats the following statement previously made in another of his publications: "A welded seam has always in it something hidden, beyond control. As a substitute for a riveted seam it is undesirable where the latter can be applied without difficulty. There are, however, cases where the welded seam may be or has to be applied for constructive purposes, with moderate stresses, or because of lack of space, etc." (*Explosion eines Dampfkessels und eines Dampfgefässes in der Schweiz. Betrachtungen über Schweissungen,* E. Höhn, *Zeits. des Bayerischen Revisions-Vereins,* vol. 19, no. 24, p. 195, December 31, 1915, 4 pp., 6 figs. *dp.*)

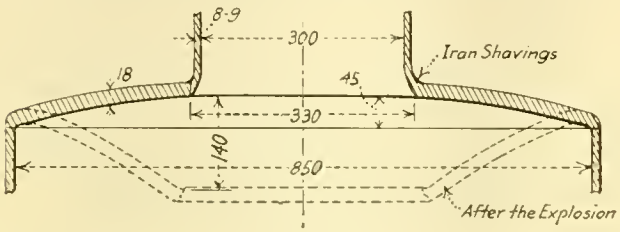


Fig. 9 Portion of the Boiler Affected by the Explosion

New Wisconsin Boiler Code

The Industrial Commission of Wisconsin has just issued the New Wisconsin Boiler Code to govern all steam boilers except those regularly inspected by the Federal government, steam fire engines, those used exclusively for agricultural purposes, all of less than 10 h.p. and those on which the pressure does not exceed 15 lb. The Code follows the requirements of the National Association of Stationary Engineers. (*The Iron Age,* vol. 97, no. 9, p. 560, March 2, 1916.)

Flow of Steam in Pipes, W. L. Durand

An article discussing methods of determining the sizes of steam pipes by the use of formulas and by a curve chart by which, if three of the four variables are known, the fourth can be found.

The writer proposes a formula in which the length of the pipe and friction loss are reduced to one variable "friction loss per unit of length" such as "per 100 ft." The formula is as follows:

$$W = 87.5 \sqrt{\frac{p}{100}} \times \sqrt{D} \times \sqrt{\frac{d^5}{1 + \frac{3.6}{d}}}$$

where W = weight of steam flowing in pounds per minute, p = drop in pressure pounds per square inch, D = density, pounds per cubic foot, d = internal diameter of pipe.

In addition to this formula the author gives a chart for quickly determining the fourth variable in this formula if three of them are known. (*Power,* vol. 43, no. 10, p. 324, March 7, 1916, 2 pp., 1 fig. *p.*)

Peat Burning Furnace for Locomotives

There have been references in American papers several times in the past year to the Porat system of peat burning in locomotives. In the present article is described from a German patent (No. 287837) the construction of this furnace which has been already extensively experimented with on the Swedish railways. The essential element of this system is a connection between the fuel supply and the valve gear of the locomotive which serves to regulate the draft by the blast pipe and an auxiliary blower. This connection is arranged in such a manner that fuel can be supplied only at a certain normal strength of blast. In the illustrations, Fig. 10A gives a vertical cross-section of a locomotive fire-box with the new arrangement and Fig. B a similar cross section through the fuel hopper, while Fig. C gives two views of the adjusting gear.

The fuel is led from the funnel shaped container a on the tender to the fire-box d through the pipe c. The fire-box is closed in front by door e in a passage for the air of combustion, in which passage there is built a regulating valve l. On the fire-box is also installed a separate chamber n for solid fuel fed with air through passage o. Liquid or gaseous fuel can be admitted through pipe p. A slight fire is maintained in the chamber n which furnishes sufficient heat to ignite the peat powder when the supply of fuel has been renewed after an interruption of the supply.

The fuel pipe c opening into the cap e has its free end bent upwards and ends in a funnel f, opening under the container a. Air can enter into pipe c through the opening g in the rear of the funnel. The container a is provided with a bend and a valve to regulate the fuel supply. The arrangement is such for example that the steam cylinder receiving steam from the boiler has its valve gear regulated by the throttle lever t located on the locomotive or by the valve of the auxiliary blower.

The slide valve h is located in front of the discharge opening of the container a and is connected with the rod h^1 of a piston h^2 moving in a cylinder. This latter receives its steam also from the boiler and has a valve gear regulated in a similar manner. The piston h^2 is forced into the closing position of the valve h by means of a spring. The nuts h^3 on the piston rod h^1 are used to adjust the sliding valve h in proper position with respect to piston h^2 so as to vary the dimensions of the fuel discharge opening. The regulating shaft q which opens and closes the steam valve leading to the working cylinders of the locomotive is provided with a handle t located above the fire door. The article describes in detail the connection with the auxiliary blower. (*Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 39, no. 3, p. 19, January 21, 1916, serial article, not finished.)

Varia

Proposed Standard Numerals for the Scales of Measuring Instruments, A. P. Trotter

Discussion of the outward appearance of numerals for the scales of measuring instruments. The paper is published at the suggestion of the Meter Panel of the Engineering Standards Committee on Electrical Accessories (Great Britain).

The paper compares three sets of numerals proposed as

standards. The principal characteristics of the numerals proposed by the author are as follows: There should be no serifs; the figures should be of block character, that is, there should be no marked difference in the thickness of the line in any part of the figure; with a height of 10 units, the width ought not to be less than 7 units, as otherwise legibility begins to suffer, while a greater width is a waste of space; the thickness of the line should not be less than one-twentieth of the height of the figure, that is, half a unit, nor greater than 1½ units.

As regards individual figures, the 0 should be an ellipse with the height 10 units. In 1, if any serif is used, it should be a very small one to avoid confusion with 7. In 2, the width is 7 units and the upper part of the figure should be half an ellipse. For the sake of legibility, a curve at the lower part of the breast is much better than a straight line making an acute angle with the bottom bar. In designing the figure 3, care must be taken to avoid confusion with 5, as well as with 8. For this reason the author recommends the flat topped 3. To emphasize the difference from 5 the upper part should be set back a little to the right. The 4 is with the stem united to the sloping line, with the line one unit thick; the lower side of the bar should be 3 units from the base line and the bar should overhang to the right 2 units which gives a slope of three in two for the slanting line.

In 5 the line joining the bar with the lower part is not quite vertical but has a slope of one-half unit in five; more would tend to confusion with the 3. The lower part of the 5 should consist of about three-quarters of a circle of outside diaemter of 7 units. The top bar may be 5.5 units long. In drawing the 6, care should be taken to provent confusion with 8 and with zero. The author proposes that the lower part should be an ellipse, width 7, height 6, and the upper part an arc of 7 units radius struck from the end of the major axis of the ellipse. The 9 is simply the 6 reversed. The top bar of 7 should be 7 units wide and the down stroke should have a slight curvature, say 30 units radius. The 8 consists of two slightly unequal parts with the major axis of 6 for the upper part, and a minor axis 5 units, while for the lower part the minor axis is 6, making the middle of the common line 5.5 units above the base. (*The Journal of the Institution of Electrical Engineers*, vol. 54, no. 255, p. 273, February 1, 1916, 2 pp., 5 figs. *g.*)

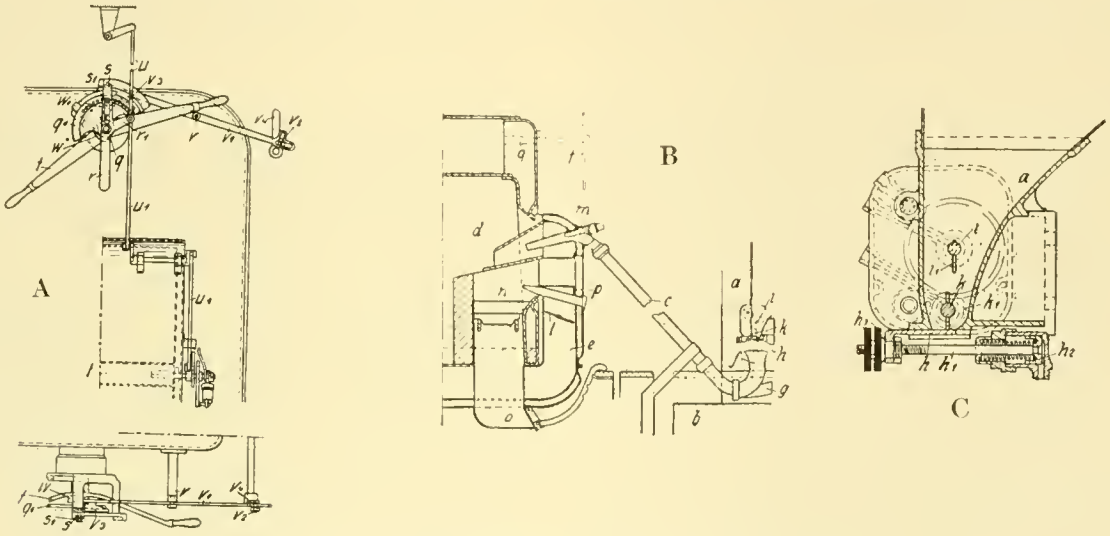


Fig. 10 Peat Burning Arrangement for Locomotives

The Small Oscillations of a Kite, Professor G. H. Bryan

The mathematical investigation of the small oscillations of a kite.

The main difficulty which distinguishes the problem of the kite from that of the aeroplane is connected with the action of the kite string, and as it is uncertain how far it would be worth while to give a general solution of the problem, the paper is limited to the consideration of the small oscillations of the kite about its position of equilibrium. In this case, the expressions for the linear and angular accelerations for fixed and moxing axes become the same, while the conditions introduced by the forked string may be satisfied by treating the point of attachment as being different for the longitudinal and lateral oscillations.

In this paper, equations are formulated for the general case in which the string is of finite length and extensible, and particular modifications occur when the string is inextensible and when it is practically infinite in length. Neither the weight or inertia of the string, nor wind resistance on the string are taken into consideration.

Among other things, it is of interest that the author uses the method of cross multiplication in writing down some of the expressions, because, as he states, he finds it of very great use in writing down the equations of motion of a rigid body or the six components of a system of forces; it is well that anyone who is obliged to make use of these formulae should know of this simple method of writing them down.

The paper covers the general equations of small oscillations with the center of mass as the origin, and the changes of constants due to displacement of the vectors representing the components of tension, gravity, and wind velocity with the rotation of the axes.

The problem of lateral oscillations is considered for the cases of an infinitely long string of a plane kite without keels or auxiliary surfaces offering no tangential resistance, and for the case when the point of attachment is fixed. The longitudinal oscillations are considered for the case where the string is of finite length and extensible; finite but inextensible; infinitely long and inextensible; very extensible, and finally when the point of attachment is fixed. (*The Aeronautical Journal*, vol. 19, no. 76, p. 114, October-December 1915, 8 pp., 1 fig. *tm.*)

Turbo-blowers and Compressors, H. L. Guy and P. L. Jones

General discussion of the theory and to a certain extent practice of turbo-blowers and compressors from a paper read before the South Wales Institute of Engineers.

The paper discusses the advantages of the rotary type of machinery of this kind as compared with the reciprocating type and then passes on to the theory of design and operation of turbo-blowers. It takes up general formulæ, the question of the surging point, the effect of the use of blades of various shapes and presents some formulæ on design. It discusses also in considerable detail the question of governing. A similar discussion is given in connection with turbo-blowers.

The subject of commercial testing of blowers is discussed in detail, the formula and calculation being given in the article. An appendix describes a convenient and accurate method of measuring large air quantities. (*Engineering*, vol. 101, no. 2615, p. 143, February 11, 1916, 6 pp., 20 figs. *dt.*)

Two-stage Air Refrigerating Plant for Dry Blast

Discussion of various methods of desiccation of air for blast furnaces, in particular those based on air cooling and depositing of the moisture in the form of a condensate or frost.

The first step in the way of an improvement on the original Gayley process was the application of two-stage refrigeration. Since the air has to be cooled from perhaps 80 deg. fahr. down to about 16 deg. fahr., it is clear that if the whole of the cooling be carried out at one constant back pressure on the refrigerating plant, there will be a great waste both of refrigerating capacity and power, for that back pressure would have to be such as to produce an evaporating temperature for the ammonia within the refrigerating system low enough to cool the air to its lowest limit of 16 deg. fahr.

When the two stages of the cooling are kept separate, a different back pressure can be used for each and this means a considerable economy since at higher back pressures both the density and the latent heat of ammonia are increased; that is the useful refrigerating effect per stroke of the compressor piston is greater. The effect is also produced per ton of refrigeration so that the net result is a smaller plant for the same duty operating at less expense. From data taken from a plant erected for the Steel Company of Canada at Hamilton, Ont., it was found that in the first stage the temperature is so high as to preclude the formation of frost, and only second stage cooling pipes require thawing off.

In the two-stage system adopted by Messrs. Haslam, of Derby, water instead of brine is used for the first stage cooling. They use an interesting type of cooler consisting of a series of direct expansion cooling pipes in conjunction with batteries of galvanized corrugated steel plate over which the water or brine trickles. All the frost that would otherwise be formed in the second stage is carried away in the brine and the latter can be brought up to strength as required by evaporation or addition of fresh calcium chloride.

Of a still more recent design is the dry blast plant of L. Sterne & Co., Ltd. using the so-called Heenan cooler (for a complete description of this cooler see *Engineering*, Sept. 4, 1914, page 313). The principal parts of this cooler are a casing, a drum which revolves slowly within the casing, and a fan. The lower part of the casing is formed into a trough which is filled at one end with water and at the other with brine, both cooled by the refrigerating plant. The air in its course through the cooler meets the water first and after that the brine and is progressively cooled by these two agents to its final temperature of 25 deg. or below. Shell coolers are used for refrigerating the water and the brine, and the ammonia suctions from the two coolers are taken to different compressors at different pressures, so realizing the benefits of two-stage compression.

An important feature in the action of the cooler is that the cooling liquids are picked up in thin films and not by drops or globules as in the cases where the liquids trickle downwards over the cooling surfaces. Hence there is no danger of moisture being entrained by the air and carried over to the tuyeres. A chart given in the article shows that while the air before cooling has a humidity varying from 3.5 to 11.6 gr. per cu. ft., it leaves the apparatus with a fairly constant humidity, averaging about 0.75 gr. (*Engineering*, vol. 101, no. 2615, p. 125, February 1916, article not finished. *d.*)

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Vergleich der van der Waalsschen mit der rein thermodynamischen Zustandsgleichung, und eine neue Methode zur Bestimmung der kritischen Grössen, der Grenzdichten und der Inversionskurven. L. Schames. Beiblätter zu den Annalen der Physik, vol. 40, no. 1, 1916, 2 pp.

Comparison of the van der Waals equation with the purely thermodynamic equation of state, and a new method for the determination of the critical magnitudes and curves of inversion.

Experimentelle Bestimmung der kritischen Grössen von Sauerstoff, Stickstoff, Kohlenoxyd und Methan. E. Cardoso. Beiblätter zu den Annalen der Physik, vol. 40, no. 1, 1916, 1 p.

Experimental determination of the critical magnitudes of oxygen, nitrogen, carbon monoxide and methane.

VARIA

Compound Technical Terms. D. E. Carpenter. Bulletin of the Society for the Promotion of Engineering Education, vol. 6, no. 6, Feb. 1916, 4½ pp.

PROCEEDINGS SECTION

THE papers selected for this issue are from contributions by Local Committees, and it is a striking commentary on the national scope of our organization that they have been read at meetings in the widely separated states of Louisiana, California, Massachusetts, Minnesota and Missouri. The first two papers deal with the reclamation of the lowlands of the South and Southwest; one of these was presented at the Spring Meeting. Papers on a new development in safety valve design, portland cement chemistry and manufacture, and on specifications and contracts conclude the section.

THE EVOLUTION OF LOW-LIFT PUMPING PLANTS IN THE GULF COAST COUNTRY

BY W. B. GREGORY, NEW ORLEANS, LA.

Member of the Society

SINCE the time, ages ago, when an arm of the Gulf of Mexico extended as far north as Cairo, Illinois, the mighty Mississippi and its tributaries have been building up the alluvial deposits of the delta through which it flows. Wells drilled at various points in the alluvial country have shown that the depth of the deposits is more than 3000 ft. in some instances. The deposit is very fertile as it was formed from the best of surface soil from the various states above. Usually the surface of the wet prairies, when first reclaimed, is covered with muck or humus, the decayed vegetation of hundreds of years, to a depth varying from a few inches to several feet. This material is rich in nitrogen and is a valuable fertilizer. The Southern half of Louisiana contains much wet prairie land, the Eastern portion of which is alluvial, while the Western part and the wet lands of the coast of Texas are the lower and poorly drained portions of the coastal plain, elevated from the bed of the Gulf during some mighty upheaval in a geological epoch long ago. This soil is usually a silt loam with an impervious clay subsoil. It has been found especially well adapted to the cultivation of rice.

As the alluvial soil was deposited by the rivers, the highest land is found near the banks and there is a gradual slope from the rivers and bayous back to the swamp. Previous to the last decade the only reclaimed agricultural lands in Louisiana were in the rear of sugar plantations. The early planters cultivated the narrow strip of land along the streams, which could be drained by gravity. The width varied greatly, but usually the distance from the levees back to the swamp was from half a mile to two miles. The cultivation of sugar cane created a demand for more land and the demand was met by continuing the plantations in the direction of the swamps and removing the water by means of pumps from lands too low to drain by gravity.

About ten years ago a movement was started by Edward Wisner to reclaim the wet prairie lands lying at or near Gulf level. The work is now being carried out on an extensive scale. More than a quarter of a million acres of agricultural lands have been reclaimed or are at present in the process of reclamation in the State of Louisiana. These lands in their natural state produce nothing more valuable than water grass, but when reclaimed they are classed with the most fertile and productive to be found in the world.

In this section, it was only natural and normal that pumps used successfully in drainage work would be employed in the irrigation of rice when that industry developed. Often the lift for irrigation did not exceed that in common use in drainage plants and especially in relift irrigation pumping plants. Drainage by pumps was an accomplished fact before the irrigation of rice assumed proportions that made the industry of economic importance. Later on drainage received a fresh impetus from the reclamation of the wet prairie lands while the rice industry had attained maturity. The story of pumping plants in this section at times must therefore deal with drainage and at times with irrigation.

New Orleans was founded by Bienville in 1718. The site on a narrow strip of land with a swamp in the rear, was

FIG. 1 MISSISSIPPI RIVER LEVEE IN LOUISIANA

chosen because on one side Bayou St. John gave an opportunity for transportation, with the small craft of that day, from the rear of the city into Lake Pontchartrain, and out through the Rigolets to the Mississippi Coast; while on the other side of the river, opposite the city, Bayou Barrataria offered transportation facilities to the South through a network of bayous to the Gulf. By both these routes the city could be approached without stemming the current of the river. One of the first acts of the early colonists was to build a small levee in front of the city. The height has been raised from time to time because of increased flood heights, due largely to the confining of the upper river between levees instead of allowing it to overflow large areas.

In the city of New Orleans a large portion of the surface is at or near Gulf level and an artificial water level must be maintained several feet below that of Lake Pontchartrain, which opens into the Gulf and normally is at the same elevation. The city is not only protected from the Mississippi on the river front by a levee, but is entirely surrounded by levees. There is one near the shores of Lake Pontchartrain, while

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protection levees extend from the river to the lake both above and below the city to guard against the possible danger due to crevasses in the levees of the river above or below the city. All the run-off must therefore be pumped and some of the water is elevated two or three times before it is finally discharged into Lake Pontchartrain or through Bayou Bienvenu into Lake Borgne.

The drainage of agricultural lands is quite a different problem from the drainage of a city. While it is undesirable to have ditches and canals overflow their banks on farm lands, because of the possible injury to crops, flooding at rare intervals, provided the water may be removed before serious losses result, may be justified as good engineering; while in a city all floods are to be prevented in so far as possible. In any

Fig. 2 Drainage Wheel, Southside Planting Company

case, the first cost of the works required to eliminate the danger, the interest on the investment, and the depreciation and the upkeep are to be considered and balanced against the possible damage from floods and the damage which is dependent on the average period between the occurrence of unusual storms.

The capacity of pumping plants varies with many factors among which may be mentioned: (*a*) rate and distribution of rainfall; (*b*) general design of collecting ditches and canals, including their storage capacity, cross section, slope and arrangement; (*c*) nature of the territory drained. The run-off will be much greater for a city with paved streets and closely built structures than on agricultural lands. Again the condition of agricultural lands or the kind of crop produced will affect the run-off.

The rainfall map of the United States shows that there is an area extending from the North shore of Lake Pontchartrain, east along the coast of the Gulf of Mexico, and far into Florida, where the rainfall is 60 in. or more per annum. West of New Orleans the rainfall decreases to 50 in. per annum near the Sabine River, the boundary line between Louisiana and Texas, and falls to 30 in. in the eastern half of Texas. But the rate at which precipitation takes place has an important bearing on the capacity of the pumps that are required to remove the run-off from the nearly level lands. A few examples of unusual storms will make clear that the problem is one not shared by the other parts of this country. On April 25, 1907, 7 in. of rain fell in 5 hours and 8.59 in. in 12 hours. On March 22 and 23, 1912, unusual rainfall occurred. The records kept by the Sewerage and Water Board of New Orleans showed the following rates of precipitation:

5 minutes	.68 in.
5 minutes	1.09 in.
10 minutes	1.38 in.
15 minutes	1.69 in.
20 minutes	2.00 in.
1 hour	2.48 in.
2 hours	4.66 in.
2¼ hours	5.07 in.
Total, 2 days	7.23 in.

The United States Weather Bureau records at the New Orleans station show that there have been 57 storms in the past 26 years during which the precipitation in 24 hours exceeded 3 in. These storms are classified as to their intensity as follows:

57 rains exceeding 3 in. in 24 hours.
25 rains exceeding 4 in. in 24 hours.
10 rains exceeding 5 in. in 24 hours.
5 rains exceeding 6 in. in 24 hours.
3 rains exceeding 7 in. in 24 hours.
3 rains exceeding 8 in. in 24 hours.
0 rains exceeding 9 in. in 24 hours.

The maximum rainfall in 24 consecutive hours recorded at New Orleans was 9.22 in., April 7 and 8, 1883. The normal rainfall, which is typical of that for a large portion of the State and especially for the reclaimed lands to the South and Southwest of New Orleans, is remarkably well distributed and the growing season of June, July and August receives the maximum rainfall.

Run-off is usually stated in terms of a drainage coefficient or the depth in inches of water, if spread over the entire area to be drained, removed in 24 hours. In the Upper Mississippi valley and along the Illinois River, a drainage coefficient of ¼ in. has been found satisfactory. In the later plants, however, there has been a tendency towards greater capacity and pumping plants recently installed have been designed for a drainage coefficient of $^3/_{10}$ in.

In Louisiana, it is only in recent years that a drainage coefficient has been worked out. The older pumping plants varied widely in capacity according to the ideas of the parties who installed the machinery. In its 1909 Drainage Investigations, the U. S. Department of Agriculture started some work in Louisiana along the following lines:

(1) To study the soil, climate, and the natural condition with special reference to the drainage problems encountered and the value of the land for agricultural purposes when successfully drained.

(2) To collect such technical data and to examine such details of present practice as will afford information of value to land owners and especially to engineers interested in the reclamation of such lands.

(3) To disseminate in available form the results of the investigations and to encourage land drainage by emphasizing the benefits to be derived from bringing such lands under cultivation.

This work, inaugurated by Arthur M. Shaw, Drainage Engineer, and the writer, has been continued since 1909 by Chas. W. Okey, Drainage Engineer, and much information of value has been collected and made available.

The area of the individual drainage districts varies from

[1] The Wet Lands of Southern Louisiana and Their Drainage, U. S. Dept. of Agr., Bulletin 71, by Charles W. Okey.

a few hundred acres in the smaller districts to several thousand acres in the larger ones. The pumping capacity in 24 hours was found to vary from less than 0.9 to 1.51 in. These figures represent average practice in Louisiana and are being used as a guide in deciding the capacity of drainage pumping plants for agricultural lands.

Mr. Okey sums up the records of a rainfall and run-off from four drainage districts of Louisiana, as follows:

In the year 1914 the results from the Poydras, Des Allemands, Jefferson, and Raceland plants may be said to be typical. In addition, the results from the last-named district for 1913 are also typical. An average of the records for 1914 for each of the districts and including the records for 1913 from the Raceland district, gives the following results:

Rainfall	50.85 in.
Run-off	22.59 in.
Days per year on which operation occurred	104
Number of times per year boilers were fired	97
Number of 24-hour days per year at full capacity	21.1
Average number of hours run at full capacity per fire-up	5.2

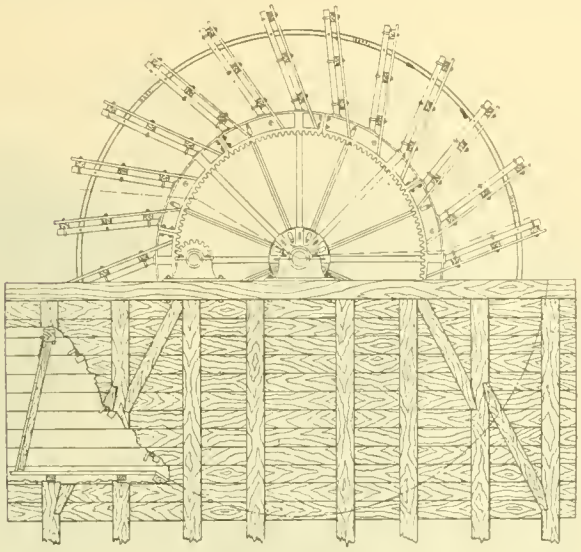


Fig. 3 Drainage Wheel, Southside Planting Company

While the above rainfall is slightly below normal for this section of the State, it is believed that the percentage of rainfall appearing in run-off in the above average will not be far from normal. With the mean annual rainfall of 56 in. and the same percentage, the amount to be pumped would be 25 in. per year. Therefore a plant with a 24-hour capacity of 1.25 in. in depth of water over the area drained would have to operate an average of about 20 days of 24 hours each, per year. Where such factors as leaky levees enter in, the amount of pumping would of course be greatly increased. Where the capacity of the plant is much less than specified above, the amount pumped would be somewhat less, due to evaporation prior to pumping.

It must not be thought that the large rainfall and run-off impose too great a burden in the cost of pumping water from the reclaimed wet prairie lands. Information has been collected and compiled by C. W. Okey in regard to the cost of operating several drainage pumping plants for periods varying from two to eight years and for a variety of types in equipment. The tabulated costs include fuel, labor, repairs and incidentals. The figures indicate that the cost per acre per year will range from $0.50 to $1.25, depending on the sort of machinery used, the cost of fuel and the peculiarities of the season. For those using steam plants he finds the cost of fuel per acre foot, lifted one foot, less with Corliss engines than with slide valve engines. For average seasons, in each case, the depth of water to be removed from land in drainage is less than the depth of water pumped onto the land in rice irrigation and the average lift in drainage is much less than that in irrigation.

THE DRAINAGE WHEEL

The first pumps to be used in the Gulf Coast country for artificial drainage were undoubtedly of the "drainage wheel" or "scoop wheel" type. The latter term is misleading, for it would seem to imply that the paddles were made in the form of scoops, which is not the case. The paddles are usually straight boards, inclined back at the periphery of the wheel. Small drainage wheels have been operated by horse or mule power, and there are many of the steam-driven drainage wheels yet in use in Louisiana. Some are of venerable age, while others date from a comparatively recent period. Many of the old drainage wheels of the sugar plantations worked between brick piers that were substantially constructed. Some of the later installations used foundations of wood, resting on long piles. The cost of foundations and the difficulty of holding

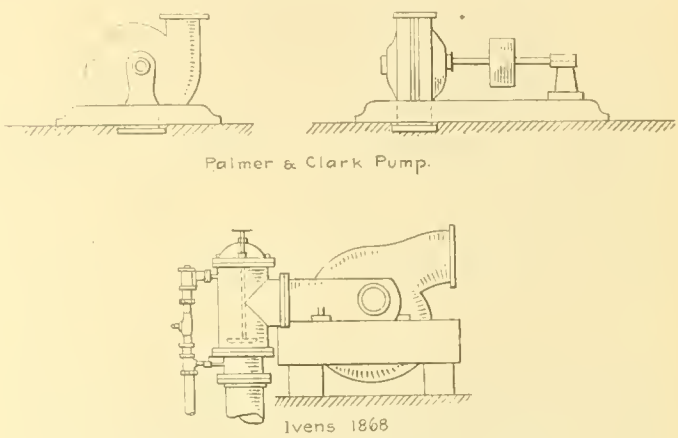


Fig. 4 Types of Centrifugal Pumps

them rigidly in most localities has increased the cost of the drainage wheels to such an extent that they have been practically eliminated from competition with other cheaper forms of pumping plant.

A point against the drainage wheel is the difficulty involved in adjusting its height. Once set, the depth to which the water may be lowered is definitely fixed. As a rule these wheels are expected to pump against a maximum head equal to one-fourth the diameter. The large steam-driven wheels usually range from 28 to 32 ft. in diameter with a width of from 4 to 7 ft. The humus of the reclaimed land in time disappears as the land is cultivated and the level of the land seems to fall. The amount of shrinkage varies with the conditions as the depth of humus is not uniform. As a result, after a few years it has been found desirable to pump to a lower level and with a drainage wheel it requires either a lengthening of paddles or the lowering of the foundations and power plant.

TESTS OF DRAINAGE WHEELS

The writer made a test of a drainage wheel in 1905 used to drain the sugar plantation of the South Side Planting Co., on the right bank of the Mississippi River, opposite New Orleans. The plantation contained 1700 acres, 1600 of which were then under cultivation. Fig. 2 shows this wheel.

Open ditches were used exclusively. The smaller ones were brought together successively and terminated in a large canal leading to the drainage wheel. The water drained away from the river. The flow was obtained by deepening the ditches as

they approached the pumping plant, as well as from the natural slope of the land. Here the water was elevated and then flowed back into the swamps. The plantation was protected from backwater by means of a levee.

The general design of the wheel and method of bracing are clearly shown in Fig. 3. It is a type of its class, but has some distinct features in the double gearing and in the number of paddles. Care was exercised so to design the wheel that the water would not be lifted unnecessarily. The backward flow through the pump wheels when at rest was prevented by the swinging door shown in Fig. 3.

The diameter of the wheel is 28 ft., and the width 6 ft. It is driven by a simple non-condensing engine of the slide valve type, having a cylinder 16 in. in diameter and a stroke of 24 in. The steam pressure was 40 lb. or less and wood was ordinarily used as fuel.

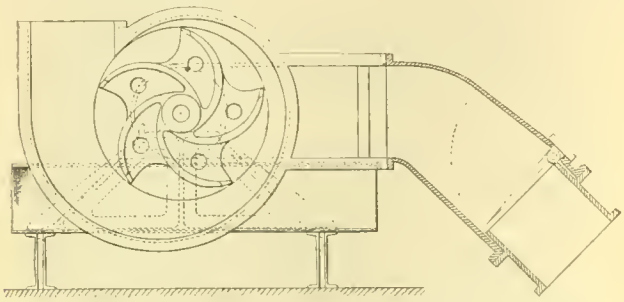


Fig. 5 Ivens Centrifugal Pump, Horizontal Shaft

The test was made while pumping out the canal system and was necessarily short, lasting only about an hour. The method of testing consisted in traversing the discharge flume with a current meter and taking indicator cards and other observations as quickly as possible after traverse was finished. By this means the indicated horsepower was a little less than the mean corresponding to the water measurement, but as the latter required only about ten minutes, the error was not great. This method was rendered necessary by lack of observers.

The results given below are very satisfactory, as they show an efficiency of engine, transmission gears, and pump in every case exceeding 38 per cent, and in two cases considerably above that figure, while the actual lift of the pump varied from 2.4 ft. to 2.86 ft. During the last observation the paddles dipped into the water to a depth of approximately 1 ft., and the slip or backward flow was quite large. The clearance on the sides of paddles was about ¾ in.

Location, Southside Planting Co.

Steam pressure, average, lb	38.2
Speed of engines, average, r. p. m.	66.1
Indicated horsepower, average	9.68
Speed of wheel, average, r. p. m.	2.22
Head, average, ft.	2.69
Discharge, average, cu. ft. per sec	14.34
Useful water horsepower, average	4.27
Efficiency, average, per cent	43.4

These results are confirmed by a test made by W. M. White, Mem.Am.Soc.M.E., of a similar drainage wheel in New Orleans in August, 1900. The wheel tested was used at that time in one of the city drainage stations at London Avenue. Since the inauguration of the new drainage system it has been taken down and removed.

The log of the test shows that between 50 and 60 cu. ft. of water per sec. were pumped through a height varying from 4 to 5 ft. The efficiency of engine, gearing and pump ranged from 45 to 50 per cent. The duty per 100 lb. of coal was approximately 13,000,000 ft-lb.; the water rate of the engine 50.5 lb. per i.h.p-hr. The engine was of the type used in Mississippi River steamboats; diameter of cylinder 18 in., length of stroke 54 in. During the test the engine made about 35 r.p.m.

The drainage wheel was used extensively in this city previous to 1900. The combined capacity of the drainage wheels in the drainage equipment of New Orleans previous to the inauguration of the present system was 1170 cu. ft. per sec. with a lift of 5 ft. The one centrifugal pump then in use brought the total amount up to 1214 cu. ft. per sec. However, the accuracy of the capacity rating of these wheels is in doubt. While a capacity of 300 cu. ft. per sec. with a lift of 5 ft. was claimed for the two London Avenue machines or 150 cu. ft. per sec. for each, the test made by W. M. White in 1900 gave between 50 and 60 cu. ft. per sec. with a lift of approximately 5 ft. However, it is possible that the machinery might have been speeded up and the capacity considerably increased.

THE CENTRIFUGAL PUMP

So far as the writer has been able to learn, the first centrifugal pump manufactured in the State of Louisiana was

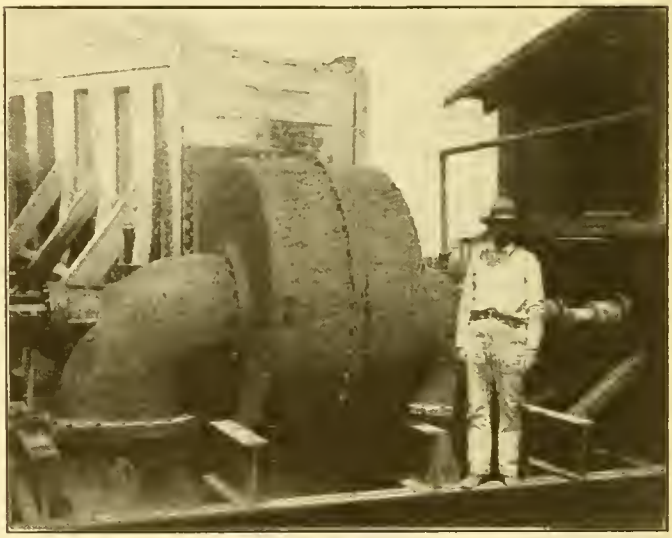


Fig. 6 Ivens Pump at Acadia Canal Relift

made by John Clark, a prominent foundryman, in the early fifties. It was similar in design and construction to the Palmer pump which had been used with varying success about that time in drainage work. The origin of the Palmer pump is uncertain.

Both pumps were decidedly crude as there was very little machine work done on them and all joints were made with red lead, excepting that between the shells, which was composed of sal ammoniac and cast iron borings. The vertical suction extended through the bed plate and great difficulty was experienced in making a satisfactory joint with the suction pipe.

The centrifugal pump in some of its various forms has proved to be a favorite for the work of irrigation and drainage where large volumes of water must be elevated through only a few feet lift. In Fig. 4 are diagrams of two of the early types of centrifugal pumps.

There are many reasons for the popularity of the centrifugal pump among which may be mentioned low first cost, reliability of operation and simplicity of construction. If properly designed for the conditions under which it is to

operate, it is efficient. Twenty-five years ago efficiencies of 50 to 60 per cent were considered good practice where the lift was moderate. Today many different centrifugal pumps may be found in irrigation work that have shown efficiencies of more than 80 per cent under carefully conducted tests. Drainage pumps of the centrifugal or screw type or a combination of both have developed efficiencies on lifts less than 10 ft. that were thought impossible a few years ago.

It has also been realized that the design of the pipes to conduct the water from the suction basin to the pumps and from the pumps to the discharge basin or flume is well worthy of careful consideration. A few years ago it was a common practice to use straight suction and discharge pipes having the same diameter throughout. In recent years examples of this kind of ignorance of the fundamental laws of hydraulics have been uncommon in the Gulf Coast country, although they are found in parts of the Mississippi valley and occasionally descriptions of such plants find their way into the technical press.

In drainage installations where the lift is usually between 4 ft. and 10 ft., the losses at the entrance of suction pipes

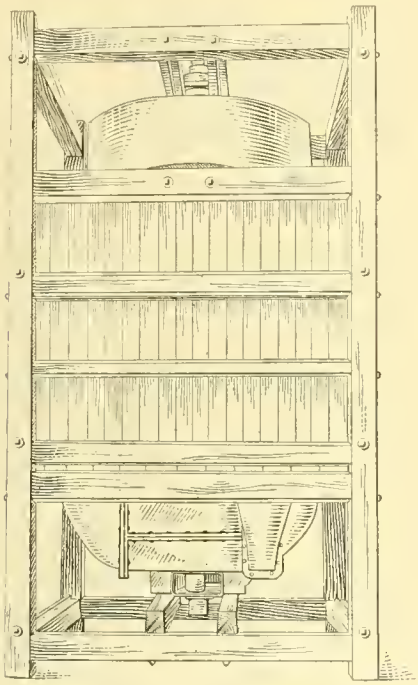


Fig. 7 Ivens Quadruple Discharge Pump, Box Type

and the kinetic energy that may be thrown away at the end of the discharge pipe, together make up a large percentage of the energy required. The entrance loss in feet of water is usually estimated at 0.93 of the velocity head at the entrance. The discharge loss is equal to the velocity head at the end of the discharge pipe. If the pipes are round and the diameter is doubled at suction and discharge end, the area is multiplied by four and if pumping a constant quantity of water there will be entrance and discharge velocities one-fourth as great as with straight pipes. Losses vary as the square of the velocity so they will be reduced to one-sixteenth of the loss of a straight pipe, if the diameter of the ends of suction and discharge pipe are gradually enlarged to twice the diameter of the straight pipes, or if not round in cross section, the area is increased to four times that of the original pipe.

In the late sixties the Ivens pump was invented by Edmund M. Ivens of New Orleans, grandfather of E. M. Ivens, Junior Member of the Society. It was mounted on a heavy wooden frame, and was readily installed over the intake or suction water and discharged through a flume bolted to the discharge.

The pump was fitted with a surface valve to which was connected a steam jet. The jet discharged through a check valve, thus priming the pump. During the process of priming, the connecting valve on the lower side of jet was opened slightly and vacuum established between valve and suction water. When in operation the valve rode the suction column, thus permitting the full area of suction opening. The pump was

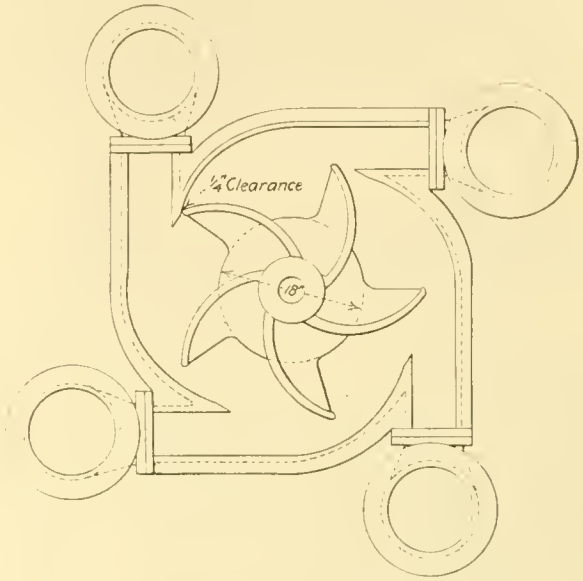


Fig. 8 Diagram of Casing and Impeller, Ivens Quadruple Pump

properly finished and on account of the results obtained is prominently identified with the drainage work of that period, in this section. Later on it was used in rice irrigation.

The Ivens pump was made in a variety of forms and sizes. Vertical shaft iron pumps had double suction openings. The smaller sizes had a single suction pipe but cored passages around the outside of the volute of the pump so that water entered the impeller from both sides. In the largest size independent suction pipes were used. The writer tested several Ivens pumps during the irrigating season of 1905 and the results from two different plants here follow.

TESTS OF IVENS CENTRIFUGAL PUMPS

A test was made by the writer on July 31, 1905, of the pumping plant forming the first relift of the Abbott-Duson canal system. The plant is located at Egan, La., about 2½ miles east of the main pumping plant. There are two Ivens pumps rated as 36 in., but the lift is so small that the pumps each discharge through a rectangular opening into a separate flume, having gradually expanding cross sections. The two flumes are brought together at a distance of about 50 ft. from the pumps into a larger flume, which discharges into the canal beyond the plant.

The boiler equipment consists of three horizontal return tubular boilers, 72 in. in diameter by 18 ft. long, each containing seventy-two 4-in. tubes. Crude petroleum is used as fuel. The two pumps are driven through the medium of a rope driven by a simple condensing Corliss engine, 24 in. diameter of cylinder and 48-in. stroke. The flywheel is 16 ft. in diameter and has 18 rope grooves. There are 1850 ft. of 1¼-in. rope required for the drive.

Under ordinary conditions an open heater is used. A direct-acting steam pump furnishes water to the heater, and a similar pump takes the water from the heater and delivers it to the boilers. The heater receives the exhaust from these two pumps and also from the condenser pump. During the test the heater was not used, as the water had to be measured. The piping was changed so that one of the pumps furnished water to fill two calibrated barrels, so placed that they could be emptied through a 2-in. valve into a lower barrel. The suction of the second pump was attached directly to the lower barrel, and this pump was used to feed the boilers.

The measurements of the water discharged by the pumps were made by the pitot tube. The discharge flume in which the measurements were made was 18.75 ft. wide. The depth of water varied from about 1.5 ft. to a little over 1.6 ft. The

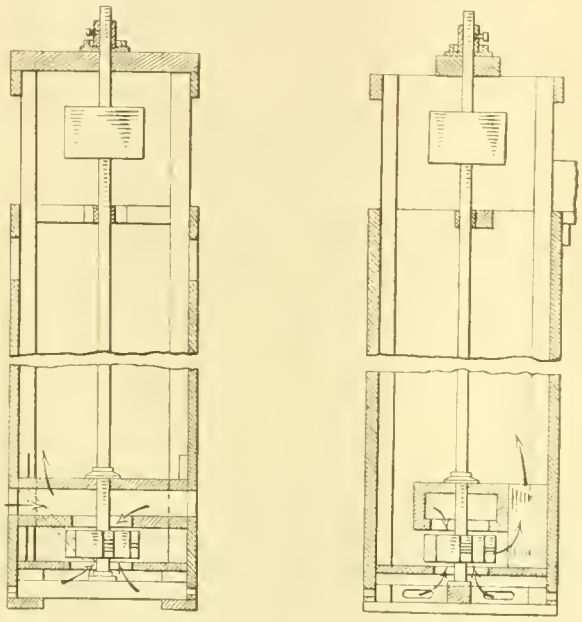


Fig. 9 Menge Pump

cross section was divided into 20 rectangles of equal size and the mean velocity obtained at the center of each rectangle, or, in other words, the velocity was observed at ten different stations across the flume and at two different depths at each station.

The crude petroleum used for fuel during the test was measured in a calibrated barrel, the amount per hour being 712 lb. The following day fuel oil was measured for 1 hr. and 57 min., the feed-water heater being in use. It was found that the consumption of oil per hour was 603 lb. The temperature of water entering boiler was 200 deg. fahr. instead of 92 deg. fahr., as found when heater was not used. The theoretical gain by using the feed water is about 11 per cent, while the actual difference in fuel used amounted to nearly 20 per cent. The discrepancy is accounted for by the difference in the amount of water present in the fuel oil. For example, during the test on July 31 the amount of water in the fuel oil was sufficient to put out the fires momentarily on two occasions, and to require careful oversight of the oil burners to prevent irregularities in the amount of combustion and, consequently, in steam pressure. On the second day the oil in the supply tank had become quite thoroughly separated from the water, the latter having settled to the bottom, and the result was that there was no trouble with the burners.

During the test, indicator cards were taken at 15-min. intervals, and observations were made of steam pressure, vacuum gage, revolutions of engine and pump, and of head pumped against. At intervals of a half hour water measurements were taken in the flume, and the temperature of water, oil and air was noted. The amount of water and fuel oil used was also carefully noted.

The efficiency of engine, transmission and pump is excellent—in fact, the best of any of the plants tested in 1905 in which centrifugal pumps are used. This efficiency had an average value of 64.2 per cent. If the efficiency of the rope drive is assumed to be 95 per cent and the mechanical efficiency of the engine as 90 per cent, the efficiency of the pump is found to be about 75 per cent. The results of the tests are as follows:

Location, First Relift, Abbott-Duson Canal.

Duration of test, 4 hr.
Total fuel oil, 2886 lb.
Average steam pressure by gage, 65.6 lb. per sq. in.
Average temperature of feed water, 92 deg. fahr.
Factor of evaporation, 1.157.
Total weight of water fed to boiler, 28,629 lb.
Equivalent water evaporated from and at 212 deg. fahr., 33,112 lb.
Boiler horse-power, 240.
Average temperature of fuel oil, 171 deg. fahr.
Average air temperature, 92 deg. fahr.
Water apparently evaporated per pound of oil, 9.92 lb.
Equivalent evaporation from and at 212 deg. fahr. (not corrected for quality of steam), 11.47 lb.
Total feed water (including steam used by auxiliaries) per indicated horse-power hour, 31.2 lb.

Average speed of engine, r.p.m.	66.8
Average indicated horse-power	229.8
Average speed of pump, r.p.m.	118.5
Average head, ft.	11.24
Average discharge, cu. ft. per sec.	115.4
Average useful water horse-power	147.1
Average efficiency, per cent	64.2

The Acadia relift, which was tested by the writer in August, 1905, is located on the main Acadia Canal, about a mile north of Iota, La. The pump is nominally an Ivens 36-in. pump, similar to those at the Abbott-Duson first relift, and having two suction pipes 24 in. in diameter (see Fig. 6).

The equipment of this plant includes two horizontal return-tubular boilers 72 in. in diameter by 18 ft. in length, each containing seventy-two 4-in. tubes. Fuel oil is used. The boilers are fed by means of two direct-acting steam pumps. One pump takes water from the canal and furnishes it to the open heater. Another pump takes the water from the heater and pumps it into the boiler. Both pumps and the engine exhaust into the heater.

The engine is a simple, non-condensing Corliss, cylinder diameter 22 in., stroke 42 in. The pump is driven by rope drive. There are 10 grooves in the engine flywheel and 958 ft. of 1½-in. rope are used.

The discharge from the pump was measured in the flume about 50 ft. from the pump. At this place the flume had a uniform cross section 9.27 ft. wide and about 1.8 feet deep. A current meter was used and the cross section slowly traversed at three different depths to obtain the mean velocity in all but two observations, when the pitot tube was used. With the latter instrument the velocity was observed at ten different stations across the flume and at three different depths in the first observation and at two different depths in the second.

The arrangement of the plant is similar to that of the Abbott Duson first relift, except that there is only one engine and one pump, instead of one engine and two pumps. Both the engine and the rope drive were larger in the case where two pumps were used, but the loss due to friction in the two cases probably was not very different. The height through which the water was lifted was a little greater with the two

pumps than with the single pump of the Acadia relift, and this probably had some effect on efficiency.

It was practically impossible to make a complete boiler test because the necessary changes in the piping could not be made for measuring the feed water. Fuel oil, however, was measured by means of a calibrated barrel, and a partial boiler test of 4.45 hours duration was run, during which time the average steam pressure by gage was 79.4 lb. per sq. in. and 1567 of fuel oil were consumed. The data of the engine and pump test are given below:

LOCATION, ACADIA RELIFT.

Duration of test, 4 hr.	
Steam pressure, average, lb	79.4
Speed of engine, average, r. p. m	68.8
Indicated horse-power, average	137.7
Speed of pump, average, r. p. m	117.2
Head, average, ft	9.49
Discharge, average, cu. ft. per sec	71.4
Useful horse-power, average	76.5
Efficiency, average, per cent	55.6

The Ivens pump was made in a special form for low lifts. A wooden box was used for the body of the pump. Into the box the impeller discharged its water through two or four expanding nozzles. The impeller, the vertical shaft and the parts surrounding the impeller including the cast iron nozzles, were made of metal while the remainder was constructed of wood. Figs. 7 and 8 show some of the details of this pump which was especially adapted to drainage where low lifts prevail.

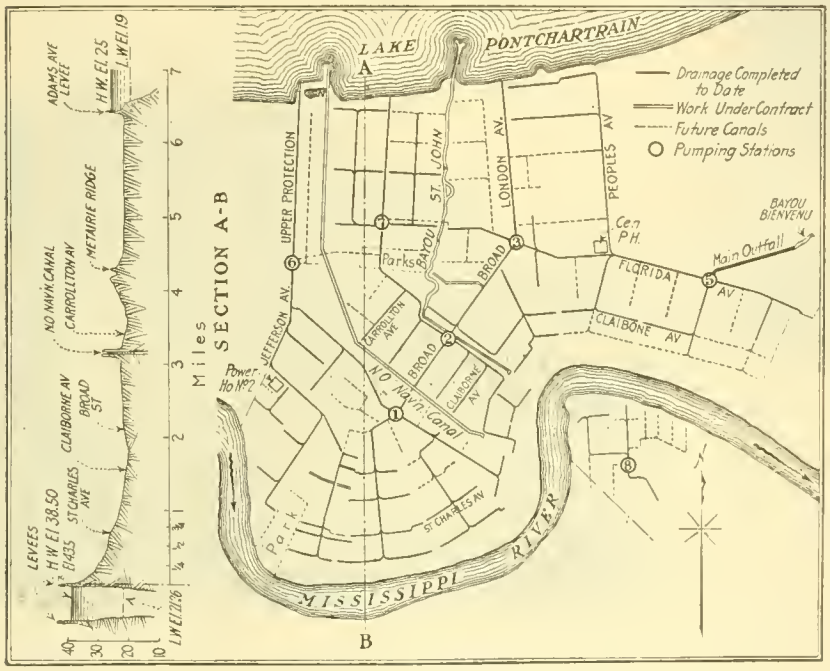


FIG. 10 MAP OF NEW ORLEANS SHOWING COMPLETED AND PROPOSED DRAINAGE CONSTRUCTION

THE MENGE PUMP

The Menge centrifugal pump was brought out by the late Joseph Menge, to whom patents were issued in 1888 and 1891. S. L. Menge, son of Joseph Menge, patented in 1910 an improvement in the number and area of passages by which the water enters the pump.

As ordinarily constructed, the body of the pump is of wood, although concrete has occasionally been used. The shaft is vertical and the impeller is submerged in the water to be pumped. The openings in the bottom of the pump box were arranged to admit water both above and below the impeller. A ball bearing at the top of the shaft takes the weight of the moving parts. Aside from the shaft, impeller and bearings the pump is entirely of wood and can be easily and cheaply erected. As the water pours over the top, the quantity of water pumped is impressive.

The pump is made with impellers varying in size from 8 in.

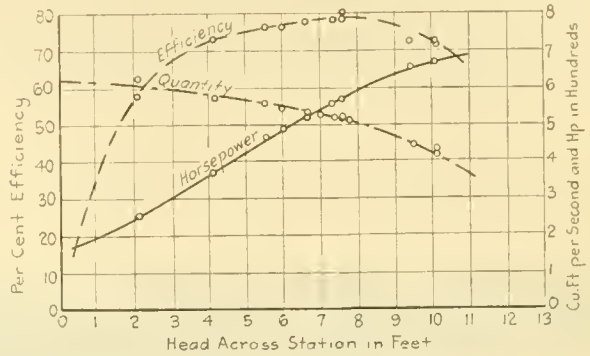


FIG. 11 TESTS OF 12-FT. SCREW PUMP

diameter by 4 in. high to 60 in. diameter by 20 in. high, and in rated capacities from 833 gal. per min. to 60,000 gal. per min. Either a belt or rope driver is used to connect the pump with the source of power. Sectional views of the Menge pump are shown in Fig. 9.

A single impeller is used for low lifts, while for higher lifts two or three impellers are arranged at intervals on the same shaft. The pump was justly popular from the time of its inception because of its cheapness and its ability to handle large quantities of water at good efficiencies, especially at low lifts. In the drainage of sugar plantations this pump found a particularly favorable field and it has been used quite exclusively in rice irrigation.

The Menge pump is still extensively used in this territory and several thousand are in operation in various parts of the United States and in foreign countries. The writer has made several efficiency tests of Menge pump installations, both for drainage and irrigation. Where the pumps were favorably located and the plants in good condition, the efficiencies were excellent. In a few cases where the pumps were set to lift the water higher than was necessary, or the wooden box was allowed to get out of repair, the results were not so good.

The results obtained from a test of a drainage plant made at Paradis, Louisiana, Sept. 16, 1909, are of interest: With an engine speed ranging from 81 to 116 r.p.m., and the pump operating against a difference in head of from 3.42 to 5.30 ft., the combined efficiency of engine and pump varied from 36.2 to 47.1 per cent. The indicated horsepower of the engine ranged from 22 to 76.5 h.p. and the water horsepower from 6.4 to 33.7. If the mechanical efficiency of the engine be asumed as 90 per cent and the efficiency of transmission 95 per cent, the efficiency of the pump will be approximately 55 per cent with a 5-ft. lift.

The plant consists of a 48-in. by 18-in. Menge pump run by means of a rope drive from an Atlas steam engine, diameter of cylinder 14 in., stroke 20 in. Various speeds of rotation were employed for the purpose of finding the best efficiency.

The results were excellent and have been confirmed by tests of other plants.

THE STREAM PUMP

The E. L. Stream centrifugal pump was manufactured in 1891 by H. Dudley Coleman & Brother of New Orleans. It was a side inlet pump, the main feature of which was the method of attaching the suction elbow by a threaded nipple with a jamb ring. By this means the suction could be pointed at any desired angle to meet the condition of a falling river, as the angle of the suction could be changed to conform to the surface line of the batture, without dismantling the pump.

RICE CULTIVATION

Louisiana has cultivated rice for many years. Directly after the Civil War the abandoned sugar plantations were planted

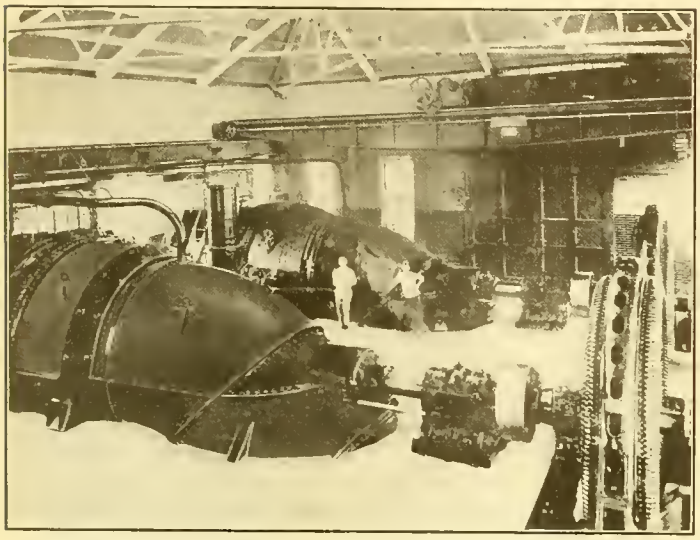


FIG. 12 12-FT. SCREW PUMPS, DRAINAGE STATION NO. 1

to rice and this grain became one of the staple crops of the state. For several years planters were allowed to place flumes in the levees for the purpose of irrigating their rice fields. The flumes became a menace during high water and several crevasses were directly due to leaks around flumes in high water. This led to the passage of the law prohibiting their use. Since that time siphons have been used over the levees. In years of extreme low water, it is necessary to pump the water from the river to shallow pools that supply the siphons. The pumping plants are usually very crude.

By far the greater part of the rice crop is now raised on the upland prairies. The increase in the amount of rice produced in the Gulf States has been due chiefly to the utilization of these lands. The water for irrigation must be pumped, the lift varying from a few feet to 55 ft. or more.

IRRIGATION PUMPS FOR RICE

The rapid increase in the rice industry, beginning in the early nineties, created a demand for pumping machinery in the prairie country of Southwest Louisiana and many different types were installed. Among the first of the larger pumping plants, erected near Crowley, La., was one which consisted of two cast iron vessels, into which steam at a moderate pressure was introduced alternately. On condensing the steam by means of a spray of water, a vacuum was formed and water entered through suction pipes, partially filling the vacuum. The vessels were placed sufficiently high to allow the water to flow from them to the land to be irrigated. Valves were opened automatically to accomplish the various steps referred to above.

The process of pumping was slow and the capacity small when compared to plants of similar size but operating on more modern systems. Worse than this, the pumps failed to act at a time when water was most needed, because the water used for condensing had become too warm, and consequently the vacuum formed was not sufficient to raise the water to the height of the vessels. Mechanical engineers will recognize this pump as very similar to the one used by the Marquis of Worcester and described by him in 1663.

Among the other freak designs for pumps in the early days of rice irrigation by pumping, there was a pump that scooped up water at the periphery of a large wheel and discharged it near the axis. The water passages were spirals. The wheel was about 25 ft. in diameter with a width of about 6 ft. It was driven by gearing in a manner similar to the drainage wheels. This type might, with propriety, be called a "scoop" wheel. At least one of these wheels was built for irrigation and another for drainage. The type has now disappeared.

The Hollingsworth Water Elevator was another curiosity. It was built with a shallow inclined flume up which water was carried by slats attached near their ends to sprocket

FIG. 13 DISCHARGE FROM ONE SCREW PUMP AT STATION NO. 1

chains. The head and tail shafts were fitted with sprocket wheels, over which the chains traveled. The outfit was carried by a wooden frame and means were provided to raise or lower the upper end. The tail end was submerged several feet in suction water and by the rapid motion of the slats, the water was elevated and discharged over the upper end. The head under which the pump worked was from 1 ft. to 10 or 12 ft.

CAPACITY OF PUMPING PLANTS FOR RICE IRRIGATION

It was about 22 years ago that the first large irrigation pump was installed to irrigate rice on the prairie lands of Southwest Louisiana. At that time there was little definite knowledge regarding the capacity for a given acreage. The rainfall was fairly abundant and usually well distributed so much so that "Providence" rice had often been successfully raised. However, the uncertainty of rain at the most critical period of the growth of the crop and the small amount of land favorably situated to receive the run-off of higher lands,

soon led to the installation of pumping plants. The judgment shown in the selection of the capacity was, of course, widely variable.

Profiting by early mistakes and guided by the results of measurements made on canal systems and rice fields by the U. S. Dept. of Agriculture, the capacity became standardized. On the prairie lands where the soil and subsoil contains a large amount of clay so that the seepage is practically nil, the amount should be from 7½ to 8 gal. per min. for each acre irrigated, depending somewhat on the character of the soil and the distance from pumping plant to the field where the water is to be used. In some localities where the nature of the soil is such that it will allow more seepage, as much as 10 gal. per min. should be provided for each acre irrigated and in land having a loose subsoil where the seepage is large, the capacity needed may be as much as 30 to 40 gal. Only in isolated cases covering small areas are these large capacities required.

The total quantity of water to be pumped in a season into the large canals varies from less than 2-acre feet to 3-acre feet per acre of rice irrigated, with the average approximately 2½ acre-feet per acre. The actual plants with their canal systems vary in size from that of the Neches Canal Co., near Beaumont, Texas, which irrigated 26,853 acres in 1914, down to the individual well plant that irrigates only from one hundred to two hundred acres. About 1900 small well pumping plants have been installed in the rice country. In Louisiana the favorite source of power is the steam engine. In Texas, while steam is used to some extent, gasoline engines are largely employed. In Arkansas both the gasoline and steam engine are used.

The earlier well pumps were usually vertical shaft centrifugal type, 4 in. to 8 in. in diameter and placed in pits about 6 ft. square, dug by hand to a depth of from 30 to 50 ft. Trouble was experienced in keeping the shaft in line and this was overcome in a measure by means of the "Munger Attachment," an arrangement for rigidly fastening the bearings to the discharge pipe.

Another design of a well pump for an open pit by Stamm, Scheele & Co., of Rayne, La., had two discharge pipes on opposite sides and the bearings for the shaft were rigidly supported between the two pipes. The wood-lined pits gave considerable trouble and in the early nineties the steel pit centrifugal pump appeared. This is the only type installed for wells at present.

The Census of 1910 showed a total acreage of rice harvested in the United States of 610,175. The acreage in the Gulf Coast States was as follows:

	Acres.	Per Cent of Total in U. S.
Arkansas	27,419	4.5
Louisiana	317,518	52.0
Texas	237,586	38.9
	582,523	95.4

Since the census was taken, rice has been successfully raised in California, where it is a rapidly growing industry. There has also been an increase in the acreage in Arkansas, but Louisiana and Texas together continue to produce over 80 per cent of the rice grown in this country.

The relative importance of pumping plants in the rice territory of the Gulf States is well known by the irrigation census of 1910, which showed that the water used on 88.7 per cent of the acreage in Louisiana was pumped, in Texas, 98.8 per cent and in Arkansas, 90.8 per cent. The water that was not pumped was carried to the fields by gravity from flowing wells, from lakes and streams and through siphons along the lower Mississippi River, where the water during the irrigation season is higher than the land behind the levees.

TABLE 1 DATA ON DRAINAGE PUMPS

Sewerage and Water Board, New Orleans

Pumping Station Number	Number of Units Installed	Capacity of Unit Cu. Ft. per Sec.	Nominal Head in Feet Pumped Against	Revolutions per Min.	Guaranteed Efficiency of Pumps, per Cent	Ave. Efficiency of Pumps During Acceptance Test at Head for which Designed	Diameter of Suction Pipe, In.	Diameter of Discharge Pipe, In.	Combined Length of Suction and Discharge Pipes in Ft.	Type of Pump	Shaft	Type of Impeller	Diameter of Impeller, In.	Horsepower of Motor Driving Pump	Remarks
1	3	250	5	88	60	54	96	96	55	screw	vertical	.....	108	266	Driven by three-phase synchronous motor
2	2	250	5	88	60	56 5	96	96	60	screw	vertical	.....	108	266	Driven by three-phase synchronous motor
3	2	250	8	82	60	63	84	84	70	centrif.	horiz.	enclosed	84	400	Diam. bell suction pipe 108 in. Diam. suction inlet to pump 69 in. Diam. suction pipe 84 in. Diam. bell discharge pipe 120 in.
5															
6	4	250	10	62.5	65	66 6	96	96	60	centrif.	vertical	enclosed	114	466	Driven by three-phase synchronous motor
7	3	250	10	62.5	65	no test	96	96	60	centrif.	vertical	enclosed	114	466	Driven by three-phase synchronous motor
1	1	40	10	167	60	58	42	42	55	centrif.	vertical	enclosed	49.5	149	Driven by three-phase synchronous motor
2	1	40	10	167	60	60	42	42	60	centrif.	vertical	enclosed	49.5	149	Driven by three-phase synchronous motor
3	1	50	12	100	60	58.3	36	36	70	centrif.	horiz.	enclosed	81	120	Diameter bell suction pipe 54 in. Diam. bell discharge pipe 60 in.
5	1	150	8	125	65	no test	36	52	71	centrif.	horiz.	open	72	400	Driven by triple expansion engine
5	1	150	8	125	65	no test	36	52	71	centrif	horiz.	open	72	333	Driven by three-phase synchronous motor
8	1	150	8	125	65	no test	36	52	71	centrif.	horiz.	open	72	400	Driven by triple expansion engine
6	1	30	13.5	260	60	65 9	30	30	60	centrif.	vertical	enclosed	37	100	Driven by induction motor
7	1	30	13.5	260	60	65.9	30	30	60	centrif.	vertical	enclosed	37	100	Driven by induction motor

NEW ORLEANS MODERN DRAINAGE SYSTEM

The drainage of New Orleans and the sanitary sewers belong to separate systems. Work was begun on the modern drainage system in 1896 and it went into operation in 1900. The reports of the Drainage Board and later of the Sewerage and Water Board give the details of the various installations. Table 1 is from the Twenty-fourth Semi-Annual Report of the Sewerage and Water Board, December, 31, 1911. A map is also reproduced in Fig. 10 from the Semi-Annual Report, December 31, 1914, showing the completed and proposed drainage construction.

According to a recent report by Geo. G. Earl, general superintendent of the Sewerage and Water Board, the capacity of pumping plants for drainage will eventually be equal to 7.33 in. of run-off removed in 24 hours. The present capacity is about 3.5 in. The area drained amounts to 25,000 acres, or a little more than 39 square miles It is believed that no other city in the world has such enormous volumes of drainage water to dispose of.

The pumping capacity for the drainage of the city is being increased by the installation of eleven 12-ft. screw pumps to be used in Drainage Pumping Plants Nos. 1, 2, 3, 5, 6 and 7. The test of one of these pumps reported in Engineering Record, Jan. 8, 1916, by Geo. G. Earl and in Engineering News of Jan. 13, 1916, by Prof. W. H. P. Creighton, shows efficiencies above 70 per cent for lifts between 3.5 and 10.5 feet. The efficiency curve rose to nearly 80 per cent at approximately 7.5 ft. lift (Fig. 11). The quantity of water pumped varied from 600 cu. ft. per sec. at a 3-ft. lift to 400 cu. ft. at a lift of 10.5 ft.

These pumps were built by the Nordberg Manufacturing Co., of Milwaukee, from designs by A. B. Woods, Mechanical and Electrical Engineer of the Sewerage and Water Board. In Fig. 12 is a view of the large pumps in drainage station No. 1 of the New Orleans system and in Fig. 13 a view showing the discharge from one of these pumps.

CHAMBER WHEEL PUMPS

Chamber wheel pumps made by the Connersville Blower Company, or the P. H. & F. M. Roots Co., of Connersville, Indiana, have been used in irrigation and drainage work in this section.

The largest rice irrigation enterprise in all the Gulf Coast country, that of the Neches Canal near Beaumont, Texas, uses Connersville pumps at the first lift to elevate water from 30 to 35 ft. There are six units, having a total capacity of approximately 200,000 gal. per min.

The water is carried for about two miles through a canal, having levees 150 ft. between crowns, where it is again elevated about 7.5 ft. by two Connersville units and one centrifugal pump built by Morris Machine Works, Baldwinsville, New York.

A test of the main pumping plant of the Neches Canal was made in 1906 and reported in Vol. 28, Transactions of this Society under the title, "Tests of a Rotary Pump." The test made showed a remarkable efficiency for the pumps and the results were confirmed by a test at the same plant made in August, 1915, when almost identical results were obtained. No adjustments of the pumps in the two units tested have been necessary during the twelve years they have been used.

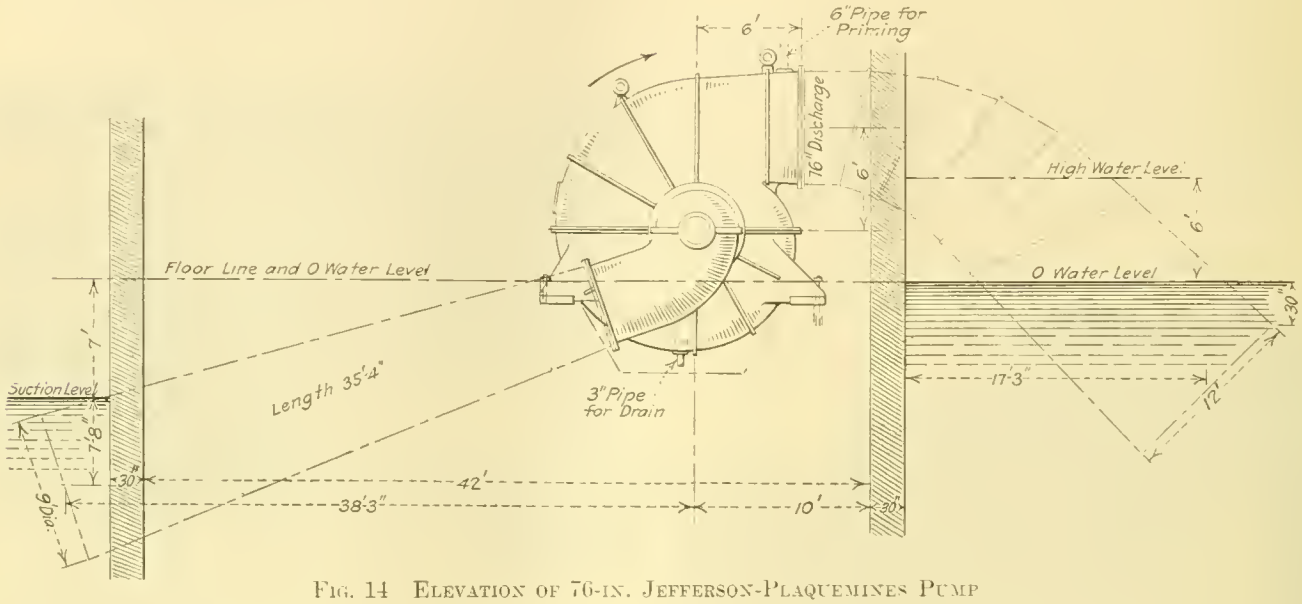


Fig. 14 Elevation of 76-in. Jefferson-Plaquemines Pump

The installations of rotary, chamber wheel pumps for rice irrigation have not been an unqualified success; there have been many troubles with some of the plants, partly because of the lack of proper talent in their operation. However, the writer has for years visited pumping plants of this type in which trouble was conspicuous by its absence, largely because of the high-grade men in charge.

As a drainage pump, where built in large units, such as are required ordinarily in drainage work, the pumps lift the water higher than is necessary and while they are efficient if credited with the higher lift, they lose their efficiency on low lifts, when actual difference of levels is considered.

This point is well illustrated by the drainage pumping plant of Willswood Plantation. This is an old river-front plantation of 2400 acres, on the Southern Pacific Railway, ten miles above New Orleans. About one-third of this tract is sloping and has good natural drainage, though practically all of the water drains into the main canal system and is handled by the pumps. An intermediate area, containing approximately one-third of the whole, has been in cultivation for a number of years, drainage originally being secured by means of a large wheel pump. About 19 years ago, several hundred acres were added to the plantation by the construction of a new levee farther back on the prairie. New canals were dug, a new pumping plant installed and the old wheel pump abandoned.

There are three pumping units on this plantation, steam being furnished by two water tube boilers and one horizontal, return tubular boiler. The fuel used is crude oil and a feed water heater is used. Following is a description of the three units:

1 A 16-in. by 24-in. automatic, non-condensing engine, connected by rope drive to a rotary, chamber wheel pump. Maximum capacity of 40,000 gal. per min.
2 A similar engine, connected by rope drive and bevel gear to a Menge pump. Size of impeller 42 in. by 16 in.
3 A double vertical engine, direct-connected to a centrifugal pump. Diameter of discharge pipe, 36 in.

Pumps 1 and 2 discharge into open flumes at an average head on pump of about ten feet, which is about five feet greater than is necessary. The bottom of the discharge flume was placed at the elevation of the top of the back levee which normally was about 4 ft. higher than the water of the swamp behind the levee.

When the pump was credited with the head through which the water was elevated at the pump, the average efficiency of engine transmission and pump was found to be 60 per cent. Assuming the mechanical efficiency of the engine as 90 per cent and the efficiency of transmission as 95 per cent, the pump efficiency is a little more than 70 per cent.

FUELS

Irrigation and drainage plants used wood or coal for fuel previous to the opening years of this century.

The Lucas oil well was brought in, Jan. 10, 1901, at Spindle-

Fig. 15 76-in. Jefferson-Plaquemines Pumps

top, near Beaumont, Texas. Soon after, oil was discovered at other fields, many of which were in or near the rice irrigation country, notably Jennings, Welsh, Vinton and Sulphur in Louisiana and Dayton, Sour Lake, Saratoga, Batson and Humble in Texas.

At first the production of crude oil was far in excess of the demand of the refineries and crude oil sold for as low as ten cents a barrel of 42 gal. at the fields. Later, as refineries were erected and means worked out to handle the output, the price of crude oil steadily advanced to from 75 cents to $1.50 per barrel and even more in some instances. The cost at any particular plant in the Gulf Coast country depends upon the transportation costs of delivery and the time of purchasing. Many of the nearby pumping plants were supplied by pipe lines from the oil fields. The problem of pumping both for irrigation and for drainage plants has been greatly simplified by crude oil as a fuel.

During the year 1915 the petroleum production of the

TABLE 2 DATA UPON JEFFERSON-PLAQUEMINES PUMPS

Difference of Levels	Gallons per Minute	Duty in Millions of Foot-pounds per 1000 Lb. Dry Steam
76-in. Pump		
1	168,000	35
3	156,000	78
5	135,000	90
7	130,000	90
10	11,000	..
13	9,000	..
48-in. Pump		
3	47,500	60
5	45,000	80
7	42,000	75
8	40,000	70

Fig. 16 76-in. Pump Discharge, Jefferson-Plaquemines Station

United States as estimated by the U. S. Geological Survey was 267,400,000 barrels. Of this amount Texas produced 26,000,000 barrels or 9.72 per cent and Louisiana 18,500,000 barrels or 6.92 per cent.

STRIKING EXAMPLE OF A MODERN DRAINAGE PLANT

The Jefferson-Plaquemines Drainage District, located on the right bank of the Mississippi, and extending in a southeasterly direction from a point nearly opposite the center of the city, comprises about 38,000 acres of land. The land along the river has been in cultivation for many years, but a large part forming the interior of the district was wet prairie. It is the largest drainage district in the State where water is pumped.

A large pumping plant is under construction and when completed the drainage coefficient will be $^{4}/_{10}$ in. removed in 24 hours. At present the equipment consists of two 76-in. pumps, each driven by a cross-compound engine, 16½ and 35 by 36 in., and one 48-in. pump driven by a cross-compound engine, 9 and 18 by 36 in. All the pumps are of the horizontal-shaft centrifugal type, designed to operate against differences of level varying from 1 to 13 ft. The engines are operated con-

densing, using surface condensers guaranteed for a vacuum, with water at 85 deg. fahr., of 26 in. of mercury. Three Heine boilers are used, one with 1380 sq. ft. and two with 2220 sq. ft. of heating surface, each. The steam piping is extra heavy and the whole plant gives the impression of excellent design, good materials and workmanship. The engines were built by the Nordberg Manufacturing Company, Milwaukee, and the pumps by the Southwark Foundry and Machine Company, Philadelphia. J. F. Coleman was the engineer for this project and the mechanical engineering work was in charge of Walter Castanedo, Mem.Am.Soc.M.E. The guarantees for capacity and duty under given conditions are given in Table 2. This plant has not been tested.

Results of Tests, Drainage Pumping Plants

The author concludes his paper with illustrations and descriptions of nine typical drainage plants upon which tests have been made, and gives results of the tests. In what follows herewith is a brief summary of the main results of these tests.

New Orleans Lake Shore Land Company, Citrus, La.: 48-in. Morris centrifugal pump; double suction pipes 38 in. diameter, 105 ft. long, with 90-deg. elbow and enlarged at end to 60 in. diameter: discharge pipe 31 ft. long; Corliss engine. Heine boiler.

Lift, 23 ft.
Overall efficiency, engine, pump and piping, 22 per cent.

Later an electrically-driven plant was constructed, supplied by outside current, with two centrifugal pumps.

Unit No. 1, 120 r.p.m.

Lift, 5.76 ft.	Lift, 6.54 ft.
Discharge, 77,800 gal. per min.	Discharge, 75,000 gal. per min.
Efficiency, 48.8 per cent.	Efficiency, 55.7 per cent.

Unit No. 2, 120 r.p.m.

Lift, 6.10 ft.	Lift, 6.25 ft.
Discharge, 76,200 gal.	Discharge, 75,800 gal.
Efficiency, 49.7 per cent.	Efficiency, 51.75 per cent.

This unit was operated under unfavorable conditions.

Morris Centrifugal Pump, Second Lift, Neches Canal, near Beaumont, Tex.: Engine-driven centrifugal pump, discharge nozzle of pump 48 in. diameter, suction pipe 37⅝ in. Oil fuel used.

Head on pump, 9.99 to 10.23 ft.; average, 10.12 ft.
Horse power, average, 261.6.
Discharge, average, 69,300 gal. per min.
Pump efficiency, 70.2 to 72.5 per cent; average, 71.6.

Grand Canal Pumping Plant: 36-in. Lawrence Machine Company centrifugal pump; compound Corliss engine; rope drive; double suction pipes 24 in. diameter, enlarged to 34 in. at distance of 4 ft. from pump, and conical frustum at intake end; discharge into flume through vertical 20-in. pipe enlarged to 42 in.

Mechanical efficiency, engine, pump and rope drive, 69 per cent.
Assuming engine efficiency 92.5 per cent., and transmission efficiency, 95 per cent, efficiency of pump would be 78.5 per cent. This high efficiency is due in part to the enlargement of the suction and discharge pipes, thus reducing entrance loss and velocity head loss at entrance to flume.

Fidelity Land Company, Dalcour, La.: 24-in. Worthington Drainage Pump direct connected to 35 h.p. "Ingeco" engine using distillate.

Average lift, 5 ft.
Average delivery, 9602 gal. per min.
Fuel, 42 deg. Baume, at 86 deg. fahr.; weight, 680 lb. per gal.
Fuel consumption, 2.99 gal. per hr.

Whitelake Land Company, Florence, La.: Two 54-in. Worthington double suction pumps; direct connected to Corliss engines; suction and discharge pipes of approved diverging construction.

Revolutions per min., 91.1.
Indicated horse power, 186.2.
Discharge, gal. per min., 86,077.0.
Static head, 4.72 ft.
Efficiency, pump, engine and piping, 55.6 per cent.
Efficiency, pump and engine, 59.9 per cent.
Mechanical efficiency, pump and engine, 91.1 per cent.
Hydraulic efficiency, pump, 65.7 per cent.

Louisiana Meadows Company, Raceland, La.: 48-in. Worthington drainage pumps, combination of screw and centrifugal types; suction and discharge pipes enlarged at outer ends; pumps driven by two-stroke cycle, crude oil Snow engines, 14½ in. by 24 in.; fuel 27.4 deg. Baume at 60 deg. fahr.

Lift, 3.55 ft. to 4.96 ft.
Revolutions per min., 195.
Discharge, 60,050 gal. per min. at lower lift; 54,700 gal. per min. at higher lift.
Useful water horse power, 53.8 to 68.5.
Fuel consumption, 1.132 lb. (lower lift), and 0.887 (higher lift) per useful water horse power hour.
Fuel consumption per acre foot of water elevated one foot, 1.55 lb. to 1.12 lb.

Onishi Plant, Mackay, Tex.: 24-in. Worthington volute single suction centrifugal pump, direct connected to Buckeye compound condensing engine; machinery located in reinforced concrete pit; suction pipe 28 in. diameter, 148 ft. long; discharge pipe, 24 in. diameter discharging into tubes.

Lift, 37.23 ft.
Head on pump, 39.43 ft.
Discharge cu. ft. per sec., 32.5.
Indicated horse power, 230.4.
Useful water horse power, 137.2.
Water horse power basis of head on pump, 145.6.
Efficiency, engine pump and pipe, 59.5.
Efficiency, pump (estimated), 70 per cent.
Fuel oil, per useful water horse power hour, 2.82 lb.; per pump horse power hour, 2.66 lb.

Moore's Bluff Plant, Dayton, Tex.: This is a high lift plant. Worthington 36-in. volute pump, direct connected to cross compound condensing Corliss engine; 28-in. double suction pipes enlarging to 36 in. and to 5 ft. of intake; 36-in. discharge pipe enlarging to 48 in. diameter, extending up a hill at 45 deg. and discharging in a flume where it again enlarges; fuel oil, 19,347 B.t.u. per lb.

Lift, 55.88 ft.
Head on pump, 57.51 ft.
Average water pumped, 39,707 gal. per min.
Revolutions per minute, 173.4.
Indicated horse power, 793.44.
Useful water horse power, 557.50.
Efficiency, engine and pump, 72.3 per cent.
Efficiency, pump, 78.5 per cent.
Fuel oil, per indicated horse power hour, 1.378; per useful water horse power hour, 1.96.

Garwood (Tex.) Irrigation Plant: 36-in. Worthington volute pump, direct connected to compound condensing Corliss engine. This is another high lift plant.

Lift, 42 ft.
Head on pump, 43.51 ft.
Mean indicated horse power, 511.4.
Useful water horse power, 395.5.
Pump horse power, 409.9.
Discharge, 37,455 gal. per min.
Efficiency, engine, pump and piping, 75.1 per cent.
Efficiency, pump (assuming engine 92.5 per cent), 86.6 per cent.
Fuel oil per useful water horse power hour, 1.82.

The author states that this pump has made the best record of any he has tested. The lift was high and conditions favorable to a high efficiency. By way of comparison the following results are given:

Name of Plant	Pounds of Fuel Oil per Useful Water H.P-Hour
Neches Canal, First, Lift, Beaumont, Tex	2.09
Jennings Canal, Jennings, La	2.16
Sabine Canal, Vinton, La	2.29
Pierce Estate Canal, Wharton, Tex	2.84
Moore's Bluff	1.96
Garwood	1.82

From these figures it will be seen that the Moore's Bluff plant, which is the best of the list with the exception of the Garwood plant, uses more than 7 per cent more oil than the latter to do the same amount of useful work. The last two plants have shown the feasibility of pumping water to greater elevations than was thought commercially possible a few years ago. A properly designed steam driven pumping plant may be operated against a lift of 55 ft. at a cost that makes rice irrigation an attractive proposition, especially if the canal reaches a reasonably large acreage.

THE DESIGN AND TEST OF A LARGE RECLAMATION PUMPING PLANT

G. C. NOBLE,[1] SAN FRANCISCO, CAL.
Non-Member

UNTIL recently reclamation work along the rivers of the state of California has been accomplished more or less successfully in the small districts. During the last few years, however, there has been a very rapid development, with a decided tendency towards forming very large districts. To accomplish true reclamation it is necessary not only to exclude the flood, or overflow waters, but also to provide a drainage and pumping system which will insure the removal of all surface water, whether from rainfall or seepage, as fast as it accumulates. In the smaller districts the matter of drainage is not of very serious moment, but in a very large district the

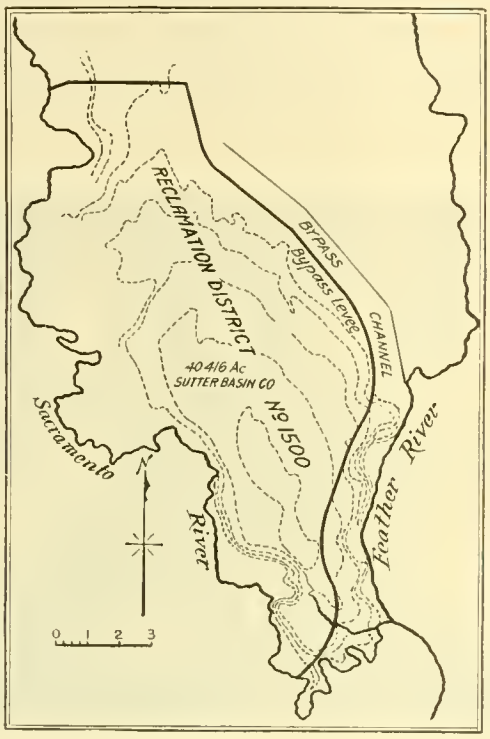


Fig. 1 Sutter Basin, Reclamation District No. 1500

amount of drainage water to be handled becomes enormous, and on account of the very great loss involved by a failure to remove this drainage water as fast as it accumulates, makes it imperative that the drainage and pumping system be designed in accordance with the best engineering practice. In this paper the writer will outline the problems involved and a solution of same in the case of one of the largest reclamation districts in the state of California, and which has resulted in the construction of the largest reclamation pumping plant in this country, having six 800 h.p. units.

In November 1913, the writer was given the following problem:—Given a reclamation district located at a definite point in the Sacramento Valley; proceed with the design and construction of a drainage pumping plant that, when operated in connection with a certain drainage and levee system, will insure the removal of all accumulated drainage water. No restrictions were placed on the writer and all details were decided on their respective merits. The district under consideration is known as Reclamation District 1500, created by act of the state legislature in 1911, and commonly called Sutter Basin. Its geographical location is shown in Fig. 1. Lying as it does between the Sacramento and Feather Rivers at their junction, it forms a large basin, with the lowest point nearly in the center. Its geographical location makes it subject to the full sweep of the flood waters of the above two rivers.

The District has an extreme length of approximately 19 miles, a maximum width of approximately 10 miles, and has an area of approximately 66,000 acres. The elevation of lowest point in basin is 19 ft. above datum, and maximum elevation of 30 ft. above datum. As the average maximum elevation of the flood waters at this point is approximately 39 ft. above

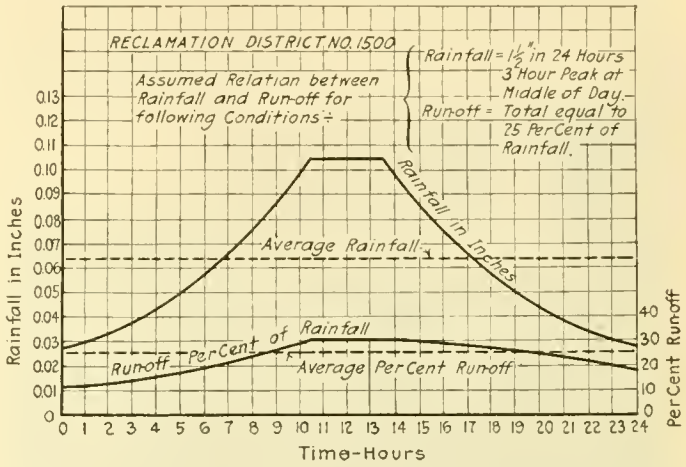


Fig. 2 Assumed Relation between Rainfall and Run-off

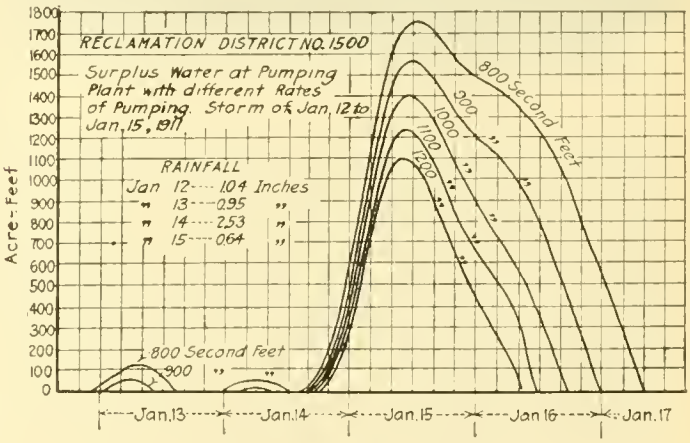


Fig. 3 Surplus Water at Pumping Plant

datum during the winter time, the entire district is under water with varying depth up to nearly 20 feet.

To reclaim this tract of land it is necessary to build levees around its entire circumference, about 70 miles, to exclude the flood waters of the rivers. The natural drainage of this tract is towards the center from the east and west and from north to south, terminating at the southerly end of the district, in what is known as Sacramento Slough, which empties into the Sacramento River near its confluence with the Feather. On account of this natural condition, it is obvious that this district should have only one drainage pumping plant, and its location should be near the point where the levees cross Sacramento Slough. This Slough has now been utilized as part of the main drainage canal of the district. This canal extends in a general northerly direction through the center of the basin.

The essential steps in the determination of the size and

[1] Purchasing Engineer, Shell Company of California.

Presented at the San Francisco local section of The American Society of Mechanical Engineers, on April 16, 1915.

character of the required drainage pumping plant, and its design, may be grouped as follows: (*a*) Determination of amount of drainage water to be pumped; (*b*) Pumping head; (*c*) Physical design of plant; (*d*) Construction; (*e*) Test and operation. The above steps will now be discussed in detail.

AMOUNT OF DRAINAGE WATER

As stated above, the amount of water to be handled by a reclamation pumping plant is made up of the run-off from rainfall and seepage through the levees, or any other underground channel. The former, while influenced by many quantities impossible to predict precisely beforehand, such as rate

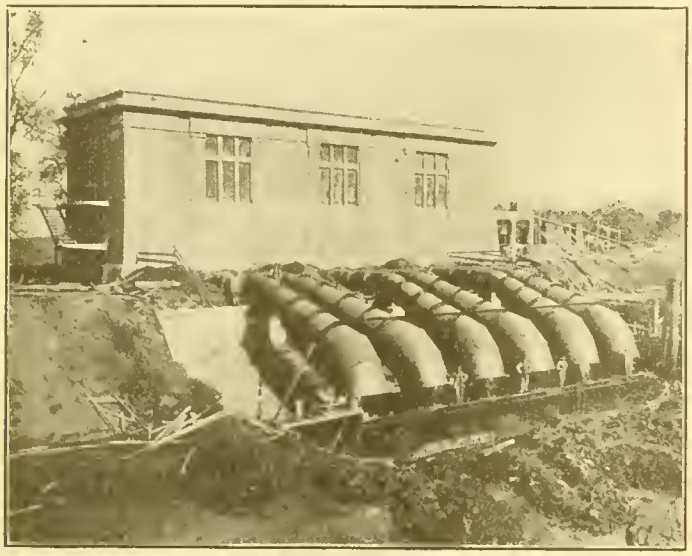


Fig. 4 Exterior View of Pumping Plant

of rainfall, duration of rain, state of land cultivation, etc., can, however, be approximated with a reasonable degree of accuracy. Since to produce true reclamation all drainage water must be pumped out of the district as fast as it accumulates, therefore the capacity of pumping plant will be determined by the *maximum* rate of accumulation of drainage water which has to be handled; otherwise a portion of district would become flooded. While the total amount of water to be handled may be made up largely of seepage, the maximum rate of accumulation is almost entirely determined by the run-off from rainfall, as explained later. It is, therefore, very essential that a very careful study be given to this phase, and as the maximum run-off may be expected at maximum rainfall, the essential point is to determine the conditions of run-off for this maximum rainfall.

RUN-OFF FROM RAINFALL

There has been in the past no actual observation of rainfall within this district. Therefore, the rainfall has been estimated from the two nearest points of record, Marysville, located at the east and north on the Feather River, and Knights Landing on the west, just across the Sacramento River, giving twice the weight of the Knights Landing readings over those at Marysville. As these readings are a matter of record they are not given here. From an analysis of the estimated rainfall thus made, the maximum rainfall for any of the years of record occurred on January 12, 13, 14 and 15, 1911, when rainfall was 1.04 in., 0.95 in., 2.53 in. and 0.64 in. respectively. Other periods of severe rainfall which might be mentioned here are, December 12, 13 and 14, 1906, where 0.6 in., 2.37 in. and 0.37 in. of rain fell respectively; also December 25, 26 and 27, 1906, with rainfall of 0.22 in., 2.01 in. and 0.20 in. respectively, and February 11, 12 and 13, 1909, with rainfall of 0.87 in., 1.40 in. and 0.69 in. respectively.

Rainfall equaling the above maximum values may be expected during any year, and it is not unreasonable to expect that at sometime they might be slightly exceeded. However, taking into consideration the fact that they are estimated values, that if the above maximum values as first given are used in connection with a conservative value of percentage of run-off, the result will probably not be seriously exceeded at any time. Therefore, the pumping capacity of plant has been determined from the estimated run-off resulting from the rainfall of January 12, 13, 14 and 15, 1911.

The yearly run-off from a district of this character can be estimated very accurately from the yearly rainfall, but in this case, since there are no storage facilities, we are concerned with the hourly run-off. It is a well established fact that the run-off varies with many conditions, among which is the rate and duration of rain. In this particular case, as will be seen, the hourly rate of rainfall will have a very material effect on the size of pumping plant. It, therefore, becomes necessary

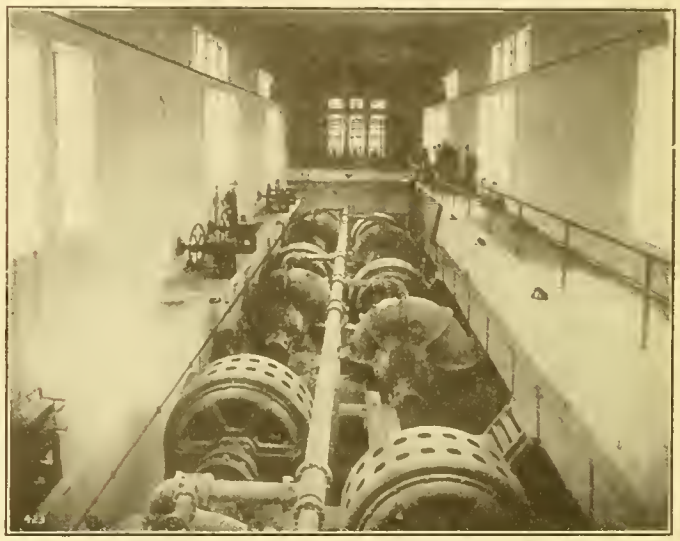


Fig. 5 Interior View of Pumping Plant

to assign to the above rainfall a given hourly rate. After careful consideration of this point, Grunsky's method of estimating hourly rate of rainfall was adopted with some modifications. This, in effect, is that 50 per cent more rain falls in any one period than in the preceding period, that is, the ratio of fall for any period to the next of equal length would be 1 to 1½.

A further assumption was made that the rainfall for any one day started at a minimum value at the beginning and increased at the above ratio to a maximum, which lasted for three hours during the middle of the day and then decreased to a minimum at the end of twenty-four hours in the above ratio. This rate of fall for a rainfall of 1½ in. per day is shown in Fig. 2.

Having fixed the hourly rate of rainfall, the next step is to determine the run-off and rate of arrival of this run-off at the pumping plant. For purposes of this calculation the total run-off has been taken as 25 per cent of the total rainfall. The rate of run-off has been assumed arbitrarily to vary with rate and duration of rainfall, being greatest for greatest rate, and

also for equal rates of fall, being greater at the end of the days' rainfall than at the beginning. This varying percentage of run-off for the rate of rainfall assumed above is shown in Fig. 2.

On account of the large area of the district and its extreme length of 19 miles, it is obvious that the run-off from the extreme northern end will arrive at the pumping plant several hours after the rain has fallen. The drainage system of this district as laid out contemplates a very extensive system of ditches. These ditches have been designed for a certain velocity of water, and the area drained depending upon slope and character of soil, so that it may be assumed that as far

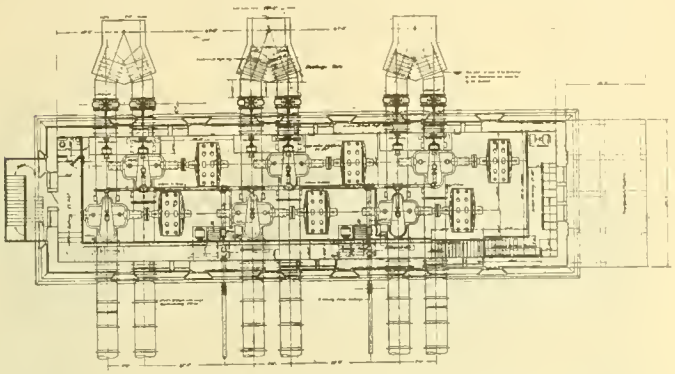


Fig. 6 Plan of Pumping Plant

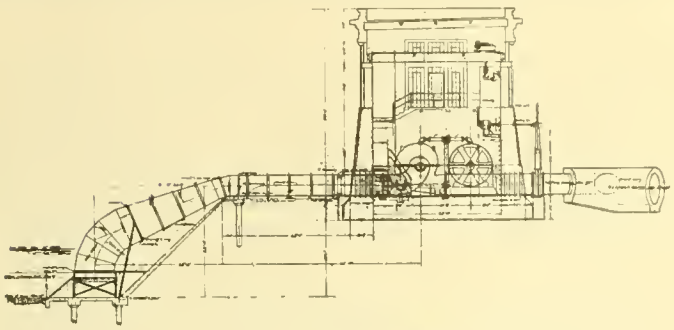


Fig. 7 Elevation of Pumping Plant

as delivery of run-off water to the pumping plant is concerned, all ditches are equally effective. From an analysis of these factors, the district was divided into zones, or areas, such that the run-off from each zone might be assumed to reach the plant in a given time, taken in this case as one hour. That is, the run-off of Zone No. 2 has been assumed to reach the pumping plant one hour after run-off from Zone No. 1, etc. There is, of course, certain delayed flow of the run-off before it reaches the ditches, but as it is the same for all zones, its effect may be neglected as far as this calculation is concerned.

Applying the above method to the rainfall of January 12 to 15, 1911, as given above, and assuming different rates of pumping at pumping plant, the surplus water given in acre-feet, accumulating at pumping plant, above that pumped, is shown in Fig. 3. Fortunately, the main drainage canal is of very ample capacity, and it has in itself considerable storage capacity, provided that water is drawn down in canal before rain sets in. Assuming that pumps can draw the water down to 10 ft. above datum, and that no serious flooding takes until 20 ft. above datum is reached, the storage capacity between these two elevations is approximately 1150 acre-feet. Applying this value to the curves in Fig. 2, it is found that a pumping plant having a capacity of approximately 1000 to 1100 second-feet, should be sufficient for the purposes of reclamation, and for this district this value has been taken.

SEEPAGE

The amount of seepage water which might be expected in this district is very difficult to estimate. With the character of soil that occurs here, and assuming well constructed levees, such as are being built, it is reasonable to assume that the rate of seepage will not be a very great amount. In other parts of the state, where the subsoil is of a peaty nature, seepage water often reaches a considerable amount. There is practically no data available to base a substantial conclusion in this matter. It has been variously estimated by different engineers that under normal conditions, with subsoil as occurring in this district, that the seepage would average from ½ to 1½ second-feet per mile of levee, or from 35 to 100 second-feet.

The rate of seepage would be somewhat influenced by the

Fig. 8 View of Discharge Pipes

height and duration of flood waters outside of levees. This seepage water is independent of the rainfall, and will have a tendency to be a more or less constant flow throughout the flood season, but its maximum value would be relatively small and therefore not have any material bearing on the maximum capacity of pumping plant; however, its effect on the amount of power consumed and the total amount of water pumped may equal or exceed that of the run-off from the rainfall. Hence, in determining the capacity of plant, seepage has been neglected.

PUMPING HEAD

The head under which the plant must operate is extremely variable. During the months of November and December, before there is any very great rise in the rivers, the head will be a minimum, and in this particular case will be about 10 ft. static. However, when the flood season occurs the plant will be required to operate under its maximum head. The calculation of the maximum flood plane is of very considerable moment, as not only does the pumping equipment hinge on it, but also the entire levee construction is based on the probable flood height. At the present time, with the district open to overflow waters, there was recorded this year a flood height of 39.2 ft. above datum. But with the completion of levee system, and the confining of the flood waters to a restricted channel, the flood plane will increase very materially.

On account of its bearing on the construction of the levee system, the calculation of the maximum flood plane was undertaken in very great detail, and very thoroughly, under

the able direction of the chief engineer of the District, Mr. George N. Randall, who, from many years' experience with the flood conditions of the Sacramento River, was able to bring a great fund of information and data to assist in determinations of this point. The problem was attacked from every conceivable angle. In general, however, the methods consisted primarily in determinations of the maximum flow of water through the By-pass and Feather River channels. The width of this channel being fixed and general slope known from surveys, having estimated the maximum flow, it is a comparatively simple matter to determine the depth of water, or, in other words, the maximum elevation of flood plane.

The data collected is too voluminous to present here, and is perhaps beyond the scope of this paper. The conclusions,

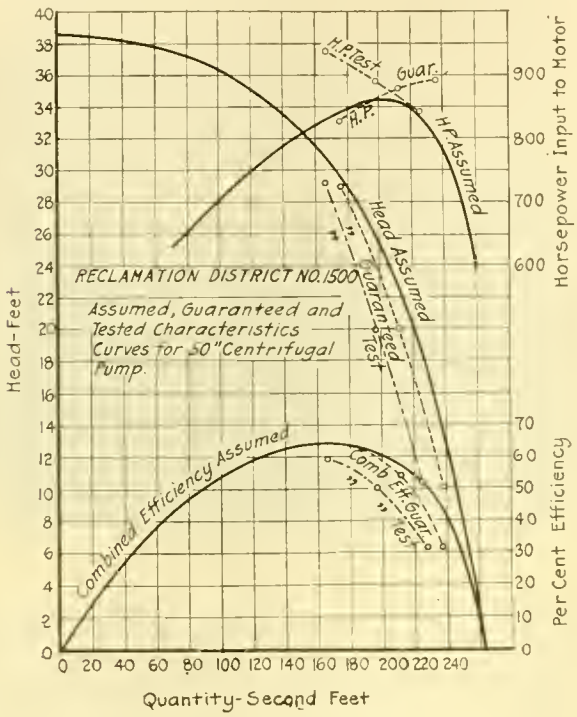


Fig. 9 Results of Preliminary Test Run of One Unit

however, were that the maximum elevation of flood waters when confined to the By-pass channel would be approximately 42 ft. above datum, and this value is used in determining the maximum head of pumping.

While as a general rule the peak of the flood waters occurs from one to three days after the rainfall, there are conditions which might arise whereby this peak would arrive at the point of discharge of the pumping plant simultaneously with the arrival of the maximum run-off water at the suction sump of plant; therefore conservatism demands that the plant be designed to handle maximum amount of water against maximum head.

While the above quantities determine the capacity of plant, in order to obtain an estimated early consumption of power, the same calculation of quantity and head were made for each day of the winter season, and also for the six years of record, 1906 to 1912. These detail calculations are not presented here, the estimated power consumption for pumping run-off only being from 700,000 to 1,200,000 kw-hr.

With an elevation of discharge water level of 42 ft. above datum and elevation of water surface in suction sump of 16 ft. above datum, the maximum static pumping head is 26 ft. Allowing for an estimated friction loss in discharge pipes of 3 ft., the total maximum pumping load was taken at 29 ft. Therefore, in conclusion, the capacity of plant will consist of pumps that can handle 1000 second-feet against a 29 ft. head. With this determined, the only remaining feature is the physical design of plant.

PLANT DESIGN

The first consideration in the plant design is the motive power. In this connection electric motors, steam engines or turbines, and Diesel engines were considered. On account of the fact that the plant was readily accessible to three power companies, the Pacific Gas & Electric, Great Western Power Company and Northern California Power Company, this had a very great weight in forming the decision to use electric-motor-driven centrifugal pumps, it also having the

Fig. 10 General View of Pumping Plant

other great advantage of lower initial investment, although a little greater operating expense.

In order to select the size and number of pumping units, a number of plant layouts were made with four, five, six, seven and eight units, and after careful consideration, both of conditions to be met and manufacturers' requirements, a plant having six units, each a 50 in. centrifugal pump having a normal capacity of 175 second-feet against a discharge head of 29 ft., driven by an 800 h.p. electric motor, was selected as offering the most satisfactory arrangement and best economical design.

At this point a consideration of the advisability of using one or two speed motors was taken up. The use of a two-speed motor offers several advantages in a condition such as presented here of variable head. The two-speed motor, if properly chosen in respect to conditions, will produce a higher overall efficiency, which in turn means a lower annual operating cost. On the other hand, it has several disadvantages, as higher first cost of motor, increase in cost of building on account of requiring more space, and great multiplicity of parts and operating gear. After careful consideration of the various advantages and disadvantages, a final selection of the one-speed motor was made, as the saving in annual cost of operation due to a slightly greater overall efficiency, did not warrant the increased investment.

BUILDING

Inasmuch as the district would be flooded the first year after installing plant on account of non-completion of levees, and also as a protection against damage to pumps from flooding due to possible breaking of levee at high water, the design of pumping plant building becomes of perhaps greater importance than actual mechanical layout of pumping units. In designing the building, it must be so constructed that

its walls and floor slab will safely resist the water pressure due to floods, also sufficient weight must be present to prevent flotation.

The building as finally constructed is of reinforced concrete, the walls so designed as to withstand a depth of water on the outside of 18 ft. above floor level. This necessitated walls 4 ft. 6 in. thick at the base of the floor line. Under the above water pressure conditions the uplift pressure on the bottom of building amounts to nearly 5000 tons. This gives some idea of the problems that had to be faced—they are similar to those of dry dock construction. On account of the water conditions to be met with, there is no opening into the building below elevation 42 ft. above datum, or 18 ft. above the floor line. The building rests on a concrete pile foundation, approximately 300 25-ft. piles being used. No difficulties of any serious moment were experienced during construction.

PUMPING UNITS

On account of the problems to be met in the building construction, every effort was made in the pump unit layout to reduce the size of the plant. The writer believes that the layout finally selected offers the most compact layout consistent with good operating conditions. The units are dovetailed in such a manner that a minimum of space is required. Each unit is independent of the balance, having each a separate steel suction pipe and the discharge of each group of two pumps is brought together outside of building into a single pipe. There are three reinforced-concrete discharge pipes, 78 in. in diameter. After passing through the levee, each of these pipes passes into a valve chamber which has a large wood and steel swinging check valve and also a sluice gate.

On the suction sides of the pumps there are no valves of any character. On each discharge side there is located just outside the building a 50 in. gate valve, operated by a direct-current motor mounted on the inside of building for flood protection, and operated by means of a shaft passing through a stuffing box in the wall; the gate valves were placed outside to reduce the size of building. All units and motors operating the gate valves are controlled from the switchboard located in one end of the building. Priming pumps are installed in duplicate, each capable of priming any one pump in ten minutes. These pumps are of the wet vacuum type, and may also be used for removing any drainage water inside of building. One rather unusual feature is the installation of a storage battery for operating motors on gate valves. This was done so that the gate valves may be operated quickly if the main source of electric power should fail, and this feature has proven very successful.

Electric power is delivered to motors at 2200 volts from three 1500 k.v.a. 60,000 to 2200 volt, outdoor-type oil-cooled transformers. These transformers are mounted outside the building on a platform sufficiently high to be out of danger of flood water.

The total cost of this plant, exclusive of engineering, is approximately $170,000, of which the building, discharge pipes and sump represent $75,000 and the pumping machinery $95,000. Views of the plant are shown in Figs. 4 to 8 and in Fig. 10.

TESTS

The writer had hoped to give at this time results of final tests on units in this plant. However, the preliminary test run has been made on one unit and the results are presented here. These results are not to be taken as final, as the pump manufacturers are to make a slight change in runner, which it is expected will modify considerably the results of the preliminary test run.

The specifications covering the pumping machinery provided for the method of test. Guarantees of efficiency were made on the combined efficiency of motor and pump, also with all losses in suction pipe charged to the pump. The electrical input to the motor was measured by means of two indicating wattmeters. The discharge head on pump was obtained by means of a U-tube of water, the total pumping head being taken as the difference in level between the water in the sump and height of water shown in U-tube. The amount of water was obtained by means of a Cole & Flad pitometer, two right angle traverses being made on suction side of pump. Care was taken to eliminate errors on account of use of this instrument on the suction side. The combined efficiency was obtained for three different heads, 10, 20 and 29 ft., as provided in the specifications. The results of the preliminary tests on one unit are shown on the curves shown in Fig. 9. On this sheet are also shown estimated curves used by the writer in his original calculations, and also guaranteed values. It is expected that changes in runner, as proposed by manufacturer, will bring about a closer harmony between guaranteed and actual test results.

In the evolution of centrifugal and turbine pumps, no factor has played a greater part in obtaining increased efficiency than the study of the laws of the surface friction of fluids. This subject has been under investigation by the most eminent engineers for more than 100 years, and today the laws governing the velocity of flow for a particular fluid are tolerably well known. Experiments establishing a general relation applicable to all fluids and conditions of flow are not known, however, though it is known that such relations must exist. A knowledge of the relations which hold between widely differing viscosities and densities, with reference to main flow and also to secondary or induced currents, will be of great value. C. G. de Laval in *Am. Soc. C. E. Proceedings, Vol. XLI, No. 9.*

Notes, with numerous illustrations, analytical data, costs, descriptions of plants, etc., to indicate the trend in Europe of some of the important fuel problems that are conspicuously before the United States, are given in *Tech. Paper No. 123, U. S. Bur. of Mines*, by R. H. Fernald, Mem.Am.Soc.M.E. The subject matter is divided into *a*, utilization of high ash coals; *b*, use of wood refuse and other similar material; *c*, recovery of fuel from by-products; *d*, recent developments in the preparation and use of peat; *e*, results of low temperature distillation of fuels; *f*, possibilities of the slagging type of gas producer; *g*, use of powdered fuel.

The science of valuation is an interdependent mixture of law, economics, and engineering: Law, to establish the governing ethical principles; economics, to establish the criteria of value or monetary standards; engineering, to apply the general criteria of value to any given specific case in accordance with ethical principles.

Some of the problems of valuation are unsolvable on any definite mathematic basis. To solve the problem as to what is the value of property requires the most logical reasoning, involving legal, economic and technical science, and in addition to all, that very rare endowment known as common sense.—S. S. Wyer, Mem.Am.Soc.M.E., in *Bul. A. I. M. E., April, 1916.*

STEAM SAFETY VALVES

A Discussion of the Principles of Safety Valve Operation in the Light of an Extensive Series of Tests Leading to a New Development in Safety Valve Design

BY GEORGE H. CLARK,[1] BOSTON, MASS.

THE object of this paper is to place before the Society a record of the experimental work and conclusions drawn therefrom, of an investigation into the theory and design of a safety valve. Safety valves have been in the past, and are at present the result of cut and try methods, rather than a mechanism based on logical and fundamental principles. The theory which is here presented is believed to be general in its application, and original in character. In the course of the experimental work undertaken at least 50 valves have been built and tested, and during the course of the experimental work I have not tested, or seen in operation under test, a single valve of a design which is now on the market. Each valve built and tested has been for the purpose of proving or disproving a step in the theory which follows.

At a glance, it seems that the problem of the design of a safety valve should be a simple one, but when the facts are brought into line, the problem becomes increasingly difficult. All present day valves employ huddling or expansion chambers, although those best fitted to know the reasons for their use disagree as to the actual part played by such chambers in the action of the valve in which they are incorporated. This is one example of the apparent mysteriousness relative to the action of present day valves. It is hard for the engineering public to understand why it is not possible to increase the lift of valves in accordance with the demands of the day for high capacity valves, without endangering the boilers to which they are connected or the valves themselves, and it is probably true that this misunderstanding is due to the lack of reasonable explanations, in which those best fitted to know concur. The pros and cons of high and low lift valves have been discussed before this Society in great detail, and I believe that I am giving the consensus of opinion in this regard in the statement that high lift valves, so-called, produce more or less shock at closure which may injure the boiler itself, and is usually a serious factor in determining the life of the valve. The Boiler Code Committee of the Society has seen fit, in its recent report, to propose a limitation in the lift of safety valves of approved design, a fact which is evidence of the above statement.

A moment's consideration will show that increasing the lift is, except for changing the seat angle, the only available means of substantially increasing the relieving capacity of a valve of given diameter, and further consideration, when the tendency in steam boiler practice is taken account of, results in the conclusion that high lift valves must come into common use. The absolute necessity for high discharge capacity valves has led English designers to employ auxiliary pistons acted on by boiler pressure, and adapted to produce high lift. To us this seems an awkward method of solving the problem, when it is remembered that most producers of safety valves state that they can build high lift valves of the ordinary type. In spite of the economical and commercial advantage to be gained, such valves are not upon the market and are, in fact, frowned upon by both manufacturers and users.

[1] Instructor in mechanical engineering, Massachusetts Institute of Technology.

Presented at the Boston local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on March 14, 1916.

SAFETY VALVE SPECIFICATIONS

Most specifications in force at the present day, both abroad and at home, are based either on grate area or heating surface, and are recognized by engineers to be misleading and entirely inadequate for present day practice. This fact is evidenced by the innovations contained in the report of the Boiler Code Committee, which bases the relieving capacity on the greatest possible amount of steam that can be generated and provides that valves shall take care of this maximum amount. There is nothing to be said in criticism of this standpoint, as experience tells us that every boiler plant will some day have to depend on its safety valves to prevent destruction, and that in this emergency they should not be found wanting. The difficulty of this method is the lack of capacity of valves of the present day to provide means for economically taking care of the situation.

I venture to say that the demands of the rules laid down by the Boiler Code Committee have not come home to the boiler users at present. Whatever the position of the boiler user, the basis of the specifications is absolutely right and just, and they distinctly put the real issue on the valve manufacturer himself. If it can be shown by one or a group of valve manufacturers that, after fulfilling all the other requirements incident to a proper safety valve, the lifts and consequent discharge capacities are well above those allowed by the specifications, then the table of capacities must be revised to meet the new conditions in order that true progress may not be blocked.

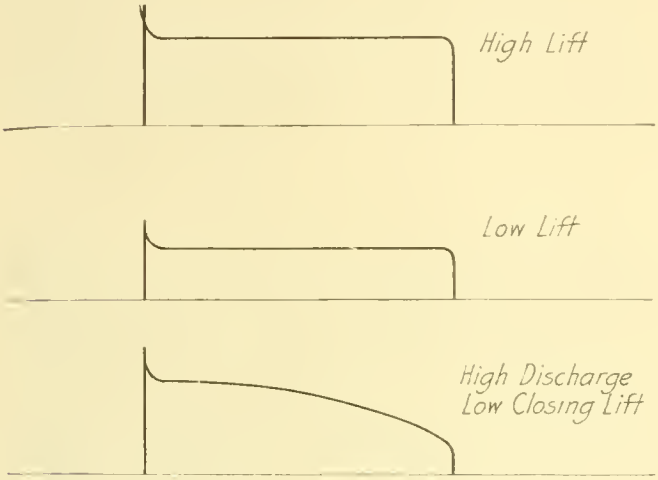
At this point it is necessary to cite a few examples of the workings of the proposed rules in order that the true status of safety valve practice may be illustrated. One of the most popular boiler units found in present day plants is the 500 h.p. water tube boiler, and, equipped with stokers, fans, and pressure regulators, this boiler represents current practice. In general this boiler is fitted for and equipped with two 4 in. valves on the drums, and one 4 in. valve on the pipe leading from the superheater. In general such valves are of the 45 deg. seat type, and reference to the table of capacities in the proposed rules allows us to determine the required equipment for this boiler. These boilers are run oftentimes at 300 per cent rating, and under these conditions generate approximately 45,000 lb. of steam per hour. If the boiler pressure be taken as 200 lb. gage, it will be found that with the maximum lift allowed in the table, the discharge capacity of one 4 in. valve is 9420 lb. per hour. This boiler will then require five 4 in. valves. Now the specifications state that should two or more valves be connected to a common base, the nozzle supplying the combination must have an area equal to the combined area of the valves connected thereto. Since most of this type of boilers have 4 in. valve nozzles, it will be found somewhat difficult to install the required capacity without extensive changes. Since the limiting size is 4½ in. diameter and since four of this size will be required, there is little to be gained in this direction, as all the connections are unsuitable without the same extensive changes.

The largest single boiler unit is a Stirling type boiler of 2356 boiler h.p. adapted to run at 210 per cent rating. A

simple calculation will show that the combined discharge capacity of the safety valves should be 148,000 lb. per hour. This installation under the rules would require eleven valves of the maximum size and maximum lift at 200 lb. gage pressure. The safety valves of a boiler of this size would probably be piped outboard, and under the proposed specifications this would require eleven separate discharge pipes. It is customary to set valves connected to the same boiler with a certain range of pressure between their respective popping points. If they are set 2 lb. apart, then the total range of pressure will be 22 lb. or slightly greater than 10 per cent of the working pressure. The rules require that the installation of valves must relieve the boiler with not greater than 6 per cent accumulation above the allowed pressure. It is true that this boiler is an extreme at present, but it does represent the tendency of present day practice.

IMPORTANCE OF DISCHARGE CAPACITY

In the development of boilers and accessory apparatus, the



Figs. 1, 2 and 3 Diagrams of Lift Characteristics

safety valve has become less of a working piece of apparatus and more of a safety appliance. Before the advent of stokers and in the days of hand regulation, either the ash pit doors or the safety valves were open all the time. Today we find ourselves providing a rule which calls upon the engineer to see that his valves are opened once a day at least to insure that they are in working order. It is clear, then, that the safety valve is called upon in the emergency only, not as a pressure regulator, and if this is the case, should not its discharge capacity be of fundamental importance?

The factors which tend to limit the discharge capacity of the ordinary type of valve when high lifts are attempted are the apparent impossibility of regulation and the shock produced at closure. The actual valuation of the shock produced at closure defies calculation for many reasons, but it can be shown experimentally that the height from which the disc drops to sudden closure plays an important part. The diagrams shown by Figs. 1 and 2 represent graphically the lift characteristics of high and low lift valves, a study of which shows that they are essentially alike in all characteristics, but that in high lift valves the distance through which the disc drops to sudden closure is much greater than in the low lift valves and actual experience tells us that the low lifts operate without shock, and that the high lifts are subject to that defect in greater or less degree. If this is the case, the logical solution would seem to be a valve giving a diagram like that shown by Fig. 3, in which the lift during the blowdown period gradually decreases to a small value before sudden closure takes place.

We are not vitally interested in the discharge capacities of valves during the blowdown period provided that high lift can be maintained at the popping pressure. If their discharge capacity is such that, after blowing, the blowdown period is finally reached, the emergency is taken care of, and the installation is safe. In order to produce a valve which will give the diagram shown in Fig. 3, it is necessary to keep the disc in equilibrium with the boiler pressure, while that pressure is being reduced and to explain the factors, it is necessary to go into some detail as regards fundamental theory.

RELATION BETWEEN DISCHARGE AND PRESSURE UNDER DISC

The first thing to investigate is the variation in pressure on the spring load area of the disc—in other words, the pressure which exists below the disc in advance of and during the period of blowing. By means of certain assumptions we can apply

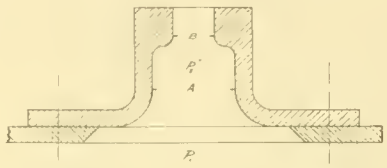


Fig. 4 Reduction in Area Between Boiler and Valve

the formula of flow proposed by Napier, and after the calculations are made they may be tempered by the actual conditions which exist, should they deviate from the assumptions.

Steam in the course of its passage from the boiler to the atmosphere encounters two reductions in area of passage, which affect the pressure under the disc, one at entrance to the valve or the nozzle, and the other at the seat. The existent area conditions may be graphically represented by Fig. 4, in which the reduction of area from boiler to valve is denoted by the section at A and over the seat by the section at B. The edges of the passage which form the approach to the section at A are rounded to a radius equal to the diameter of the passage in order that the formula that we shall use may fit the case at hand. Let P_1 represent the boiler pressure, P_2 the pressure under the disc, and then assume that by some means the area at B can be changed as desired. When flow is established and conditions have become constant, the weight of steam passing the section B is the same as that passing the section A, and if the weight passing B is varied, that passing A goes through the same variation. Now the pressure P_2 depends on the weight flowing and the pressure P_1. Assign a constant value to P_1, say 200 lb. absolute and by means of the following formula, calculate the pressure P_2 with different weights flowing. So long as the discharge capacity by B is less than that at A, the formula

$$W = 0.029\, a \sqrt{P_2(P_1 - P_2)} \text{ holds.}$$

This formula when P_1 is assumed to be constant may be written:

$$P_2 = \frac{P_1}{2} \pm \sqrt{\frac{P_1^2}{4} - \frac{W^2}{(.029a)^2}}$$

after the quadratic equation has been solved.

Assume now for an actual case, that the diameter at A is 2 in., giving an area 3.1416 sq. in. and that P_1 is equal to 200 lb. absolute boiler pressure. Then calculate different values of P_2 with different weights flowing. These values of P_2 may

be plotted against the weights and the curve shown by Fig. 5 will result. This curve is interesting since it represents quantities which may be arrived at by calculation only, and which must exist. Its significance is as follows:

With a safety valve of 2 in. nominal diameter and adapted to discharge a certain weight of steam, the pressure under its disc may be found from the curve as follows: Suppose its discharge is 6 lb. per sec.; then the points C and D are located and the pressure under the disc may be read. It is clear then from this curve that the pressure under the disc varies as the weight of flow varies, and that for valves of low lift the

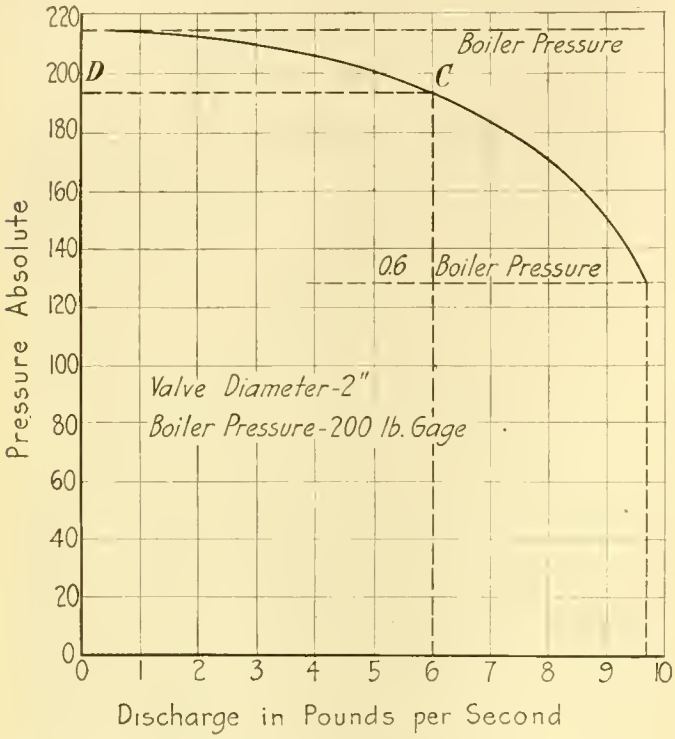


Fig. 5 Relation between Pressure under Disc and Weight of Steam Flowing

reduction of pressure is not great, but that for high lifts it increases rapidly. This curve is discontinuous when the pressure under the disc reaches a point where it is equal to 0.6 the boiler pressure, under which conditions the area at B has become equal to that at A; the pressure P_2 is the minimum possible, and to all intents and purposes we have a standard orifice, so-called, the characteristics of which are shown by Fig. 6.

Our only assumptions up to the present are the neglect of friction and the rounded edges. It is clear that friction and square edges will tend to increase the drop in pressure, since both tend to reduce the discharge capacity of A, and it also follows that maximum capacity is not available with square edges at A. In other words, the full advantage of the hole in the boiler is not available unless this hole has rounded edges.

There results from the further consideration of the curve in Fig. 5, a simple explanation of why a safety valve disc settles back after the first sudden pop. Since the reduction of pressure on the disc does not take place until the valve is open or until flow is established, the lifting force is, at opening, that due to full boiler pressure, and the instant flow is established this is reduced and the disc must necessarily settle back to a position of equilibrium. The design of a valve must then incorporate means to provide lifting force outside the seat area, to make up for the reduction of upward force on the load area due to drop in pressure over and above that necessary to compress the spring.

In any safety valve there are three factors which affect the rate of flow over the seat, which are characteristics of the seat itself. They are: *first,* vertical lift; *second,* seat angle, and *third,* the contour of the passage which approaches the seat. The flat seat is adapted to open the largest area per unit of vertical lift, and hence should be employed, all other things being equal. Since the approach to a standard orifice makes the throat sectional area 100 per cent efficient, the characteristics of such an orifice should be employed. Professor E. F. Miller, of the Massachusetts Institute of Technology, was first to round the edges of a safety valve in order to increase the efficiency of discharge per unit of lift, and in so doing took a long step in the direction of high safety valve efficiency. The valve shown in Fig. 7, in which the standard orifice, or better, its practical equivalent, is incorporated, follows the theory proposed by him several years ago. The full benefit of the standard orifice would be available, regardless of the type of lip provided, if the passage area from the seat outward increased, but to produce a high lift valve the maximum available pressure between the lips consistent with maximum discharge must be used.

Steam Flow as Affected by Shape of Orifice

A consideration of the pressure conditions within a standard orifice, of which Fig. 6 is an example, will give valuable information. In this type of orifice the area of each section after the throat section, is equal to that at the throat section, and it has been found that at the throat section and at each section of equal area thereafter the pressure is very closely equal to 0.6 the boiler pressure, and that the back pressure into which this orifice discharges has no effect on either the weight discharged or the existent orifice pressures unless this back pressure exceeds 0.6 the boiler pressure. If it does exceed 0.6 the boiler pressure the discharge capacity is reduced and the pressure throughout the orifice is increased. With the orifice of a shape shown in Fig. 8, but of equal throat sectional area, the weight discharged is the same as before, but the pressure after the throat section varies inversely as the area.

It follows from the above consideration that in order to produce maximum pressure between the lips there must exist at full lift an equality of area at each section outward from the throat of the orifice which is located at the seat. Since the effective disc diameters are constantly increasing, the effective lift must be reduced as the passage is lengthened. This can be done by giving the passage an upward slope, as is shown by Fig. 9, which illustrates graphically the reduction of effective lift with increasing diameters such as D_1 and D_2 at which the vertical and effective lifts are measured.

If a valve of the above characteristics is constructed and blown, it will be found to have an extremely high lift, and the opening of such a valve is so sudden as to be truly explosive. A very large percentage of the pop lift is sustained if the popping pressure is held constant, and when such a valve starts to blow down the lift gradually decreases during the blowdown period until a certain point is reached, where the pressure becomes such that the valve disc drops suddenly to closure. This construction will produce a blowdown which is likely to be a third of the boiler pressure and forces its designer to incorporate means of regulation which

will give a small blowdown without interfering with the capacity, or other features of valve action.

REGULATION FOR WARNING AND BLOWDOWN

The question of adjustment presents the real difficulty in safety valve design. Means for regulation should in general perform their functions with as little effect as is possible on the lift and, per unit of lift, should produce no effect on the discharge capacity. Other than lift, the two functions to be controlled by regulation of the variations in lifting force are warning and blowdown. A valve which chatters or vibrates at the instant of opening, or sizzles at that time, shows a lack of lifting force at low lifts, and one which shows an excessive blowdown demonstrates that the lifting force at low lifts is too great to allow of closure, and it follows that the requirements of warning and blowdown are somewhat combative. If it is possible, means should be provided for making, in so far as is possible, the means adopted to regulate one independent of the other. Blowdown is an absolute necessity on the spring loaded type, due to the existence of lifting force outside the spring chamber, and it is clear that attempts to reduce the blowdown will tend to decrease the lift and relieving capacity. In general, the real secret in the design of a perfect safety valve lies, not in the production of excessive lifting force, but in controlling and adjusting it; the action of a valve is dependent, not on the quantity of lifting force, but on variations of lifting force with discharge capacity and pressure.

DESIGN OF NEW VALVE

Fig. 10 shows a valve which has means for adjustment which are based on the production of variable lifting force as stated above. The two annular rings shown at *A* and *B* carry on their upper surfaces curves which approximate in shape the curve of the disc. The inner ring *A*, which I choose to call the warning ring, is threaded upon the base of the valve just outside the flat seat and carries, threaded upon it, the ring *B*, which is adapted to control the blowdown. These rings may be lowered away from the disc, or given what I choose to call initial clearance.

Now it is clear that if both of these rings are lowered, an extreme distance, when the valve tends to open no lifting force will be available. If the ring *A* is raised to a position near the valve disc, a lifting force will be provided which will depend, *first*, on the pressure produced between it and the disc, and *second*, on the extent of the disc area on which this pressure acts. As was shown in the discussion of the standard orifice, the pressure depends on the area of the passage and the area in the valve is a function of the initial clearance and the shape of the curve. These factors are built into the valve to produce the desired result, which is to provide lifting force at small lifts to overcome excessive warning, and it has been found that with the proper shape of ring, on its initial clearance, depends the warning of the valve. Since this warning ring alone produces only small lifts, it has no appreciable effect on the blowdown.

Now as the blowdown ring *B* is raised from its lowest position, there is a tendency to build up pressure between it and the disc when the valve is open, which tendency increases as the disc is approached. If a reasonably large clearance is left, it is clear that this ring produces almost no lifting force at low lift, since the area of the passage along this ring is large in comparison to that over the seat, and it follows, also, that as the disc lifts the effect of this initial clearance on the area of the passage becomes less and less as lifting continues. This can be illustrated by a simple calculation. Suppose that, measured at the extreme outside edge of this ring, the initial clearance is 0.03 in. and that the angle at this point is 45 deg.; then if the disc lifts 0.1 in. in a vertical direction, the height of the passage over the seat will be 0.1 in., and at the extreme edge the increase in passage height perpendicular to the curves will be 0.07 in., since with a 45 deg. angle the vertical lift is only seven-tenths effective—so that the total height of the passage is 0.1 in., the same as that over the seat. Suppose now that lifting continues; the area at the edge of this ring gradually approaches that over the seat and can be made to become equal to it by proper design at any chosen lift. It is clear then that for all of the initial clearance of the rings, we have at full lift gotten back to the area conditions of a standard orifice.

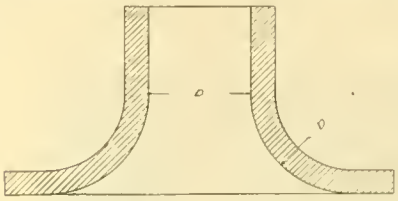


Fig. 6 Pressure Conditions for "Standard Orifice."

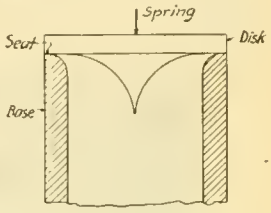


Fig. 7 Valve Incorporating Standard Orifice Equivalent

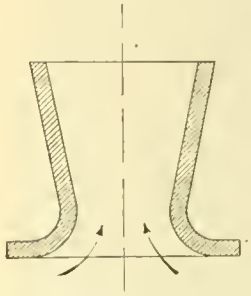


Fig. 8 Pressure Varying Inversely as Area

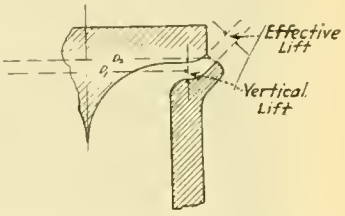


Fig. 9 Valve with Maximum Pressure Between Lips

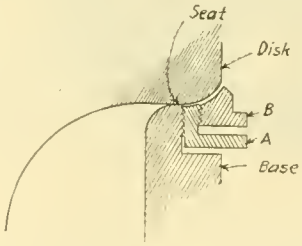


Fig. 10 Valve Adjustable for Variable Lifting Force

Tests of this valve prove the value of this method of regulation in that all the requirements of practice are afforded by it for all of the high lifts. Any one sufficiently interested can lay out a valve of this type, and he will find that if the characteristics of the spring to be used are known, he can calculate with reasonable accuracy the lifting force at any lift and also an approximate value of the total lift. In calculations of this nature, the reduction of pressure on the spring load area, as previously explained in this paper, must be taken into consideration.

DIAGRAMS SHOWING PERFORMANCE OF EXPERIMENTAL VALVES

I have with some difficulty succeeded in getting some diagrams from valves under service conditions which, I believe, show in detail the results of the methods of regulation which

are employed. Fig. 11 shows a photograph of the arrangements of the valves for testing. The tests from which the diagrams were secured were carried on at the power plant connected with the new buildings to be occupied by the Massachusetts Institute of Technology.

One of the regular 4 in. valves was removed and a Y-base substituted in its place; the regular 4 in. was then placed on one of the branches and on the other was placed a special by-passed gate valve, and finally, on top of this, the valve on test was connected. Under the above conditions the valve on test was well above 3 ft. higher than the top of the drum. Those experienced in safety valve action will realize that this height is apt to seriously affect the action of the ordinary valve. The recording apparatus used consisted of a clock motion adapted to turn a chart once in 15 minutes. Bearing on this chart was a pen rigidly connected to the spindle of the valve and adapted to leave a record thereon

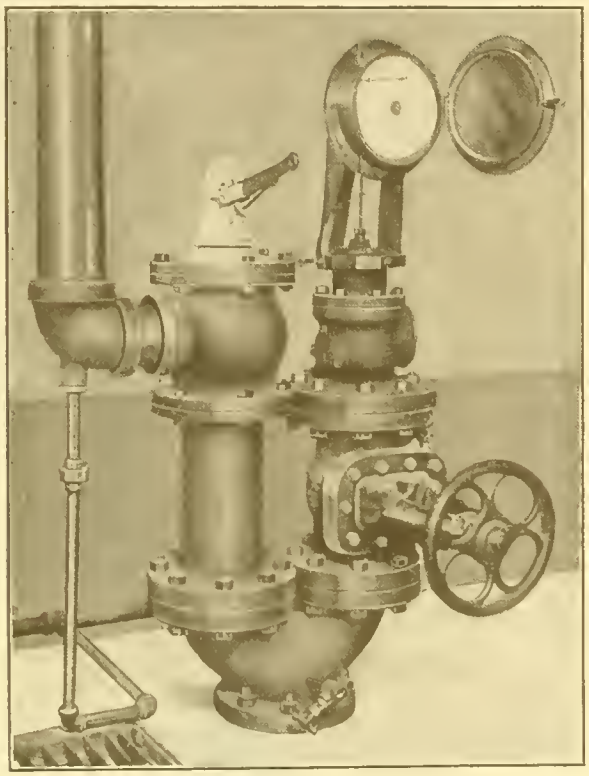


Fig. 11 Valve Arranged for Test

of lift with respect to time, the lifts being multiplied by a ratio of approximately four to one.

Fig. 12 shows a chart of the performance of a valve with a 2½ in. seat. This valve was blown at 150 lb. gage boiler pressure and showed, under the existent regulation, 5 lb. blow-down and almost no warning. In order that it may be clearly understood, it has been transferred to a diagram having rectilinear axes, on which is plotted the scale of lifts which resulted from the calibration of the recording lift gage with an accurate micrometer. In Fig. 13 the sudden pop lift is shown at *A*, and the corresponding sustained lift at *B*. The variations in lift at the point *B* are further evidence of the readjustments of pressure which determine the pop and sustained lifts, an idea of which may be gained from the theoretical considerations previously stated in this paper. The discharge capacity of this valve was such that the popping pressure was not maintained, and the curve from *B* to *C* shows the reduction in lift, which in this type always corresponds to a reduction in boiler pressure. At *C* the valve closed suddenly with less than half its initial sustained lift prevailing.

In other words, the drop lift of this valve, which is numerically 0.09 in., is about equal to that of a low lift valve, while its discharge capacity at popping pressure is nearly twice as great as regards lift, and is even more when seat angle and efficiency are taken into account. This diagram shows the action of the valve when adjusted to give action somewhat similar to that to be found in some types of valves now procurable, and is in a good many ways ideal. Attention is called to the smoothness of the curve between *B* and *C* as evidence of the equilibrium between lift and boiler pressure existent as the boiler pressure is reduced.

Fig. 14 shows precisely the same valve with its outside or blowdown ring lowered slightly. This diagram is, like the one preceding, a photograph of the actual diagram, and has not been transferred to rectilinear axes because of the difficulty in showing the fluctuations in lift. The section of the curve at *A* shows the pop and sustained lifts as before. From *B* to *C* is shown the gradual reduction of lift corresponding to decreasing boiler pressure, until the point *C* is reached, where the disc suddenly falls from a reasonably high lift to a much lower one. This action is due to the large initial clearance of the blowdown ring, which throws it out of action entirely when the lift value at *C* is reached. The fluctuations in lift at the point *C* show the lack of equilibrium at this point in the action, which results finally in the drop to the lower lift. At the lower lift, represented by *D*, all the supporting force is that due to the inner or warning ring.

The downward slope of the curve from *D* to *E* shows the tendency of the valve to decrease its lift with decreasing pressure and closure would doubtless have taken place at *D*, had not the fans been started at this point in an attempt to force the pressure back to the popping pressure. The section from *E* to *F* shows an increase in lift corresponding to the increase in pressure. The fluctuations in lift during this period show the tendency of the blowdown ring to come into action, it being prevented from doing so only by the lack of pressure. The fans were shut off without orders at *F*, and the valve immediately blew down and closed with 0.04 in. closing lift at *G*. If we suppose the diagram to have been completed by closure at *D*, as would have been the case without the attempted accumulation, this diagram would then represent the action of a high lift valve with a closing lift less than that obtainable from any low lift valve of ordinary design. That this action can be and is continually repeated by valves of this type is a fact to which every one who has been a witness of the blowing of this valve will testify. To those who have heard such valves blow no diagrams are necessary.

It was decided after the two preceding diagrams were secured to change to a smaller valve of lower discharge capacity, under which the pressure could be regulated as desired. It is my purpose to bring out by the three diagrams which follow the faculty this type of valve has to respond, under ordinary conditions of regulation, to accumulated pressure above the opening pressure. The new Boiler Code rules, if put into force, will allow 6 per cent accumulation of pressure, and I wish to show by the diagrams what advantage may be taken of this accumulation.

Fig. 15 shows a chart taken from a 2 in. valve in which the pressure was not allowed to accumulate. The low closing lift in comparison to the sustained lift is to be noted. Fig. 16 shows the same valve with an accumulation of pressure over the opening pressure of 4 per cent. This is under the

same regulation conditions as the next preceding chart. The substantial increase in lift and corresponding discharge capacity is to be noted, together with the same closing lift.

In Fig. 17 the valve was regulated to give a low sustained lift, and was then given the full 6 per cent accumulation. It is clear that the lift at *B* is more than 100 per cent greater than that at *A*, so that the discharge capacity at 6 per cent accumulation is more than 100 per cent greater than that at the opening pressure. The low closing lift is to be noted as before. The blowdown on this valve was about 2 lb., so that this chart was made between a maximum pressure of 159 lb. and a minimum pressure of 148 lb. The new Boiler Code specifications rate valves on their sustained lift at the popping pressure, and so it is clear that with this type the basis is amply safe.

In presenting the diagram (Fig. 18) for consideration I believe that I am showing a safety valve which is absolutely new, both in conception and results. It has been the aim of safety valve designers to produce a valve which relieves a boiler with an action which is smooth and containing as few sudden fluctuations in pressure as is possible. The Boiler Code Committee recognized the capabilities of standard valves to respond to accumulated pressure by incorporating the 6 per cent accumulation rule. The ideal safety valve for practical purposes is, I believe, one in which a reasonably low lift is maintained at the popping pressure, but one which will on the slightest accumulation respond with an extremely high lift to take care of the emergency. If a low lift is available at the popping pressure for ordinary relief, a low blowdown may be incorporated, the condition imposed by absolute safety being that at slightly above the popping pressure, the lift will have increased to such an extent that any possible emergency will be taken care of.

Fig. 18 shows a diagram from a valve which produces the above action, and is what may be called a second opening valve. Many of this type have been built, and it has been found that with the proper regulation of rings, all valves having two rings will produce this action in modified form. Imagine, first, one of the ordinary type blown with the outside ring removed. This would result in a low lift and a very low blowdown. Now suppose that the blowdown ring is in place, but that it is given such a large initial clearance that the valve will act, provided that it has sufficient capacity to relieve the boiler, exactly as before, but if it has not the required capacity the pressure will accumulate and the increase of lift resulting with only the inner ring in action will finally bring the outer ring into action, and a second pop will occur. This pop will result in a high lift, with corresponding high discharge capacity, and the valve size may be proportioned to give the required safety.

Fig. 12 Performance of 2½-in. Experimental Valve

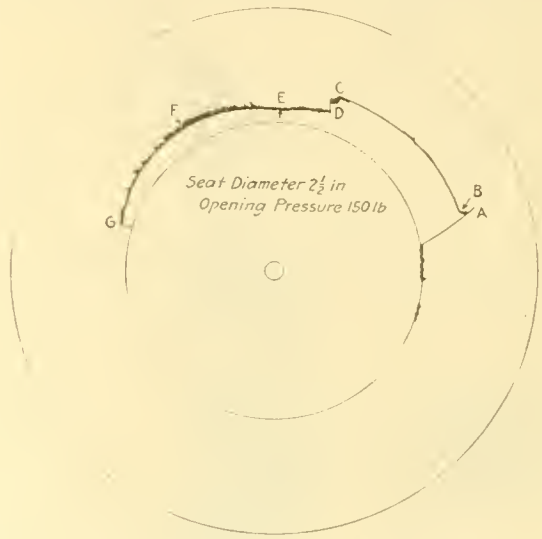


Fig. 14 Valve of Fig. 12 with Blowdown Ring Lowered

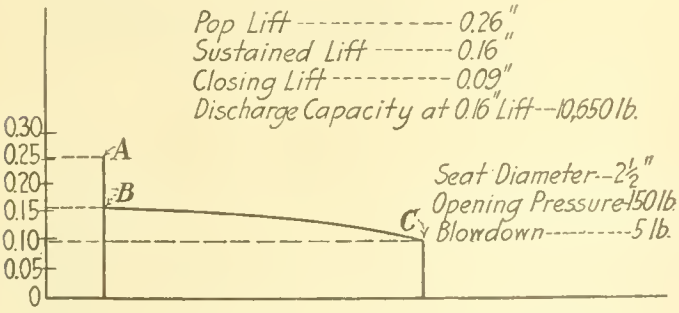


Fig. 13 Analysis of Diagram Shown in Fig. 12

That this action can be accomplished in actual practice is shown by the diagram in Fig. 18, which resulted from the action of a 1¼ in. valve on a boiler, or rather boilers, of sufficient capacity to produce the required accumulation. The first pop and sustained lifts are shown at *A*, the sustained lift being very low. The increase in lift between *A* and *B* finally results in the second pop, shown at *B*, which is the result of accumulated pressure. Between *B* and *C* the lift gradually falls as the pressure is reduced, until at *C* the outside ring goes out of action and the disc drops to a low lift, which is at the given pressure just sustainable by the inner ring. As the pressure is reduced the lift decreases, and after a slight blowdown the valve closes at *D* with a very low closing lift. This valve had a seat diameter of 1¼ in. and lifted at its highest sustained point about 0.11 in. This lift was the result of about 4 per cent accumulation, and the calculated discharge capacity is 5100 lb. per hour, which is approximately 170 boiler h.p.

FEATURES OF DESIGN

Careful design will allow of bringing the second pop down very near the first one, and the limits of regulation may be so built into the valve by limiting the possible up and down

motion of rings, so that this second pop will always come within a given range of pressure. This type of action has many advantages to recommend it. The absence of sudden excessive changes in relieving capacity and the low lift at closure are evident from the diagram. It is clear that if a boiler had two valves of this type, the second might be set to blow at a pressure corresponding to the point O on the diagram, so that the two valves would be able to handle the boiler at all ordinary times without the second pop, but in the case of emergency both would rise to the second pop lift. The installation would then be essentially a low lift installation, but would have all the advantages of high lift in the case of emergency.

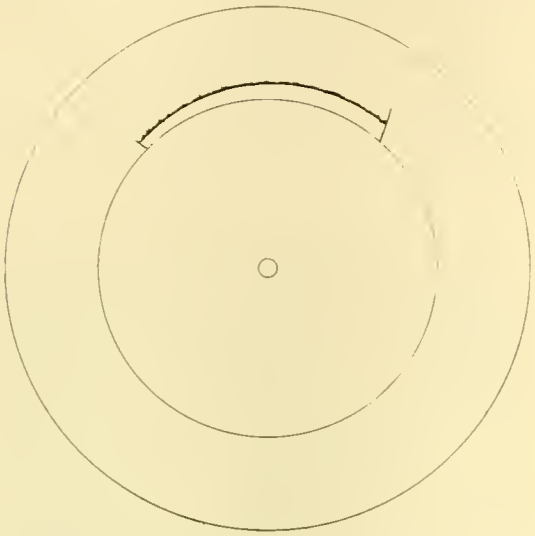


FIG. 15 2-IN. VALVE: SUSTAINED LIFT AND LOW CLOSING LIFT

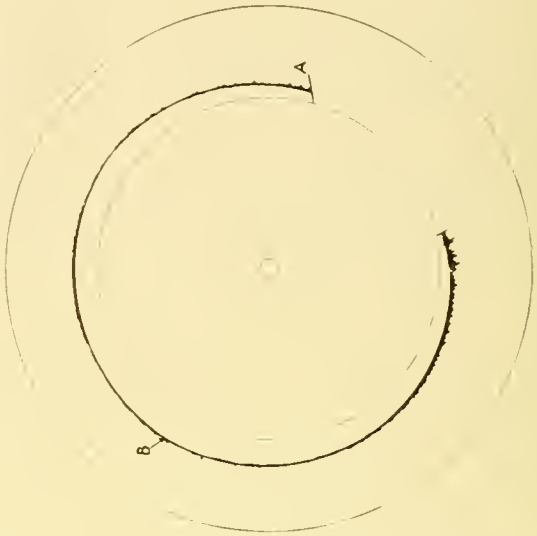


FIG. 17 2-IN. VALVE: LOW SUSTAINED LIFT WITH PRESSURE ACCUMULATION

FIG. 16 2-IN. VALVE: PRESSURE ACCUMULATION BETWEEN OPENING AND CLOSING

FIG. 18 A "SECOND OPENING" VALVE

TABLE 1 RESULTS OF DISCHARGE TESTS ON 2 AND 2½-IN. VALVES

Valve Diameter	Opening Pressure	Blowing Pressure	Percentage Accumulation	Discharge in Pounds per Hour	Efficiency	Lift
2.5″	150 Lb.	158.8 Lb.	5.86%	17,325	99.43%	.252
2.5″	200 Lb.	212.9 Lb.	6.44%	16,892	78.88%	.238
2.0″	200 Lb.	203.4 Lb.	1.7 %	10,176	101.57%	.145

Above pressures are by the gage.

DISCHARGE TESTS

In the course of my experimental work very few discharge tests could be run, since most available plants have no means of measuring the water used. Three tests were run at Annapolis, Md., at the United States Naval Experiment Station, the results of which are useful in this paper only in so far as they establish the fact that the efficiency of the standard orifice type is so nearly 100 per cent per unit of lift that the accepted formula used will not show accurately the deviation from the above efficiency. Three capacity tests were made, two with a seat diameter of 2½ in. and one with a seat diameter of 2 in. Two of the tests were run at the regular, 6 per cent over-pressure common to Navy practice. The results reported by the station are shown in Table 1.

The test in which the efficiency fell off to 78.88 per cent is reported by them to be a mistake which, after the test, was impossible of correction, so I think that it is fair to assume

that we may accept the results as evidence of the fact that the discharge efficiency is so nearly 100 per cent that for ordinary calculations the efficiency may be neglected.

It is always interesting to compare the results obtained from any piece of apparatus with those which we know to be theoretically possible. In the case of safety valves the full opening valve serves as a convenient basis of comparison, in that its capacities may be calculated without reference to the type of valve used. If we attach a standard orifice to a boiler we have then the most efficient way of discharging steam, and this on a basis of throat diameter may be characterized as the full opening valve.

In column 1, Table 2, are shown the capacities of full opening valves of several diameters figured directly from Napier's formula. Column 2 shows the discharge capacity of valves of the same diameters as read from the table in the recent A.S.M.E. Boiler Code. I have assumed that these values represent standard conservative practice. Column 3 shows the discharge capacity of the type of valve which I have described, and is the result of calculations involving the lift as measured from the diagrams at the popping pressure.

It seems reasonable to believe that the spring load of a safety valve is to some extent a measure of the shock at closure, which may be expected. Since all valves of the same

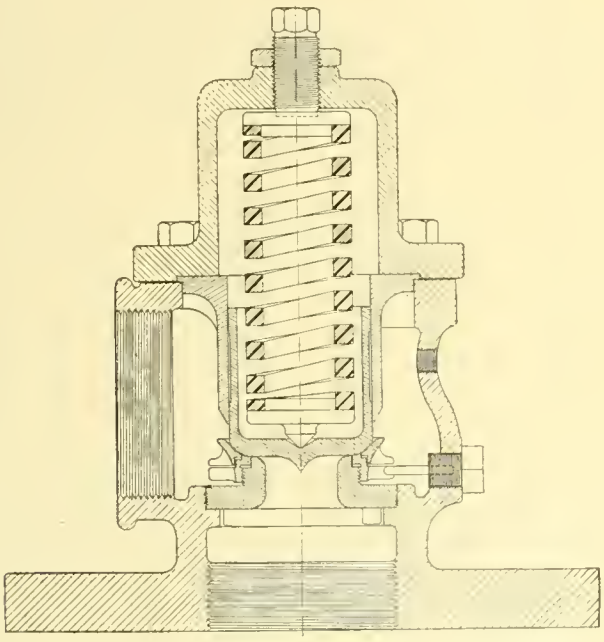


Fig. 19 Steam Safety Valve of Approved Design

diameter have approximately the same spring load, some other basis than diameter must be chosen for comparison. Discharge capacity is the first requisite in all valves, and so the spring load has been calculated per 1000 lb. of steam discharged per hour. Column 4 shows the spring load per 1000 lb. discharge of full opening valves, which is, of course, constant. Columns 5 and 6 show the same quantity calculated for A.S.M.E. valves and for the proposed type. Columns 7 and 8 show the percentage of full opening attained by the two available types.

There is reason to believe that we shall soon have boilers which will operate at 600 lb. pressure. Consideration of some of the values given in this table is interesting in this connection. A 4 in. valve set at 600 lb. pressure will have a spring load of approximately 7540 lb., or about 3½ tons. Now if a 2 in. valve can be constructed to give twice the lift of the 4 in., it will have the same discharge capacity, but its spring load will be only one quarter as great, or 1885 lb. In other words, the discharge capacity varies as the first power of

TABLE 2 CALCULATED CAPACITIES OF FULL OPENING VALVES

Opening Pressure 150 Lb. Gage

Nominal Valve Diameter	1″	1½″	2″	2½″	3″	3½″	4″
1 Discharge capacity of a full opening valve	6,660	14,900	26,600	41,600	59,900	81,600	106,500
2 Discharge capacity of A.S.M.E. valves (from table)	904	1,625	2,529	3,613	5,419	6,954	8,670
3 Discharge capacity of proposed type (from tests)	...	...	5,310	10,640	...	...	...
4 Spring load of (1) in pounds per 1000 lb. discharged	17.7	17.7	17.7	17.7	17.7	17.7	17.7
5 Same for A.S.M.E	131	120	185	204	196	208	218
6 Same for proposed type	...	...	88.5	69.2	...	...	...
7 Percentage of full opening attained by proposed type	...	...	26.6	25.6	...	...	...
8 Same for A.S.M.E	13.6	10.9	9.51	8.67	9.05	8.50	8.15

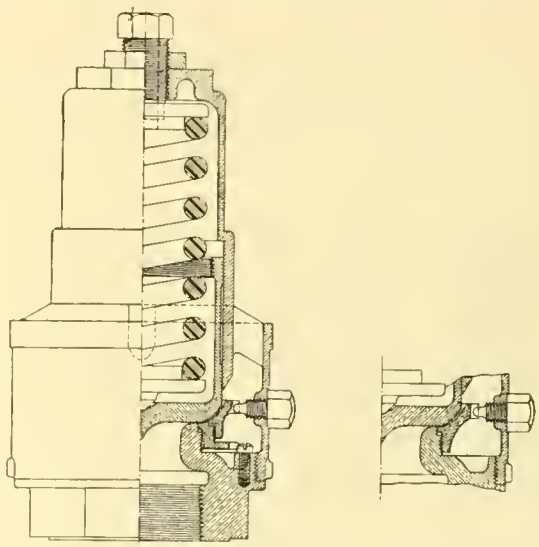


Fig. 20 Locomotive Valve of Approved Design

the diameter and the lift, but the spring load, which is independent of the lift, increases as the square of the diameter. It seems clear from this that high pressure boilers will of necessity require small-diameter high-lift valves.

This table shows the net result of the development in spring-loaded safety valves, and serves to emphasize the opportunities which may be grasped by the designer.

The question of the effect of back pressure in the casing of a safety valve has been much discussed. It has been said that it may operate in two ways to reduce the discharge capacity. *First*, the effective lifts may be reduced, and, *second*, it has been held that back pressure reduces the efficiency of discharge of the orifice. If any of the disc area is exposed to back pressure, the lifts will be reduced to some extent, but consideration of the theory of flow through an orifice, and particularly a standard orifice, brings out the fact that as long as the back pressure in the casing is less than 0.6 the boiler pressure, the discharge of the orifice is not affected.

The discharge capacity tests made some years ago by Mr. P. G. Darling went some distance in establishing this fact, although no general conclusions were drawn. It remained for a section of a Committee of the American Society of Refrigerating Engineers, with Professor E. F. Miller as chairman, to establish this fact beyond question. In refrigeration

installations long discharge pipes are required, and the back pressure built up in them as a result of pipe friction produces so much back pressure that either the ordinary type of valve is useless or its discharge pipe must be of an excessive size. The experimental work resulted in a valve which was so constructed as to take advantage of back pressure to increase its lift without in any way having its discharge capacity per unit of lift reduced. This valve is due to the ingenuity of Mr. F. L. Fairbanks of the Quincy Market Cold Storage and Warehouse Co., and has been adopted as the standard in Massachusetts.

EFFECT OF BACK PRESSURE

The possibility of back pressure operates to reduce the discharge pipes to reasonable sizes in spite of their length. There are many economical advantages to be gained for steam users by a valve which will operate without harmful effect of back pressure. *First,* the sizes of discharge pipes may be reduced, and, *second,* several valves may be connected into a common discharge pipe.

EXAMPLES OF THE NEW VALVES

Fig. 19 shows a complete view of a valve which has the above advantages. In the first place, valves of high

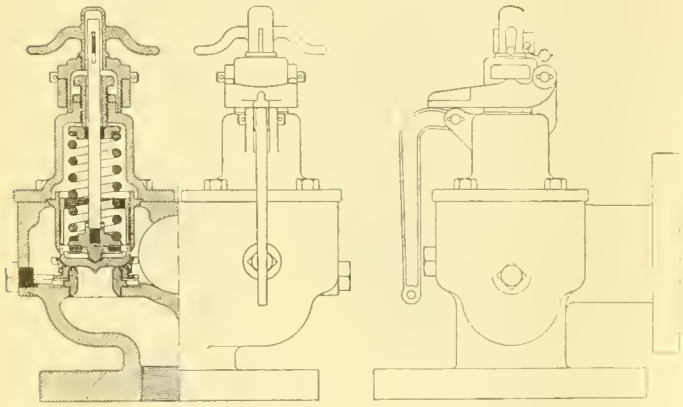


Fig. 21 Marine Valve of Approved Design

lift, and by that I mean higher lift than any of those obtainable at present, must be guided from above, as guides in the base will cause too great a drop in pressure on the disc area. In this view the disc is made in the shape of a hollow piston, which is guided by a cylindrical sleeve which encloses the spring chamber. The fit existent between these is extremely loose, and no attempt is made to prevent leakage by the disc. This loose fit insures that the disc will not bind because of expansion or contraction between the members due to temperature changes, and is long enough in relation to the diameter of the disc so that it will never cock. Its looseness alone insures that the disc will come to a uniform bearing on the seat, and it has been found that under no conditions of back pressure has the leakage by it been sufficient to produce pressure in the spring chamber, which is always fitted with a vent. With this type, the back pressure may be built up to nearly 0.6 the boiler pressure without hampering the discharge capacity in the least, and since the back pressure is a result of the effective opening of the valve, it has no effect whatever on regulation, if it is brought about by the means shown.

In the case of duplex or triplex valves having a common discharge pipe, the opening of one will tend to open the other, due to the exposed area outside the seat and the impossibility of back pressure acting downward on the disc. It must be understood that the commercial types of valves which are shown in the following illustrations are not dependent on back pressure for any part of their action, but are in every case adapted to work with it, without harmful effect. Fig. 20 shows a locomotive valve of approved design, and Fig. 21 the proposed marine type of exceedingly large capacity.

Having shown a valve in which there is substantial increase in discharge capacity over those in use at present, and having demonstrated that this may be accomplished with lower closing lifts than are now the rule, attention is called to a possible improvement in this type. It will have been noted by this time that in all the types shown, the passage turns upward from the seat region, and it is also clear that so far as the area conditions go it might as well be turned downward. If it is turned downward, the area conditions will remain constant, as illustrated in Fig. 22, but there will be available as lifting force a factor which would act upward on the disc, and which is commonly known as a jet action. Some few valves of this type have been constructed, and the results gained have been convincing of their possibilities. Enormous lifts have been attained with the same absence of shock at closure as is the case with valves herein described. The problem has been by no means solved, but advances have been made in a direction which tends to indicate that it will be solved finally, and will result in enormous discharge capacities per inch of valve diameter, with the same efficiency per unit of lift. It is clear

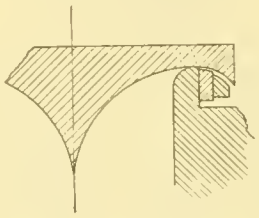


Fig. 22 Valve with "Jet Action"

from a consideration of the diagram that the force due to jet action will not be destroyed by back pressure, as the velocity of the issuing jet of steam is a function of the orifice pressure, which pressure is not affected by the back pressure.

In closing this paper, attention is directed to the fact that this valve is not essentially a high lift valve. It may be designed to give low lifts as well as high lifts, and is easily adaptable to the proposed specifications. It will, of course, under the specifications, benefit, by reason of its flat seat, by a discharge capacity about 30 per cent greater than the 45 deg. seat now in common use.

I have shown that it is possible to produce a valve of high lift as regards discharge capacity and low lift as regards the shock at closure. This one feature alone removes the most serious objection to high lift. It is clear that for all of the reasonably high initial lift the valves have a marked faculty to respond to over pressure. Finally, high lift valves must come into general use as the safety requirements in boiler practice must be more economically met than is the case at present. It is distinctly the province of the experienced and unbiased engineer to lay down the rules that will govern future safety valve installations, but in determining the rules the valves must be considered on a basis of discharge capacity and action rather than lift.

THE PRACTICAL CHEMISTRY AND MODERN MANUFACTURE OF PORTLAND CEMENT

BY GEO. P. DIEKMANN,[1] MASON CITY, IA.

Non-member

WHILE the Portland cement manufacturing industry has grown from an output of a few hundred barrels per year to about 100 million barrels annually, and while the mechanical part of the manufacture has undergone many changes, the installation of improved machinery having almost revolutionized the former art of making the cement, the chemical process in itself is carried out in the same way, based on chemical laws and definitions laid down by the investigation and work of Fuchs and Vicat, two distinguished scientists of the early part of the last century. Of course, the advanced knowledge of chemistry and the researches of eminent men have given us more and truer knowledge of the chemical composition of cement, and in order to throw more light and awaken more interest in research, a prize has been offered by the Prussian Government for the best essay on the constitution and hardening process of hydraulic cements, and efforts are renewed to solve this much disputed problem.

Portland cement is a hydraulic cementing material with not less than 1.7 parts by weight of lime to 1 part of soluble silica plus alumina and iron. The lime necessary to produce Portland cement is found as limestone called calcareous matter, and the silica, alumina and iron are found in clay, called silicious matter; the calcareous and silicious materials are mixed in proper proportions and burned to incipient fusion at a temperature of about 2600 to 2800 deg. fahr. and the resulting clinker ground, to which 3 per cent of gypsum is added to regulate the setting time. Portland cement should not have more than 1.75 per cent sulphuric acid, which is equivalent to about 3 per cent calcium sulphate or gypsum, and not more than 4 per cent magnesia, although these specifications vary in different countries.

Chemically Portland cement is a salt composed of acid and basic constituents of such a composition that none of the bases are unsaturated. The main elements are silica, alumina and iron, known as the acids, and the lime and the magnesia are known as the bases. When limestone and clay have been intimately mixed and ground together to an impalpable powder, this then represents the mechanical mixture of acid and basic constituents, or what is the same, the silicious and calcareous materials. In subjecting this mechanical mixture of limestone and clay to the influence of heat at about 2600 to 2800 deg. fahr., the mechanical mixture is converted into a chemical mixture or compound, and limestone and clay exist no longer in their original form, but are converted into an entirely new chemical compound, a clinker, called tri-calcium silicate.

Various theories are advanced on the chemical composition of cement. According to Zulkowsky, there are existing two isomorphous compounds of the di-calcium silicate, the non-ortho active modification, the ortho silicates, the active modification and the basic meta-silicates. The meta-silicate is considered a strong hydraulite, having hardening properties in contact with water. The ortho silicate has no hydraulic properties and disintegrates. In other words, silica, lime, alumina and iron must be present in such a ratio that certain chemical action is produced.

According to Le Chatelier, whose work has long been considered the modern theory on cement, cement is a tri-calcium silicate. Professor Michaelis recently advanced the colloid theory, which might give an entirely new view on the constituents of cements. Clifford Richardson made a very thorough microscopic examination of cement clinker and his studies are very interesting. According to these theories, the total basic constituents of any cement expressed in equivalents should not be greater than three times the total acid constituents expressed in equivalents. According to Michaelis, the composition of the cement should be such that the ratio of the acid constituents to the basic constituents shall be from 1.8 to 2.2 times larger by weight. This formula is the one most used and enables the composition to be judged from the analysis very quickly.

In Portland cement each element performs a certain function, and therefore the elements should have a certain ratio to each other, as follows:

Lime to silica.....	2.8:1 minimum;	3.2:1 maximum;
Alumina to iron.....	2.5:1 minimum;	3.5:1 maximum;
Iron to alumina.....	2.0:1 minimum;	3.0:1 maximum.

The chemical composition of Portland cement is very uniform and is usually as follows: silica, from 20 to 23 per cent; alumina, from 5 to 8.5 per cent; iron oxide, from 1 to 4 per cent; lime, from 60 to 64 per cent; magnesia, from 0.5 to 3.5 per cent, and sulphuric acid, from 1.5 to 2.5 per cent.

There are certain formulae for the calculation of the proper proportion of each raw material in relation to the others according to chemical composition and physical nature. One of the most convenient which is used is a formula according to C. Shoch by which the desired ratio can be determined according to the analysis of the materials which are calculated on the total silicates containing silica, alumina and iron. However, no matter what formula might be chosen, the Portland cement raw mixture contains usually from 42 to 43 per cent lime and 20 to 21 per cent silica, or a ratio of 2:1; this may sometimes be as low as 1.8:1 and as high as 2.2:1.

Portland cement contains usually from 5 to 8 per cent alumina. With an increased amount of alumina the cement becomes quicker setting, and if the alumina content reaches about 9 per cent, the cement becomes very quick setting, due to the formation of a tri-calcium aluminate. If alumina is present in quantities exceeding a certain limit it is considered detrimental, as it not only produces a quick setting cement, but has a greater expansion power, especially if hardening takes place in sea water or water containing alkaline matter. The aluminates are parts of a cement which are most easily acted upon by certain salts contained in sea water, forming water soluble compounds which in time destroy the cement.

Iron in a cement combines with lime and acts as flux similar to alumina in lowering the fusing point between the acid and basic constituents. Iron will give cement a darker color. Alumina might be replaced by iron giving an excellent cement for marine work. In fact, there are now manufactured in Germany iron Portland cements which are claimed to be superior to ordinary Portland cements for sea water construction.

The effect of magnesia on cement is still a matter of investigation, but all agree that a large amount of magnesia is detrimental to cement. It is of so much more danger than other constituents as the expansion power of magnesia will occur long after setting. The general specifications call for not more

[1] Chief Chemist, Northwestern States Portland Cement Co.

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than 4 per cent magnesia, while the German specifications allow a limit of 5 per cent. Candelot in his investigation stated that magnesia produced the same effect as free lime. In recent years the many accidents occurring in construction where magnesia cements have been used have drawn attention to this question. Magnesia cements give very good results in tests, and masonry made with these cements shows desirable solidity sometimes during several years, but after a certain time swelling begins to manifest itself, and with such intensity that nothing can resist it. Candelot stated that a rod of magnesia cement 1 m. long was found to elongate 26 mm. in three years. Dykerhoffer stated, after very thorough research work, in which he studied the effects of magnesia, that when magnesia is added to the raw material or substituted for an equivalent portion of lime, it causes a decrease in strength in the resulting cement if present in a proportion greater than 4 per cent. Cracking occurs only with 8 per cent magnesia or more.

It is known that magnesia compounds become hydrated much more slowly than calcium compounds, and this is evident as although concrete consisting of calcium silicate and aluminate will harden and set in a proper manner, cement containing magnesia either in combined form or as free magnesia will, due to the slow hydration after setting, undergo changes and molecular movements, causing expansion and cracking. The natural cements contain usually from 16 to 22 per cent magnesia, but here the magnesia has no injurious effects as in Portland cement. The trouble lays in the burning, as while Portland cement raw mixture is burned at a high temperature to effect incipient fusion, forming a very dense clinker, in a natural cement mixture only a moderate heat is applied to drive off the carbon dioxide. The resulting clinker is soft and the magnesia is hydrated here very quickly; the hard clinker obtained with this process is picked out and not used.

The amount of sulphuric acid in a Portland cement should not exceed 1.75 per cent, but according to the German specifications 2.5 per cent is allowed. The presence of sulphuric acid in a cement is due to the addition of calcium sulphate, which is added in the form of rock gypsum or burned plaster before or after grinding the clinker. Portland cement clinker is more or less quick setting, and, in order to retard or regulate the setting time, a small amount of gypsum is added. The amount depends on the composition of the raw materials—usually from 2.5 to 3 per cent is added.

Portland cement clinker usually contains about 0.1 to 0.4 per cent of sulphuric acid due to the sulphates in the raw materials, which are mostly converted by the high heat to volatile acid and driven off. A small amount of this acid is also due to the ash from the coal, which becomes part of the cement. If the burning or fusion takes place in a reducing atmosphere, the sulphates will be converted to sulphides, forming mostly iron and calcium sulphides, which will again be oxidized to sulphates. The small amount of calcium sulphate added to cement retards the setting time.

When cement is mixed with water chemical action takes place at once, according to Le Chatelier. The hardening process is due to a deposit of inter-locking crystals from a supersaturated solution, part of the water entering into chemical combination. There are two distinct chemical actions which take place, the setting or hydration and the crystallization or hardening process. The process of setting is due to the formation of aluminates of calcium, developing a certain degree of heat, but the addition of calcium sulphate prevents quick hydration by forming sulphate of aluminate of calcium, which hydrates very slowly without developing heat.

Along with the hydration the hardening process is beginning very slowly. The tri-calcium silicate is decomposed by the action of water to mono-calcium silicate and calcium hydrate. The process of crystallization begins very slowly, and as time goes on the crystals become closer interlaced, forming a denser body and attain a stone-like character, called hydraulic character, and it is this process which makes Portland cement such a high grade hydraulic mortar. If once formed, no action of the elements can disturb its increasing crystallization, and as Portland cement is the binding medium in concrete, any suitable aggregate will become embodied and form an unseparable bond of natural stone.

Portland cement develops in the hardening process about 40 per cent of its total strength in the first 24 hr., 60 to 70 per cent in 7 days, 80 to 85 per cent in about 30 days, and it will attain its maximum strength in about 6 to 12 months, depending on the season of the year. This explains why a cement of 24 hr. is not as strong as at 7 days, and at 7 days not as strong as at 28 days.

There are several processes by which Portland cement is manufactured, the wet process, the semi-wet process and the dry process. In this country almost 95 per cent of the total product is made by the dry process. The production in this country has reached 92,000,000 barrels annually.

One of the most modern Portland cement mills has been recently erected at Mason City, Iowa, by the Northwestern States Portland Cement Company. The annual capacity of this plant is about 2,000,000 barrels. In it are indicated the many changes and improvements that the Portland cement industry has undergone, by the adoption of economical machinery, etc. The plant at Mason City is the seventh erected according to the Cowham system.

The materials used at Mason City are limestone and clay, which are found in almost perfect composition in the vicinity. The quarry, which is only a few hundred feet away from the plant, has a limestone averaging about 97 per cent pure carbonate of lime, and many acres of it are owned by the company. The physical characteristics of this quarry are a very important feature. It has not only horizontal seams, but vertical seams at right angles to the others, and the seams are so close that the rock is in reality a multiplicity of small cubes, and very little blasting is necessary to tear them asunder.

A large steam shovel with a 3-yard dipper is used in loading this rock in side open cars that are hauled by a Shay locomotive to the plant. The stone is dumped into a receiving hopper of a gyratory crusher, which crushes the rock to a 4 in. cube size, and from here it is elevated to the top of the crusher building and again crushed by two small crushers to cubes about 2 in. and finer. The stone then passes into a set of rolls, which crushes it to about ½ in. size and finer. The crushed material is next discharged into the bottom run of a 24 by 32 in. McCaslin conveyor which encircles the stone drying, stone crushing and stone storage building like a belt. The stone storage building has a capacity of about 30,000 tons of stone. The top run is located in the monitor of the building, and the bottom run is located in a tunnel under the storage pile. The conveyor permits of delivering the stone directly from the rolls to the dryer bins, or into the storage building.

As it is necessary to dry the stone before further reduction in size is made, this is done by two rotary stone dryers into which the stone is fed from the stone bins by Gates oscillating feeders. Each of these dryers consists of a fire-brick-lined cylindrical steel shell, 6 ft. diameter by 60 ft. long, mounted on two sets of carrying mechanisms. They are set on a slight slope, with the feed end a little higher than the discharge end;

and the furnace is located at the lower, or discharge end. The heat comes into intimate contact with the particles of stone as the dryer has shelves in it which raise the stone and shower it through the heated air and gases passing through the dryer.

From the dryers the stone is elevated and discharged into eight steel bins, from which it is discharged by means of feeders into Krupp ball mills. These ball mills take the output of the crusher above described and reduce it to coarse grit of which 50 per cent will pass through a 100 mesh sieve. This mill consists of a drum of a diameter about double its length, filled with 5000 1-lb. steel balls, and the lining is made up of over-lapping steel plates which form steps or shelves on the inside. This drum revolves at a speed of about 26 r.p.m.

The clay fields are located about 1½ miles southwest of the plant. No stripping is necessary as the clay is suitable directly beneath the grass roots. A specially designed plow drawn by a traction engine is used to plow this clay to the depth of about 1 in., so that the air and sun can get a chance to dry it out. The clay fields are kept higher in the middle than at the edges in order to have easy drainage.

The clay is gathered by means of a specially designed gathering machine on scrapers (revolving cylinders), each drawn by a team of horses, which load automatically. When loaded the team is driven over a bridge under which the clay track runs and the clay is dumped automatically through an opening into side-dump cars. When a certain number of cars are loaded the train is hauled to the plant and up onto a trestle, where the cars are dumped in a few seconds. The clay is then discharged, by means of a belt, into clay pans, where the grinding of the clay takes place. From here it is raised into an elevated bin, from which it is fed into the rotary clay dryers, which are similar to the stone dryers. After drying, the clay goes either to the clay storage room or to the mixing station into a steel mixer alongside the stone mixer. The clay storage has a capacity of about 15,000 tons of clay. There is also another large clay storage building at the clay fields, holding approximately the same amount of this material.

In the meantime, while these materials are being prepared, samples have been taken at every step at certain intervals and tested at the laboratory, and the chemist, knowing the composition of the limestone and of the clay, is now in position to direct the proper amounts to be mixed to obtain the proper raw mix. The ground stone and the finely divided clay are stored in adjoining bins of steel, and steel spouts lead the materials through shut-off gates to steel hoppers mounted on scales. There are two sets of scales, each of which is so arranged that the weighman can see the poise but cannot tamper with the weights, as the scale beams are in a box which is locked and the key held by the chemist on watch; the adjustment of these scales is tested very often by the chemist. The stone is weighed first and then the clay is run in on top of the stone—approximately 9000 lb. of the two materials is weighed per batch.

After passing through a rotary mixer this material is conveyed to Allis-Chalmers tube mills for a finer grinding and mixing. These tube mills are steel cylinders 5 ft. in diameter by 22 ft. long, supported at each end by trunnions, and filled about one-half full with flint pebbles imported from Denmark, which are about the size of one's fist. The mixture is ground to a fineness such that about 97 per cent will pass through a 100 mesh sieve.

The raw mix, now prepared to its necessary fineness, is conveyed and elevated to the kiln building, where the raw mixture is calcined, and after all the carbon dioxide is driven off, the acid and basic constituents are fused, forming tricalcium silicates. The fusion takes place at about 2800 deg. fahr. The clinker, as the fused mixture is now called, drops from the kilns into a pit and is conveyed to the clinker cooling station. The kilns are similar in their construction to the stone and clay dryers mentioned heretofore, except that they are larger. These large cylinders, which are constructed of sheet steel 9-16 in. thick and lined with fire-brick, are supported at a slight incline from the horizontal by means of rolled steel tires, each of which revolves at about one-half a revolution per minute on four heavy cast steel rollers mounted in pairs on a rocker. Each of these kilns weighs, with its load of fire-brick and charge of mix, approximately 175 tons.

A large amount of coal is used for fuel in these rotary kilns, which after being dried and powdered in suitable grinding machinery to a fineness of about 97 per cent through a 100 mesh sieve, is conveyed to steel hoppers in the rear of the kiln building, and then fed through pipes into the lower ends of the revolving cylinders and blown with a pressure of 4 oz. per sq. in. through 5-in. pipes.

The cooled clinker is next conveyed and elevated to the Kent mill building, where the clinker is reduced to the size of fine sand. This fine clinker passes over a series of screens separating the coarser clinker from the fine clinker. The fine clinker goes on to the gypsum station, while the coarser is conveyed back to the Kent mill for regrinding. The finely ground clinker passes into a hopper having a capacity of five barrels, to which a weighed amount of gypsum is added. There are two of these hoppers, to allow feeding and discharging alternately. By this process the addition of gypsum is uniform at all times, as the clinker is weighed and the gypsum weighed also, insuring perfect uniformity.

The clinker with the addition of gypsum is then elevated and conveyed to the finish tube mills, which are similar to the raw mix tube mills. Here the clinker is ground to the desired fineness, which is on the average of about 96 to 97 per cent through a 100 mesh sieve. Tests of fineness of the cement are made from each mill every hour before the cement enters the warehouse. At this point samples of the cement are delivered to the laboratory each hour for the general tests of fineness, setting time and soundness. The warehouses in which the finished cement is stored have a capacity of 600,000 barrels.

After the cement has been tested for the necessary tests already mentioned, with the addition for tensile strength, the cement is then discharged from the warehouse bins into a conveyor running in a tunnel underneath the bins and elevated to bins above the packing machines, where the cement is packed in bags ready for shipment. Samples are taken during the loading of each car of cement and tested again at the laboratory before the car leaves the yards. The samples of cement are kept on file for six months. Perfect records of shipments and tests are kept in the laboratory, where they can be referred to.

The entire building equipment of the Northwestern States plant covers an area of about 40 acres of ground, and the buildings on the plant proper are arranged in a unique order, so that the material always advances from the crushing end through the various departments until it arrives at the packing room, where it is loaded onto the cars. About 1,600 carloads of machinery, materials, etc., of construction (exclusive of sand, gravel and crushed rock) were used in the building of this plant. The plant as it is to-day represents an actual cash investment of $2,750,000, and the daily capacity is 6,000 barrels of cement.

EQUITABLE SPECIFICATIONS AND CONTRACTS

BY HILLIS F. HACKEDORN,[1] INDIANAPOLIS, IND.

Non-member

THE American Society of Engineering Contractors, ever since its organization in 1909, has had a number of ideals to which it has clung tenaciously. One of these is the idea of equitable specifications and contracts; specifications that are written fully and completely describing the work down to the minutest detail, eliminating all guesswork and conveying to the contractor completely the ideas of the engineer; describing fully what work he expects to do, how he expects to do it, sequence of the performance and the results he expects to obtain, leaving nothing for future argument, nothing for guesswork.

In reading over many specifications and contracts, it more than frequently occurs to me that the engineer who has written them seems to take the position that the contractor is bound to be dishonest, ever ready to take advantage of the slightest point to "put one over" the engineer and owner. But all contractors are not dishonest, and it has been my pleasure during an experience of almost 20 years in the construction of reinforced concrete bridges, to meet a number of gentlemen in the contracting business with ideals and aims as high and honorable as in any other industry, occupation, business or profession; likewise have I met contractors whose knowledge of the contracting business, and incidentally of the engineering profession, has been as broad, liberal and authentic as any engineer I have ever known.

One of the greatest impositions that is ever placed on the contractor is by the engineer whose specifications fairly teem with the expression "to the satisfaction of the engineer." This very-much-abused, never-understood, and impossible-to-forecast expression is about as serious a handicap as can be hung onto a contractor who is making up an estimate of cost on any type of construction. It leaves such a wide field for guesswork, it opens up such a broad avenue of opportunity for the engineer or inspector to "get even" with the contractor for some fancied or real grievance. It is something against which a contractor has no opportunity whatever to protect himself.

This phrase impresses the contractor as an evidence of either lack of knowledge on the part of the engineer or laziness in preparation of the specifications, and in many instances the contractor views these clauses in the light of a club to be held over his head during the construction of the work. They impress him with the belief that the engineer *thinks* he wants certain things done but if the contractor learns during construction that the engineer wants something else done, the contractor must pay for the change. The engineer should be sufficiently advised and have sufficient knowledge of all conditions surrounding the work to enable him to make up a correct detailed guaranteed design and estimate. He should have the nerve to stand pat on his estimate and likewise should not expect the contractor to make good the cost of any mistake he may make in the preparation of plans and specifications; neither should the contractor be put to the expense of thoroughly checking the engineer's estimates, and all engineering and contractors' organizations should join in an effort to educate specification writers to a proper conception of what is fair and equitable to owners, engineers and contractors alike.

In Great Britain carefully prepared schedules as to quantities are submitted to the contractor. These quantities are guaranteed, and in case of error, the contractor has a ground of action against the quantity surveyor if his bill of quantities is wrong. This method enables the contractor to estimate much more closely as to the cost of the work than under customs in this country, where all estimates of quantities are *frankly* labeled as guesses, and the engineer dodges all responsibility by stating that the contractor must assume all the hazard as to errors in such estimates. Of course, the contractor under these conditions, must charge for an element of chance which should not enter into the proposition. The engineer should make his estimates carefully and thoroughly and be ready to stand behind them in case of error. I know of but one bridge engineer who guarantees his quantity estimates and as a result bidders can make much closer estimates, knowing as they do, that he will stand responsible for any errors in his quantity statements.

An unfair engineering practice frequently resorted to in the writing of specifications is to require the contractor to prepare the detailed working drawings for the job, including, for reinforced concrete, bending diagrams and special details as to connections of reinforcement, thereby making it necessary for the contractor to maintain a much more extensive engineering and drafting department than would be otherwise required if the engineer did his full duty, preparing all detail plans and working drawings so that there would be no question in the contractor's mind, when he bid on the work, exactly how the work was to be executed to the most minute detail. In addition to this, some specifications require that the contractor "having checked the plans shall be responsible for the correctness of all drawings, as to dimensions, elevations and mutual correlation of various parts," thereby making the contractor absolutely responsible for the correctness of the engineer's design and drawings, and in case of an error, the expense of correction is unfairly placed on the contractor. The contractor is given no extra allowance for preparing these drawings, but must do it at his own expense and deduct it from his estimated profits, when it should be taken from the engineer's fee.

Our position in the matter of detailed specifications is that we know of no legitimate reason why the contractor should not have full detailed information as to what will be required in the execution of a given contract *before* the contract is signed, rather than make haphazard guesses on small scale drawings and indefinite specifications frequently lacking in vital information. If detailed drawings have not been completed before the date upon which bids are requested, the date should be postponed to give the engineer an opportunity to prepare complete working drawings. It takes no longer to study the details of a structure before the contract is executed than after, and a careful preparation of detailed drawings and the writing of complete specifications, would frequently result in saving of cost to the owner because of the necessity of the contractor to add a certain percentage to cover the uncertainties of plans and specifications.

Another question in which many engineers err in judgment is in specifying a short time for completion and requiring the starting of work immediately upon the awarding of contract. A short limit reduces competition because it admits only the contractor who is fully equipped and ready to begin immediate work, and where a short time limit is provided, the engineer should include a certain compensation to cover the cost of night work necessary on the part of the contractor in order

[1] President of the Hackedorn Contracting Co., Past-President of the American Society of Engineering Contractors.

Presented at a joint meeting of the American Society of Engineering Contractors and the St. Louis local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on December 1, 1915.

to complete the work within the time set. It has been our experience that where the engineer coöperates with the contractor, the quality of work is very much improved, resulting in a great benefit to the owner. Of course, if the contractor knows that the engineer is disposed to treat him fairly and not impose unnecessary hardships upon him, he will in return for this confidence, exert every effort to give the owner the benefit of his experience in producing the highest class of results. If the engineers will write their specifications with the most complete details, setting out definitely in every paragraph what is expected, how it is expected to be done, avoid all reference "to the satisfaction of the engineer," then when the contract is commenced the contractor understands the case, what he is expected to produce for the compensation promised him, and there is no argument, no quibbling and no trouble. An owner gets a high class piece of work, the contractor gets paid for doing it and the engineer reaps the credit for the design.

One of the most dangerous conditions in the great majority of specifications is the clause providing that the engineer shall be the final judge as to the interpretation of the specifications. The lawyer would call this ex parte, for the reason that the engineer is in the employ of the owner, and his judgment is bound to be biased toward that side.

One manifestly unfair condition in many specifications is that of giving the engineers the right to make minor changes in the plans, without extra compensation to the contractor, unless "in the opinion of the engineer" he is entitled to such extra compensation, the amount of any such extra compensation to be determined solely by the engineer. This condition leaves a very large opening and opportunity for the engineer to abuse his authority over a contractor whom he does not like, or seriously cripple him, when the wrong man, in the opinion of the engineer, has landed the job.

One of the ideals of the American Society of Engineering Contractors is that the specifications should provide in the event of any disagreement between the contractor and engineer, regarding the reading of the plans or the interpretation of the specifications, the quality of the work, the justice of any claim for extras, or any other controversy arising out of the contract or the specifications, that such question shall be submitted to arbitration—the engineer and owner on the one side and the contractor on the other being bound beyond appeal, to the decision of the arbitrators. In our opinion, this removes the danger of the contractor being injured by the decision of the engineer, or the owner being defrauded by any unfair work of the contractor. It would mean the elimination of controversies between engineer and contractor and place their relations on the broad peace basis of arbitration, that is bound to be a controlling spirit in future times, which we trust are not far distant.

In my mind, one of the greatest injustices which enters into nearly all specifications, is the clause requiring the contractor to "indemnify, keep and save harmless the owner and engineer from all liabilities, judgments or costs and expenses which may in any wise come against the owner or engineer on account of any infringement of any patent on the use of any design, material, machinery, device or apparatus used in the performance of the contract." In other words, the engineer goes along, prepares his design, specifies his materials and method of construction and puts the responsibility on the contractor for ascertaining whether or not there are any patents on the type of design, or material used, or on the method of construction. It seems to me that this is part of the duty of the engineer, and that in making his design he should ascertain beyond the possibility of a doubt whether or not his design infringes any of the many patents which have been granted by the Patent Office at Washington, and in case he cannot make a design without infringing a patent, he should either notify all bidders of the existence of such patent, and the fact that his design infringes, or he should obtain from the owner of the patent the right to use it for a specific price on the work. It is entirely unfair to shoulder this responsibility and liability on the contractor, in addition to the many other troubles which he has to guard against in executing the contract.

Another inequity is that of giving the engineer the right to direct the sequence of the work and issue orders as to the manner and time in which the various parts of the work shall be done, and the force required to complete it within the time specified. I believe I can state, without fear of contradiction, that no two contractors would handle the same job in the same manner and sequence. It is customary in making up estimates, to carefully plan the manner and sequence of the construction, and if the contractor is not permitted to follow his own methods, it frequently results in turning a contract, that would otherwise be profitable, into one that results in a loss to the contractor.

The experience of many contractors has demonstrated that many of the engineering profession are guessers on cost construction with no actual experience to guide them. Of course, we as contractors do not charge the engineering profession with doing this guessing on cost with any malicious intent to injure a contractor, but the result is the same. If an engineer, having a lack of actual knowledge as to the cost of the various elements making up the construction of a given piece of work, relies on a rough guess, it is bound to bring grief to the contractor, either in the way of blaming him for charging exorbitant prices for the work, or if, as is frequently the case, the contractor has had no personal experience in the cost of this element and uses the engineer's guess as a basis for bidding, he is bound to lose.

Many contractors hesitate, and some even refuse, to furnish engineers any details as to actual cost data, which in my opinion, is more injurious to contractors than to the engineers. If contractors would supply the engineering profession with actual experience data, I have no doubt the engineers would be glad to use it in making future estimates, but it is doubtful if the contractors as a class can be convinced that this method would correct frequent carelessness and loose methods in making up estimates by engineers.

Another practice followed by some engineers is the trimming and pruning of monthly estimates for payment. As a general proposition the engineer or inspector directly in charge of the job, who is frequently a young man, will make a *decided* practice of *underestimating* work actually done, refuse to include in his estimate many items which in equity, a contractor should be allowed, and then, after taking off the percentage held back as provided by the contract, a contractor gets in reality 50 or 60 per cent of his work actually done where he should get 80 or 90 per cent. Of course, this has no bearing on the engineer's ability, but it frequently embarrasses the contractor in financing big jobs.

We all know the average contractor will take on work in excess of what he really should undertake with a fair and reasonable consideration of his financial ability, which frequently makes it necessary for him to watch every corner, and make many twists and turns in a financial way to meet his payrolls and material bills. This is chargeable in most instances to ambition and an eagerness to make money, but when

this condition is evident, and on top of this, the engineer trims his estimate approximately 20 or 30 per cent below what the contractor is entitled to receive and has reasonably expected, it very often gets him between the millstones of the banks, which proverbially grind slowly but exceedingly fine.

An important point in the preparation of estimates for pay, is that engineers should make an allowance for material on the ground ready to be worked up, a sum covering forms and preliminary work, and in some instances a sum approximating the cost of new equipment that is to be bought to handle the especial job. Of course, I realize that the engineer will say that many contractors will be unreasonable in these claims, but if the engineers would show a disposition to help the contractor along these lines, I believe that 90 per cent of the contractors would be disposed to strain points in favor of the engineer and owner, and give them a higher type of construction. It would be nothing more than an appreciation of a favor extended, and along this line, we are all human and willing to show our appreciation of any such help.

The business relations between the contractor and the engineer are little understood by the public at large. We frequently hear a contractor on public work condemned for failures in bridges, roads or pavements, when he was entirely innocent, having built the work in strict accordance with specifications furnished, yet the general public makes him the goat, and the engineer, who has prepared faulty specifications, goes "Scot free." Of course, the engineer may take the high position that if the contractor does not like his specifications he need not bid on the work, but this is not only unfair to the contractor but also to the owner, because it reduces competition by eliminating intelligent and responsible contractors. Some contractors go so far as to refuse to bid on work where the specifications are not fair and completely detailed, but where a contractor has a large organization with a certain amount of overhead expense, he is, of course, anxious to make as good a showing on the capital invested as he can; hence by passing up unfair specifications, many pieces of work which he could do at a profit under fair specifications, are lost. We, as contractors, realize that one of the most difficult problems confronting an engineer is the preparation of his specifications, in making them rigid enough to control the bad contractor and at the same time work no hardship on the contractor who is honest and sincere in his work.

A prominent engineer, in a paper recently read, refers to the personality of the engineer as probably the most important factor in the relations between engineer and contractor, stating that some engineers have a notoriously bad name and do not seem to appreciate the responsibility of the honorable position they occupy. If the contract is used merely as a legal document to hold over the contractor's head as a club and unnecessary harassing and vexatious conditions insisted on, trouble will surely follow. The wise engineer knows that many contract conditions can be ignored without any harm being done, and that many facilities can be given the contractor to help expedite the work. We believe that the contractors as a body will not take unfair advantage of these concessions, but in their turn, will go out of their way, even at extra expense, to meet some special request of the engineer, playing the game of "give and take" in a reasonable way without expecting extra pay for every trifling piece of work, thus bringing about a great improvement in the relations between engineer and contractor and eliminating many of the disputes which at present are too frequent.

The National Association of Builders Exchanges, of which Mr. H. L. Lewman of Louisville, Ky., is the president, has been working for a number of years in conjunction with the American Institute of Architects, to secure standard specifications and contracts for the use of builders. Their effort has been:

To accurately define and standardize, wherever practicable, plans and specifications in order to eliminate unnecessary hazards and uncertainties in construction contracts;

To reduce the cost of improvement to the owner;

To give the contractors and surety companies a proper understanding of the obligations they assume;

To establish contracting and suretyship on a more stable and definite basis;

To provide for the settlement of differences by some equitably constituted authority;

To establish building contracts on such a basis that banks and commercial institutions may intelligently determine the amount of credit to be extended to owners and contractors, and to eliminate the present uncertain conditions of credit based on such contracts.

How well they have accomplished this work is evidenced by The Standard Documents of the American Institute of Architects in collaboration with the National Association of Builders Exchanges. These documents define the duty, scope and power of the architect, the duty of the contractors, the scope and limit of arbitration, the rights of sub-contractors and a carefully prepared, detailed article entitled: Advice to Contractors by Mr. William B. King, general counsel to the National Association of Builders Exchanges. The specifications and contract forms have been so carefully prepared and revised that it is difficult to find any point wherein there can be criticism. Their theory is to insist upon the use of the principle of arbitration on every possible question that can be settled without resort to the courts. But the greatest lesson to be derived from this joint work of these two great national organizations is the benefits and justice that are sure to accrue as a result of the joint organization, coöperation and close affiliation. The result has been to increase the membership of the National Association of Builders Exchanges more than double during the year of 1913, which number was doubled in 1914 and almost doubled so far in 1915, making this organization now one of the largest and most powerful commercial organizations in the United States, representing as it does, the broad field of building construction.

If it were possible to bring about such close relations and affiliations between the various national engineering societies, and all of the national contractors' organizations, it would be a result which would be beneficial to all engineers and contractors and almost entirely eliminate losses caused by misunderstandings of contracts and specifications. Such a uniform action could bring about an adoption of standard specifications and contracts based upon equity, intelligence and fair dealing, ever guarded by the idea of arbitration. It is my fondest hope as the executive head of the American Society of Engineering Contractors, that the day is not far distant when all of the National, State and local organizations of Engineers and Contractors may be brought into such close relationship and coöperation that equitable specifications and contracts will be the rule instead of the exception, resulting in standard forms that will not only represent fully the engineer's ideas but will be fairer to the contractor and economical to the owner. I cannot imagine a better declaration of principles and creed than that of the International Rotary Clubs, and if we can get together under some such banner, we can exemplify to the letter the motto of that magnificent organization—"He profits most who serves best."

Society Affairs

Engineering Survey

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National Defense and International Peace

What the Engineers are Doing

THIRTY thousand American engineers are making a card index survey of American industry so that it may be prepared for its vital part in defending the country, if need comes. The past eighteen months have taught us here in America what lack of industrial preparedness has meant to some of the countries now at war. These nations had the ships and they had the men; but when the hour struck, their factories were not able to furnish the colors with arms and shells and powder. Their factories were not prepared. And our factories are not prepared.

But it is not enough to draw a moral. In the United States five great Engineering Societies—Civil, Mining, Mechanical, Electrical and Chemical—have pledged their services to the Government of the United States, and are already working hand in hand with the Government to prepare industry for the national defense. They receive no pay and will accept no pay. All they seek is opportunity to serve their country, that she may have her industries mobilized for defense.

All elements of the nation's life—the manufacturers, the business men, and the workingmen—should support this patriotic and democratic work of the engineers, and assist them cheerfully when asked. *There can be no better national insurance against war.*

The Associated Advertising Clubs of the World, representing all advertising interests, have offered their free and hearty service to the President of the United States, in close co-operation with these five Engineering Societies, to the end that the country may know what the engineers are doing. The President has accepted the offer. The engineers have welcomed the co-operation.

This advertisement, published without cost to the United States, is the first in a nation-wide series to call the country to the duty of co-operating promptly and fully with the engineers.

NAVAL CONSULTING BOARD OF THE UNITED STATES

IN CO-OPERATION WITH

THE AMERICAN SOCIETY OF CIVIL ENGINEERS — THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE AMERICAN INSTITUTE OF MINING ENGINEERS — THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

THE AMERICAN CHEMICAL SOCIETY

ENGINEERING SOCIETIES BUILDING — 29 WEST 39th STREET, NEW YORK

THE SPRING MEETING

THE Spring Meeting at New Orleans, with headquarters at the Grunewald, was successful from every standpoint. The local membership of the Society, the Association of Local Members of the American Society of Civil Engineers and the Louisiana Engineering Society joined as hosts, and arrangements were perfectly worked out through their local committee, W. B. Gregory, *Chairman*, A. L. Black, *Treasurer*, and H. L. Hutson, *Secretary*.

The engineering developments of New Orleans in connection with its drainage problem, sewerage disposal and water supply and the handling of its freight for foreign shipment, are of unusual interest. The old town of New Orleans, which still reflects the characteristics of the French and Spanish who were the first settlers, is an alluring place for visitors, and dinner parties at the noted restaurants in this section were very much in order during the convention. Most of the historic buildings, sites and landmarks are to be found here and their proximity to headquarters made possible frequent between-time trips to this almost foreign land.

The papers presented were all of a high order, there was a large amount of discussion, and the keynote session of the meeting, on the subject of Industrial Preparedness, aroused a great deal of interest and called forth contributions from engineers from every section of the country.

The attendance was good considering the great distance from the center of gravity of the Society's membership, there being a total registration of 485, of which 114 were members, 92 of whom were from out of the city. Special cars were run from New York and Chicago, through Chattanooga and stopping for a day at Birmingham, where the visitors were entertained by the newly-formed local section of the Society in that city, of which R. E. Brakeman is chairman and Paul Wright, secretary. A small group also went to New Orleans by boat from New York.

THE STOP AT BIRMINGHAM

On Monday morning, April 10, the party going by rail left the special cars for the day at Birmingham. Representatives of the Birmingham Section were on hand at Chattanooga to acquaint the visitors with the day's arrangements.

After breakfast at the Tutwiler, the party boarded a special train which was at their disposal for the day and was taken to the Thomas furnaces of the Republic Iron and Steel Company, and to several of the plants of the Tennessee Coal, Iron and Railroad Company, inspecting during the forenoon the blast furnaces at Ensley, the open hearth furnaces, the rail mill and the turbo generator station for the rail mill. The train then proceeded to Bayview where a much anticipated barbecue dinner was served on the shores of an artificial lake used for water supply for a part of the company's plants. To many this dinner was a novelty and to all it was a treat.

After dinner the party spent a few minutes at the Edgewater coal mine in the vicinity, and inspected the Fairfield by-product coke plant which produces ammonium sulphate in large quantities, and several lighter distillates of coal tar.

The last inspection was at the Fairfield plant of the American Steel and Wire Company, affiliated with the Tennessee Company. There is a large production, not only of wire, but of wire nails and wire mesh and barbed wire fencing.

Of particular interest is the welfare work undertaken by the Tennessee Company. There are 18,000 employees, almost exactly half of whom are white and half black. A considerable percentage live in company houses in separate groups for the white and the black, laid out after an exhaustive study of the best to be found among industrial communities in this and other countries. As a preventive measure, strict supervision is maintained of the sanitary condition of the surroundings and the health conditions of the people. The water supplies are analyzed once in two weeks. There is frequent inspection of the sources of milk supply, daily disposal of all waste, street cleaning, etc. Welfare workers give instruction in hygiene, in the care of yards and surroundings and in home duties. There are kindergartens for children below school age, courses in domestic science, and medical and hospital service, regardless of the extent of treatment needed, for a small sum paid monthly by each family. The company coöperates with the county in the conduct of public schools. The attractive appearance of Fairfield, the model town, the commissary department of which the visitors were privileged to inspect, and the evidence everywhere of cleanliness and orderliness throughout the various plants of the company, called forth favorable comment.

In the evening, dinner was served at the Hotel Tutwiler, after which there were several addresses. R. E. Brakeman, chairman of the Birmingham section, was toastmaster, and the visitors were welcomed to the city by Commissioner John R. Hornady, who also represented the Chamber of Commerce. Frank H. Crockard, vice president and general manager of the Tennessee Coal, Iron and Railroad Company, who is also the Society's choice in Alabama as its director for the industrial survey of the state, told something of the resources, operation and products of his company in relation to the plants which had been visited during the day.

Dr. W. F. M. Goss, Past-President Am.Soc.M.E., said a few words in response, referring to the visit of the Society

A MESSAGE FROM PRESIDENT WILSON

My dear Mr. Jacobus:

It is with great pleasure that I acknowledge your letter of April fourth as it gives me the opportunity of expressing my appreciation of the high sense of loyalty and patriotism displayed by the members of The American Society of Mechanical Engineers in their prompt and earnest volunteer of service to the Government of this Republic. It is the kind of response that was expected from the members of your organization and is expressive of the real spirit of Americanism which is ever ready to serve the interests of our common country.

In the hope that your meeting will result in your highest anticipations, I am

Sincerely yours,

WOODROW WILSON

APRIL 7, 1916.

to old Birmingham in England, six years ago, and the educational institutions there. In the new Birmingham he found comparable conditions through the splendid work along educational lines among its employees by the Tennessee Coal, Iron and Railroad Company.

ARRIVAL AT NEW ORLEANS

Members of the New Orleans local committee joined the party en route Tuesday morning and gave an early greeting to those on the official train. The arrival was on schedule time during the forenoon and during the afternoon there were personally-conducted trips to the French quarter. In the evening all gathered in the ballroom of the hotel for an informal reception and dance.

OPENING SESSION

The first session on Wednesday morning, April 12, was opened by Chairman W. B. Gregory of the local committee of arrangements, whose cordial welcome made those present doubly glad that they could be there to enjoy the hospitality in store for them. Professor Gregory referred to two early and distinguished members of the Society who were claimed by New Orleans. Lewis Johnson, a charter member, remembered with affection and esteem, lived his life and died in New Orleans. For many years he was president of the Sewerage and Water Board of the city, and chairman of the Executive Committee. The work of the Sewerage and Water Board stands as a monument to his memory. The city has been transformed as regards sanitation and drainage, and has been given an abundant water supply.

The other name, high on the honor roll of The American Society of Mechanical Engineers, is that of Maunsel White, a native of Plaquemine Parish, below New Orleans. He will best be remembered for his part in the extended investigations which led to the discovery of the Taylor-White process of treating steel, and the development of high-speed steel, revolutionizing the machine shop work of the world and doubling and trebling the output of machine tools. He was a man of wide interest, who loved literature and art, a poet and mathematician. Mr. White died in New Orleans in 1912.

Following Professor Gregory, A. M. Shaw, Past President of the Louisiana Engineering Society, welcomed the visiting engineers as a representative of the Louisiana Engineering Society and of the local association of members of The American Society of Civil Engineers.

The Chairman then introduced Hon. Martin Behrman, Mayor of the city of New Orleans, who recounted briefly the long struggle of the city to solve its problems of sanitation, water supply and shipping facilities. New Orleans is an old town, full of romance and history. A great street, Canal Street, divides the old from the new. Below Canal Street are scenes that remind one of France and Spain, and above Canal Street is the bustling, up-to-date city rapidly forging to the front. He had one request. Reference had already been made to the modern water system of the city, and when strangers come to New Orleans it is insisted that they drink at least one glass of water, for there is an old adage of the French which says, "Lorsqu'on a bu de l'eau du Mississippi, on y revient toujours."

President Jacobus responded and afterwards took the chair for the session which followed on Organizing for Industrial Preparedness. It had been his privilege to arrive early in New Orleans and to attend a meeting of the Louisiana Engineering Society. Prof. C. W. Williamson presented a paper on the Industrial Resources of Louisiana which had a direct bearing on the subject of the morning's discussion. There was also a Spring Meeting paper by William Von Phul on the facilities of the Port of New Orleans. These two papers, and the remarks by the speakers of the morning, indicate the importance of New Orleans and of Louisiana as an industrial and an engineering center. Tulane University of New Orleans and the State University at Baton Rouge both contribute to this end. The engineers of New Orleans are to be congratulated on the commercial promises of the city and the features which are bound to make the locality a center of engineering; a movement in which all will wish to coöperate, since engineers in fact are all brothers and wish to pull together for the best success of all concerned.

DISCUSSION ON INDUSTRIAL PREPAREDNESS

In the absence of the author, the paper on Organizing for Industrial Preparedness by Spencer Miller, member of the Council and Representative of the Society on the U. S. Naval Consulting Board, was presented by Charles Whiting Baker. This paper has been sent in pamphlet form to the entire membership and was briefly abstracted in the last number of The Journal.

Calvin W. Rice, Secretary, read a telegram from Howard E. Coffin, Mem.Am.Soc.M.E., which called attention to the opportunity as well as the obligation resting with the members of the Society in the matter of industrial preparedness, saying that a successful performance of the great task of preparing the industrial inventory to which our technical societies have been pledged by their governing bodies cannot but bring the American engineer enhanced reputation and closer future relations with the national government. Mr. Coffin is chairman of the Committee on Production, Organization, Manufacture and Standardization of the Naval Consulting Board, through whose efforts the industrial inventory of the country is being developed.

The discussion on the paper continued throughout the morning; and in the evening, after the address by Commissioner Thompson, more time was given to the consideration of the subject and the audience had the privilege of listening to two brief discussions by representatives of the army and navy who are stationed at New Orleans. Written discussions were received from all parts of the country showing the widespread interest in industrial preparedness and containing many constructive suggestions. A full report of the session will be published in an early issue of The Journal.

At the morning session a resolution was offered and passed, proposed by L. P. Alford, requesting the Council to consider the advisability of appointing a standardizing committee for machine tools, realizing the necessity of standardization in our industrial preparation for war.

The Society was honored by receiving a communication from President Wilson, too late, however, to be read at the Wednesday morning session, congratulating the engineers on the movement which they were undertaking and heartily commending it. This letter appears on the insert on the first page of the report of the Spring Meeting in this issue.

A letter was also received from Secretary Daniels of the U. S. Navy as follows:

Accept my thanks and appreciation for your letter of April fifth and the very interesting paper of Mr. Miller which you enclosed therewith. Permit me again to express my appreciation of the service your Society is rendering to the country

Yours truly,

Josephus Daniels.

WEDNESDAY AFTERNOON AND EVENING

It was the intention of the Committee on Meetings that, following the session on Wednesday morning, the local committee at New Orleans should be given the balance of the day and the whole of Thursday to carry out such plans as they had arranged for. Accordingly, the session on Thursday morning consisted of papers on local subjects by local engineers, and Wednesday and Thursday afternoons and evenings were devoted to various entertainment features.

On Wednesday afternoon there was a trip on the steamer Sidney to inspect the harbor of the Port of New Orleans, formed by the Mississippi River. There are many miles of water front controlled by the Board of Port Commissioners as representatives of the State of Louisiana, and the docks and warehouses, totaling nearly 20 acres in area, are uniformly of most modern construction with mechanical handling devices, as, for example, for the unloading of bananas, one of the chief imports, for which specially designed conveyors are used. The exports and imports through the port of New Orleans are valued annually at over $300,000,000.

During the trip a landing was made at the recently constructed public cotton warehouses erected at the expense of $3,000,000 for the safe storage and shipment of cotton. This not only provides the best possible facilities for handling at low cost, but the large storage capacity enables the cotton crop to be handled at the most advantageous time in relation to the market conditions.

Many interesting facts about the harbor and the cotton warehouse were brought out in the lecture by Commissioner W. B. Thompson, given in the evening, on The Debt of New Orleans to the Engineer, an abstract of which follows this report. Mr. Thompson's address was carefully prepared, pleasingly delivered, and gave the visitors a most acceptable resumé of the striking engineering developments of New Orleans which have meant so much in the city's growth and for which the city is indebted to the engineer as its master worker.

THE DAY THURSDAY

At the session on Thursday morning, devoted, as stated, to subjects of local interest, the following papers were presented which drew out considerable discussion: Capacity and Economy of Multiple Evaporators, E. W. Kerr; The Evolution of Low-Lift Pumping Plants in the Gulf Coast Country, William B. Gregory; Mechanical Equipment Use in the Port of New Orleans, William von Phul. The paper by Professor Gregory is given in this number of The Journal and an account of the other papers and a discussion upon all of them will appear in later issues.

Several clubs of New Orleans, including the New Orleans Country Club and the Chess, Checkers and Whist Club, extended their club privileges to the members and on Thursday afternoon as many as desired to go were taken in automobiles to the Country Club, one of the beauty spots of the city, which, unlike most such outdoor places, is located near the center of the city and conveniently accessible from almost any point. From here the party went to the Newcomb School of Art, a department of Newcomb College, the woman's college of Tulane University, where many beautiful art objects are made by the students under the personal direction of their instructors. The Newcomb pottery, which is widely known as ranking among the most attractive products of the potter's wheel, is made and decorated here with designs characteristic of the Southern flora, rich and beautiful in its subdued tones. The visitors were graciously received at the school by ladies of New Orleans and the students of the college. Tea and refreshments, including New Orleans candies, were served, and the college glee club afforded entertainment.

On Thursday evening was the culminating feature in the reception and dance held in the ballroom of the Grunewald, which was largely attended and greatly enjoyed.

FRIDAY, THE FINAL DAY

On Friday morning were simultaneous sessions at which the following list of papers was presented: Establishing a Standard of Measurement for Natural Gas in Large Quantities, Francis P. Fisher; Deviation of Natural Gas from Boyle's Law, Robert F. Earhart and Samuel S. Wyer; Some Experiments on Water-Flow Through Pipe Orifices, Horace Judd; Dynamic Balance, N. W. Akimoff; The Measurement of Viscosity and a New Form of Viscosimeter, H. C. Hayes and G. W. Lewis; On the Transmission of Heat in Boilers, E. R. Hedrick and E. A. Fessenden.

Dr. Jacobus presided at one session and Professor Gregory at the other. At the former D. R. Yarnall of Philadelphia offered a resolution to which he had previously referred at the Wednesday evening session, stating that as engineers we should seek to find and remove the causes for war with even greater effort than we devote to national defense, and by the same methods of scientific research as followed in our other professional work; and providing that the members present should request the Council to appoint a committee of five to consider and report to it as to whether there is any way by which the profession can exert its influence toward the prevention of war.

This resolution was warmly seconded by H. L. Hutson, Charles Whiting Baker and others, Mr. Baker saying that it is our duty as American citizens to take our part and assume our responsibility as leaders in industry in molding a right public opinion in matters of this sort, and that it is the engineer's responsibility to find the sources of trouble and to remove them rather than merely to remedy troubles when they appear.

One view expressed was that the gathering was a small one to pass upon so important a resolution for the Society at large. Upon vote the motion was finally laid on the table. Later a resolution was unanimously carried to extend a vote of thanks to all who had participated in the substantial evidence of friendship and good will shown during the convention and expressing the sense of gratitude which every visitor personally felt.

On Friday afternoon a party was taken to the New Orleans Lake Shore Land Company's project to inspect the reclamation work in process there. This trip was of interest for other as well as its engineering features, because the tract is devoted to the growing of oranges. The large developments of this kind which have come into being during the past few years in the vicinity of New Orleans are very fully outlined by Professor Gregory in the present number of The Journal.

SATURDAY

Probably a third of the visitors remained for the day Saturday to continue their trips about New Orleans and on this day as well as previously, many took occasion to inspect some of the most interesting municipal plants, including the water filtration and pumping plant, and certain of the drainage pumping stations.

THE DEBT OF NEW ORLEANS TO THE ENGINEER

Address by W. B. Thompson, Commissioner of Public Utilities of the City of New Orleans

On Wednesday evening of the meeting, an address was given by W. B. Thompson, Commissioner of Public Utilities of the City of New Orleans, in which was summarized the salient features of the great engineering enterprises which have been carried through by the engineer for the benefit of the municipality. Mr. Thompson said in part:

The City of New Orleans, as age is reckoned on this side of the sphere, is an ancient city. While its growth has not been rapid, nevertheless, when consideration is given to the difficulties which its people have encountered, we have reason to be proud of its record. When, in 1718, Bienville established his civic corporation on the banks of the Mississippi River between destroying flood and miasmatic swamp, the destiny of New Orleans as the daughter of effort, struggle and self-defence was irrevocably fixed. What its people have has been *won*; and the fortitude and spirit of self-reliance which are the products of victory over hostile forces are more valuable than mere prosperity as the result of a fortunate inheritance.

THE FIGHT FOR LIFE AND PROPERTY

Situated in a basin between the river and the lake, with the highest point behind the river banks lower than the high water level of the river, and with the greater portion of its land lower than the high tides of the lake, it is perceived that the first misfortune which threatened the young community was the destruction of life and property by flood and overflow. The engineering genius of that crude period took hold of the situation and built levees, first for protection against the river floods and later against inundation from the high tidal waters of the lake. These primitive improvements constituted the beginning of the levee system which, though not always an impregnable defense, has at least given sufficient protection to make a great city possible, and finally under progressive improvement, has made New Orleans flood proof.

THE FIGHT FOR HEALTH

Until the latter part of the century just closed a few years ago, the City of New Orleans seemed permanently held within the bondage of insanitation. Because of its topographical location the soil was super-saturated and soft. There was no drainage system worthy of the name. Mosquitoes were plentiful. There were no sewers. For a water supply the city depended mainly upon overhead cisterns storing water caught from the roofs of the houses. Sometimes the supply was insufficient and in consequence inconvenience and suffering resulted. At all times the water so caught was unclean and oftentimes impure, and unsafe. The so-called public supply provided by a private company was water pumped directly from the Mississippi River, which in its natural state was too muddy to be of much practical use, and which as a filtered product was too expensive to encourage any general consumption. It is not surprising that as results of these conditions the disease and mortality rate was high, growth in population slow and business enterprise unprogressive.

But there were dreamers among the people and their dreams have all come true. A few dauntless men and women in the late nineties led a movement under the force of which the people of the city were aroused to vote the measures required to finance a complete and comprehensive system of sewerage, drainage and water supply.

SEWERAGE, DRAINAGE AND WATER SYSTEM

The chasm separating project from realization is ever broad and deep and notwithstanding the fact that the tax to provide the necessary means had been voted by the people, consummation was still afar. Many asked, how was it possible to overcome the hitherto unconquerable natural difficulties? How was it possible to trench and effectively drain the sodden soil, to sewer the city safely and to supply the required amount of pure water at a cost within the reach of all? Every citizen realized that the undertaking was gigantic, many believed it to be impossible. It is needless to say that the men who accomplished the herculean task were engineers.

It is no part of my purpose to try to tell how the thing was done and I am destitute of any scientific knowledge as to how the several functions of the completed system are performed. I do know, however, that the soil is no longer soft with supersaturation but is firm and dry; that waste matter heretofore disposed of in a manner offensive and injurious is now, through our sewerage mains, carried secretly into innocuous oblivion; that a limited supply of muddy river water and impure cistern water has been replaced by an unlimited volume of clear, pure liquid as good and as cheap as any city supply in the world; and that since our sewerage, drainage and water facilities have been in operation the mortality rate and the disease ratio of the community has shown a phenomenal decrease and that our health statistics compare favorably with those of our sister cities.

Although good health conditions constitute the foundation upon which any and all civic progress must of necessity be based, still the solution of the physical problems alone by no means answers all of the demands of the city's well-being and well-doing. New Orleans is the seaport of the Mississippi valley, the gateway through which this, the most prolific section of the United States, should and to a large extent does send its surplus of production into the great world market. But even as the old city was restricted by the bonds of insanitation, so was the seaport of the older days hampered in its development by intrinsic defects of equal relative importance.

PUBLIC DOCKS

The docks and shipping facilities of the port are of necessity the vital factors of its existence. They constitute, in figurative speech, the channel through which the stream of foreign commerce flows. If this channel be narrow or is usable only at a high toll of expense, then the volume of business passing through will be restricted to the necessary movement and the increase of such volume will be discouraged.

Under the former regime the dock facilities of the Port of New Orleans were operated by private persons or corporations under lease from the State. This policy of administration of an essentially public utility is vicious from the core. The results that followed from the instance in question were the results which always follow the surrender of such a distinctly public function to the grasp of private monopoly and private greed. The wharves supplied by this private administration were merely wooden floors of primitive construction, open and exposed to the elements, limited in area, destitute of equipment, expressive to the users and wholly inadequate both in point of capacity and service to properly care for the business from necessity forced thereover or to encourage a new and broader commerce.

Some seventeen years ago the State, led by men of vision who appreciated the great advantages to be derived from the public ownership and operation of the port facilities, redeemed the river front from its bondage to private interests and inaugurated the system of public administration, of which our splendid dock equipment of today, capable of caring for the second largest export and import movement in the United States, is the result.

Under the administration of the State through its instrument, the Board of Commissioners of the Port, the wretched equipment of the old order has been replaced at the cost of approximately four million dollars, by more than five miles of commodious wharves of the most substantial construction, protected for the much greater part by steel sheds of the best approved design. Instead of excessive charges for poor service, commerce now pays for a high and improving and expanding order of service the minimum impost consistent with proper operation and the protection of outstanding bonded obligations.

PUBLIC BELT RAILROAD

But the port problem is not settled by the construction of a dock system, no matter how commodious and complete these particular facilities may be. It is necessary to supply the means whereby export goods in quantity may be assembled on the docks for shipment, and whereby imports may be from the docks distributed through the several avenues of transportation to local or inland destination. These means are supplied by the terminal switching facilities of the port.

Under the old order, the important detail of terminal switching was operated by the several private railroad lines which had secured track privileges along the commercial river front. The track grants under which the railroads operated were each limited to a certain locality, hence each grantee could operate only on its own unit. This arrangement subjected the general commerce movement to the necessity of interchange between the switching railroads, and the number of interchanges would run from one to five according to the origin and destination of the freight handled in the switch movement. Moreover each railroad operating on its own unit naturally levied its own separate switching charge, and naturally was not particularly interested in the expeditious movement of freight originating on or destined to other lines. The inevitable result of such a situation was that excessive burdens both in respect to cost and delay were imposed upon the intermediate freight traffic of the port, and in consequence shippers were, to a great extent, forced into the wholly uneconomic alternative of draying. Under these transportation conditions not only was the movement of commerce seriously impeded, but any future considerable growth was rendered impossible.

Again dreamers in the community, some seventeen years ago, began a movement looking towards the unification of switching facilities under municipal ownership, control and operation and about eight years ago this movement reached the stage of concrete reality through the inauguration of a Public Belt Railroad system by the City, to be administered through the instrumentality of a board, called the Public Belt Railroad Commission of the City of New Orleans. Up to the present time the Belt Railroad system has cost approximately one million dollars. It has some fifty-three miles of track, including main lines and switches, already constructed and additional mileage is about to be constructed. It serves the public wharves and the public warehouses, supplies switch track facilities to a large and constantly increasing number of mercantile and industrial plants, connects and interchanges with all railroad lines, and finally, effects upwards of 250,000 car movements per year at the flat charge of two dollars per car to or from any point on the system, which charges cover the double movement of the loaded and empty car.

PUBLIC WAREHOUSES

In the movement of export and import commerce a portion of the freight must be assembled prior to ocean shipment in the one case, or inland distribution in the other. The wharves are intended for transit goods and should not and cannot be utilized for the storage of commodities detained for any considerable length of time pending shipment or re-shipment. In the conduct of the export and import business, as well as in the operation of a market of deposit and distribution, a material proportion of transit freight and market deposits require this sort of storage accommodation. It is obvious, therefore, that warehousing facilities constitute an essential adjunct to a complete port equipment.

Under the old order there was no such adjunct. Such warehousing facilities as were available were supplied at high cost by private enterprises in plants located without reference to the docks, and at inconvenient distances therefrom, thereby entailing excessive expense on the goods so housed, or else undue crowding and congestion on the wharves, or both.

In line with their forward movement, the people of Louisiana in 1910, by an amendment to the Constitution of the State, supplied the Board of Commissioners of the Port with the necessary authority to construct a system of warehouses to be operated in conjunction with the dock facilities. Under this authority, at a cost of approximately three million dollars, the board has recently built a monster cotton warehouse, has already begun the construction of a grain elevator and warehouse, which will require approximately one and a quarter million dollars to complete.

THE COTTON WAREHOUSE

The improved facilities which the cotton warehouse supplies for the more profitable marketing of the cotton crop, invests it with an economic significance which reaches out beyond the limits of the port of New Orleans, and through its bearing upon the cotton problem touches the vital interests of the entire South.

The value of the cotton crop amounts annually to approximately one billion dollars, but under the faulty and uneconomic marketing methods which have prevailed, this great product has not yielded a full return to the producer. The cotton crop, which requires nearly twelve months in the making and harvesting, and fully twelve months in the spinning, has heretofore passed from first hands within three or four months. The great bulk of the crop has been precipitated upon the market during the last three months of the calendar year. This uneven distribution is all in favor of the buyer, hence it means low prices to the seller.

The cotton crop to a very considerable extent is made on credit. When harvested, the farmer must pay his debts, for which he must either borrow money on his cotton or sell it. In order to borrow he must be able to carry his cotton in a safe, dependable warehouse and receive therefor, for negotiation, a good warehouse receipt. If these conditions could not be fulfilled he could not borrow on living terms, if at all. Unfortunately the general warehousing conditions in the South have fallen far short of fulfilling these prerequisites.

The people of Louisiana have taken the first great step toward reforming these uneconomic conditions. The mammoth State-owned plant, equipped with most modern and efficient devices of safety and operation supplies the necessary facilities; administered under the economies of public ownership, the absolute minimum of handling and carrying charges is assured; and guaranteed by the good faith and credit of a sovereign state, the warehouse receipts covering the commodities stored therein are current in all the money markets in the world, and what is most important current at low interest rates. The public cotton warehouse is therefore not only a monumental exhibit of modern engineering skill, and not only an imposing unit of our port equipment, but it is the exponent of an economic principle which in logical operation is destined to revolutionize the cotton trade, emancipate the cotton producer and establish American markets for the world-wide distribution of an American product.

And so the city's fight for economic progress was won.

PREPAREDNESS

The port which offers the maximum of facility at the minimum toll places the merchants and manufacturers within and in the territory behind it in the most advantageous competitive position with regard both to the sale of their output abroad and traffic in foreign commodities at home. The extent to which the American exporter can compete with or undersell his rivals in the foreign markets depends, to a large extent, upon the cost of placing his commodities in such markets; and the price at which domestic consumption shall secure its foreign supplies is materially affected by the cost of importation and distribution. Hence, the extent, the completeness and the availability of port terminal and transportation facilities, and the cost at which these are supplied, are items of importance not only to the port city itself but to the entire territory tributary thereto. These considerations, important at all times, are vital at this time, in view of the impending trade revolution which will involve the United States and the world. The doctrine of commercial preparedness cannot be too vigorously advocated. There is hardly a more important element in trade preparation than the development of the port facilities mentioned. In point of present ability to handle the great volume of export and import traffic now moving, the New Orleans equipment equals that of any port in the United States; and in point of capacity for indefinite expansion and for encouragement of a broader commerce, the port organization of New Orleans is distinctly superior to any.

THE DEBT

But let it not be imagined that the revolution in sanitary and economic conditions which has worked the transition of the old city of romantic history into the new city of virile though no less romantic promise, was accomplished without travail and suffering, or that the improvements of which we are justly proud and for which we are duly grateful have sprung from the ground in a night like Jonah's gourd, or have flowered from the glib facility of the orator's period or the demagogue's promise. It has required effort, long continued and stern, and work, even to prepare the ground for these developments. But after the ground has been prepared and the plans formulated, and even after the means for consumation had been secured, the *Fact* was yet afar, and our fine projects still remained nothing but dreams and nebulous hopes until the *Engineer* was called and this great materializer took hold and wrought the miracle of translating the ideal into the real.

NOTES

Those who arrived in New Orleans by boat had the pleasure of attending a meeting of the Louisiana Engineering Society on Monday evening, April 10, when a paper by Prof. C. W. Williamson of Tulane University was presented on the possibilities in Louisiana for additional chemical industries, and through the courtesy of that society copies of the paper were placed at the headquarters for any who desired them.

Splendid service is being rendered in the development of the resources of Louisiana and the south by the graduates of the technical courses of Tulane University at New Orleans and of the State University at Baton Rouge. Many of the students at Tulane attended the sessions of the Spring Meeting and the members of the Student Section of the State University came to New Orleans to hold a dinner during the convention, which it was the pleasure of the President and Secretary to attend.

The five members of the Nominating Committee, selected by the Local Sections of the country and appointed by the President on their recommendation, were on hand from the five cities of Boston, Philadelphia, Atlanta, Chicago and San Francisco. Several meetings were held, but no intimation has been given of the outcome of their deliberations. The procedure followed by Dr. Jacobus this year in appointing this committee received words of approval on every hand.

The efficient local committee consisted of W. B. Gregory, *Chairman;* A. L. Black, *Treasurer,* and H. L. Hutson, *Secretary,* who acted in coöperation with several sub-committees, of which the following were chairmen: George H. Davis, Finance; H. F. Rugan, Hotels; A. M. Lockett, Entertainment; R. T. Burwell, Reception; E. L. Jahncke, Printing and Publicity. These chairmen and J. F. Coleman, President, New Orleans Association of Members A.S.C.E., Samuel Young, President, Louisiana Engineering Society, and L. C. Datz, constituted the Executive Committee.

COUNCIL NOTES

At the meeting of the Council on April 11, 1916, held at the headquarters of the Spring Meeting, Hotel Grunewald, New Orleans, Louisiana, the following were present: D. S. Jacobus, *President,* W. F. M. Goss, James E. Sague, Members of the Council; Oberlin Smith and S. T. Wellman, Past Presidents, and Calvin W. Rice, *Secretary.*

The President reported the appointments of George I. Alden, G. C. Anthony, H. S. Baldwin, A. G. Duncan, C. H. Fish, W. A. Hall, Franklin W. Hobbs, W. R. Park, George F. Swain, J. A. Tilden, A. C. Walworth, A. K. Warren, H. S. Baldwin, G. H. Barrus, John A. Stevens, Richard H. Rice, C. T. Plunkett, E. F. Greene, E. W. Thomas and C. T. Main as Honorary Vice-Presidents to represent the Society at the funeral of C. J. H. Woodbury, an organization member of the Society.

H. C. Gardner was appointed to represent the Society at a conference in Chicago, April 14, called by Dr. F. H. Newell on "Engineering Coöperation."

The President reported invitations to the Society to participate in the exercises to be held on the 150th Anniversary of the founding of Rutgers College, and at the opening of the new buildings of the Massachusetts Institute of Technology. The Council requested the President to be present and represent the Society, but if not possible the President was authorized to appoint a representative.

Subject to the approval of the Committee on Sections, the following committee was appointed in charge of the Atlanta Section: E. F. Scott, *Chairman*, P. A. Dallis, *Secretary*, Oscar Elsas, L. W. Robert and F. H. Neely.

F. W. Dean, *Chairman*, J. S. Coon and A. M. Mattice were appointed a Committee on Resolutions on the death of Honorary Member and Past-President E. D. Leavitt.

A communication was read from the Boiler Code Committee with respect to the standardization of open feed water heaters, and it was voted that the President nominate a committee to undertake this work.

Calvin W. Rice, *Secretary*.

COÖPERATIVE SPIRIT AT NEW HAVEN

It is believed that never before has the spirit of coöperation so permeated a Local Section meeting as it did the Spring meeting of the New Haven Section held on April 5.

In the first place, no less than seven other local organizations coöperated with the Section in carrying out the program of the meeting. These were the Engineers' Club of the Sheffield Scientific School, Yale University; the Yale Mechanical Engineers Club, Student Branch, Am.Soc.M.E.; the Yale Branch, A.I.E.E.; the Mining Society of the Sheffield Scientific School; the Connecticut Society of Civil Engineers and Surveyors; the Winchester Engineering Club; and the Yale Dining Club.

In the second place, particularly at the afternoon session, the audience included many manufacturers and representatives of local industries who "came to get information the engineers had to give them."

Other evidences of the coöperative spirit manifested themselves throughout the meeting, resulting in the most successful get-together meeting yet held by this progressive Section.

Following the precedent of this Section, two sessions were held, one in the afternoon and the other in the evening, and a dinner was served between the sessions. This Section holds two such meetings each season. The meetings were practically continuous from 3 p. m., to 10:30 p. m., with the interest maintained all through, thanks to the efforts of the New Haven Committee and of the officers of the coöperating organizations.

Henry B. Sargent, Chairman of the New Haven Section, Am.Soc.M.E., opened the afternoon session in the Mason Laboratory of Sheffield Scientific School, with an attendance of about 150. After the usual announcements, Prof. L. P. Breckenridge took the chair, and introduced H. I. Harriman, civil engineer, of Boston, who presented a paper on The Water Powers of New England. The speaker called attention to the fact that on account of the general poorness of the New England soil for agricultural purposes, the people had early been obliged to turn their attention to manufacturing, with the result that they had early made demands for power. He reviewed the history of the efforts to supply this power by utilizing the available water; and by means of lantern slides he gave recent examples of impounding reservoirs and hydroelectric plants in New England. He then gave a detailed description of the construction of the Moosehead Lake Dam and the Somerset Dam, and the hydroelectric plants on the Deerfield River, concluding with illustrations of recent equipment for long distance transmission lines.

This paper was followed by a general discussion on The Power Requirements of Connecticut Industries, opened by R. J. S. Pigott, Mem.Am.Soc.M.E., who gave a large amount of valuable data on the cost of steam power in a modern industrial establishment, and methods of reducing that cost. One of the most interesting phases of Mr. Pigott's discussion was the question of bleeder turbines and their economy in plants using a large amount of low pressure steam for heating and for processes. Another was the question of individual motor drive vs. group motor drive, which latter he strongly advocated; he said that many plants were "overmotored," with the result that most of the motors were running on only a fraction of their load for the greater part of the time, insufficient attention being paid to diversity factor in loading.

Others taking part in this discussion were John W. Lieb, Mem.Am.Soc.M.E., who took up the question of water power vs. steam power, and said that none of our large centers of population could afford to depend solely on water-generated power, and that the best we could hope for in large cities was the utilization of power from all kinds of sources; S. Ferguson, who said that the primary need in all industries was reliable power, and that to increase reliability many water powers should be, and were being, "tied-in" with steam powers; Prof. C. F. Scott, who said that in the case of any manufactured article, since the cost of power to produce it was not over 1 per cent of the cost of the article, doubling the cost of power to secure reliability would be justified; C. R. Harte, who advocated greater study of such problems as re-forestation, etc., before deciding on sites of impounding reservoirs for water powers; Prof. Breckenridge, and others.

Calvin W. Rice, Secretary Am.Soc.M.E., spoke for a few moments and commended the Section upon the splendid results of its coöperative work as evidenced by such a successful meeting. He also gave recent illustrations of our Society's coöperation with the other national engineering societies and with the Government in engineering matters affecting the nation-at-large.

Winfield S. Huson, Mem.Am.Soc.M.E., expressed his admiration of the good fellowship in evidence at the meeting, quoting the words of Grosman:

"To-day a man who is out of touch with fellow-men is a useless man. His beatitude and exaltation do not in the slightest enhance his value. For men ask of one another that each help in the work and business of life, and contribute his ability and his manhood."

Following the afternoon session an excellent dinner was served in the inspiring Yale Dining Club Hall.

The evening session, held in North Sheffield Hall, was devoted to a paper on The Progress of Economic Power Generation and Distribution, by Samuel Insull, President of the Commonwealth Edison Co., Chicago. The meeting was opened by President Arthur T. Hadley, of Yale University, who introduced the speaker. There were about 300 present.

Mr. Insull's paper, which was profusely illustrated with lantern slides, reviewed the history of the business of electric power generation and distribution, from its inception in the early 80's to the present time, with special reference to the speaker's own connection with the business in the City of Chicago.

Mr. Insull considered the limitations of the early business, when small areas only were served and when there was no diversity. He described the effect of the introduction of the a.c. system and, later, of the steam turbine, to which he paid tribute by saying that the introduction of this prime mover was the one thing above all others which had made possible the massing of production of electric power for all kinds of purposes.

By means of slides, he contrasted the early apparatus used in the business with that now used, and traced the evolution of this apparatus through its radical stages of development.

He gave his opinion that the limit of economical size of unit was reached in the large units now being employed, and that it was unwise to exceed these maximum sizes.

He concluded with a discussion of some of the figures of modern electric production, and the effect on them of increasing the diversity of utilization by "massed production," generating power for all kinds of purposes.

CONFERENCE ON ENGINEERING COÖPERATION

The second conference of the Committee on Engineering Coöperation, to which our Society was invited to send a delegate, was held in Chicago, April 13 and 14. The Committee is self-constituted, and Dr. Frederick H. Newell, Mem.Am.Soc.M.E., is chairman and Clarence E. Drayer, is secretary; its aim is the formulation of a plan of increased coöperation between engineers with a view to securing greater efficiency in the larger matters of concern to the individual engineer, the profession and the public. Over thirty technical and engineering societies, engineering clubs, and like organizations were represented at the conference. H. C. Gardner, Mem.Am.Soc.M.E., attended as the delegate of our Society.

The conference was opened by the chairman, greetings were extended by B. E. Grant, President of the Western Society of Engineers, and an address of welcome delivered by B. F. Affleck, President of the Chicago Engineers Club.

During the conference there was a good deal of discussion upon the scope of the plan of attaining the objects in mind; as to whether a separate organization should be formed or how best the activities of the existing societies could be correlated. The representative of our Society argued for the development of the plan through existing organizations. At the close of the conference resolutions were passed establishing a subcommittee, with Dr. Newell as chairman, to prepare a plan for consideration at a third conference on engineering coöperation, to be called by the subcommittee at such time and place as may seem to be desirable, and expressing appreciation for the courtesies extended to the delegates.

SCIENTIFIC MANAGEMENT CONFERENCE

An elaborate conference on Scientific Management has been planned by the Frederick W. Taylor Coöperators, to be held at the University of Michigan, Ann Arbor, Mich., from May 11 to 13, 1916. A feature of the conference will be seven round table discussions on scientific methods of management applied to various types of industry.

The address of welcome will be delivered by President Harry B. Hutchins, of the University of Michigan, and Harlow S. Person, President of the Taylor Society, will respond.

Papers will be presented on Scientific Management, Its Nature and Significance, by Henry P. Kendall, Mem.Am.Soc.M.E.; Scientific Methods of Management Applied to Various Types of Industry, by Sanford E. Thompson, Mem.Am.Soc.M.E.; Scientific Management in the Operation of a Public Service Corporation, by Charles Day, Mem.Am.Soc.M.E., and An Illustrated Trip Through Scientifically Managed Factories, by H. K. Hathaway, Mem.Am.Soc.M.E.

The round table discussions will cover continuous manufacturing processes, including paper and pulp manufacture, textiles, books, clothing, boxes, envelopes, handkerchiefs and printing; non-continuous manufacturing processes, particularly machine shop practice; practically continuous processes, exemplified by automobile manufacture; construction work; store sales management and traveling sales management. Leaders in the round table discussions will be Keppele Hall, Mem.Am.Soc.M.E.; Robert B. Wolf, Mem.Am.Soc.M.E.; Henry V. R. Scheel, Mem.Am.Soc.M.E.; Arthur E. Barter, Richard A. Feiss, Mem.Am.Soc.M.E.; Frank R. Wallace, R. B. Fraser, D. J. Walsh, Jr., John H. Williams, Carl G. Barth, Mem.Am.Soc.M.E.; Com. Allen M. Cook, H. K. Hathaway, Mem.Am.Soc.M.E.; F. A. Parkhurst, Assoc.Am.Soc.M.E.; Albert R. Shipley, Assoc.Am.Soc.M.E.; F. F. Beall, Jun.Am.Soc.M.E.; J. C. Regan, Mem.Am.Soc.M.E.; W. B. Laine, Mem.Am.Soc.M.E.; Wm. O. Lichtner, Mem.Am.Soc.M.E.; John H. Scoville, Miner Chipman, T. K. Corey, H. A. Brown, John M. Bruce, Assoc.Am.Soc.M.E.; Henry T. Noyes, Assoc.Am.Soc.M.E., and R. Mayo-Smith.

M. L. Cooke, Mem.Am.Soc.M.E., will act as chairman at the closing session, which will be a summary and discussion.

The Richard A. Feiss Co., Clothcraft Shops, Cleveland, Ohio, will entertain visiting members on their way to the Congress, as will also the Executives' Club of the Detroit Board of Commerce.

JUNIOR AND STUDENT PRIZES

The Committee on Awards of prizes for papers contributed by Junior Members and members of Student Branches desire to call attention to the fact that the limiting date for sending in contributions for competition for these prizes is June 30.

One cash prize of fifty dollars and engraved certificate are available for the best paper of the year by a Junior Member, and four cash prizes of twenty-five dollars each, and engraved certificate, are available for the four best papers of the year by members of Student Branches.

Full information regarding these prizes and the Rules of Award are given in the 1916 Year Book. The Committee desire to emphasize that contributions should be typewritten in double spacing on paper of uniform size, preferably 8½ x 11 in., and with illustrations neatly drawn and tabulated matter clearly arranged; the whole should be enclosed in a binder. Papers must be the *bona fide* production of the contributor and must not have been previously made public.

The awards for 1916 will be announced at the Annual Meeting, December, 1916, and will also be published in The Journal.

CLASSIFICATION OF TECHNICAL LITERATURE

A meeting of the joint committee of the National Engineering Societies and leading technical and industrial organizations of the country, on classification of technical literature, was held in the council room of our Society on April 1. Henry W. Peck, Mem.Am.Soc.M.E., who has been actively identified with the movement from its inception, presented a progress report reviewing the work of the committee to date. W. P. Cutter, librarian of the United Engineering Society, presented a paper entitled How to Make a Classification.

Two general schemes of procedure were then presented,—the one to assign parts of the classification to organizations vitally interested therein, the final compilation and correlation to be performed by one central body under the supervision of an expert classifier; and the other to have classifiers or librarians intimately acquainted with present technical literature prepare classifications subject to revision by engineering organizations. After considerable discussion, it was decided to adopt the former plan. F. R. Low, Mem.Am.Soc.M.E., has resigned the chairmanship of the executive committee in favor of Henry W. Peck, Mem.Am.Soc.M.E.

INDUSTRIAL PREPAREDNESS

The names of the members of our Society selected by the Council from each of the states of the Union, the Territory of Alaska and the District of Columbia, to act as State Directors of the Organization for Industrial Preparedness and Associate Members of the Naval Consulting Board, have now been approved by the Secretary of the Navy and the appointments made. The Secretary of the Navy has also made the appointments in the cases of the four other great technical societies mentioned in the letter to the Society from the President of the United States, published in the February issue of The Journal, and the personnel of the organization is now complete.

Below are the names of the State Directors appointed from our Society, correct to April 16, 1916.

Alabama. F. H. Crockard, 1524 Brown-Marx Bldg., Birmingham, Ala.—V. P., Tenn. Coal, Iron & R. R. Co.

Alaska. George A. Diamond, Nome, Alaska—Mngr., Scheid & Co.

Arizona. A. G. McGregor, Warren, Ariz.—Calumet & Ariz. Mining Co.

Arkansas. B. N. Wilson, Fayetteville, Ark.—Prof. Mech. Eng., Univ. of Ark.

California. C. W. Merrill, 121 Second St., San Francisco, Cal.—Merrill Metallurgical Co.

Colorado. T. B. Stearns, 1720 California St., Denver, Colo.

Connecticut. H. B. Sargent, New Haven, Conn.—V. P., Sargent & Co.

Delaware. R. W. Smith, Wilmington, Del.—V. P., Hilles & Jones Co.

District of Columbia. Dr. W. S. Stratton, Washington, D. C.—Director, Bureau of Standards.

Florida. R. E. Chandler, Gainesville, Fla.—Prof. Mech. Eng., Univ. of Fla.

Georgia. Oscar Elsas, Atlanta, Ga.—Pres., Fulton Bag & Cotton Mills.

Idaho. Geo. F. Waddell, Squirrell, Fremont County, Idaho.

Illinois. Dr. W. F. M. Goss, Urbana, Ill.—Dean, Coll. Eng., Univ. of Ill.

Indiana. Geo. O. Rockwood, 1801 English Ave., Indianapolis, Ind.—Pres., Rockwood Mfg. Co.

Iowa. S. M. Woodward, Iowa City, Iowa—Prof. Mech., State Univ. of Iowa.

Kansas. A. A. Potter, Manhattan, Kansas—Dean, Div. of Engineering, Kansas State Agric. College.

Kentucky. W. S. Speed, 325 West Main St., Louisville, Ky.—Pres., Louisville Cement Co.

Louisiana. A. M. Lockett, 533 Baronne St., New Orleans, La.—Pres., A. M. Lockett Co., Ltd.

Maine. J. S. Hyde, Bath, Me.—Pres., Bath Iron Works.

Maryland. C. C. Thomas, Baltimore, Md.—Prof. M. E., Johns-Hopkins Univ.

Massachusetts. Ira N. Hollis, Worcester, Mass.—Pres., Worcester, Poly. Inst.

Michigan. Alex Dow, 18 Wash. Ave., Detroit, Mich.—Pres. & G. M., The Detroit Edison Co.

Minnesota. J. J. Flather, Minneapolis, Minn.—Prof. Mech. Eng., Univ. Minn.

Mississippi. R. C. Carpenter, Agricultural College, Miss.—Prof. Mech. Eng.

Missouri. E. Flad, DeMenil Bldg., St. Louis, Mo.

Montana. C. V. Nordberg, 305 Elec. Bldg., Butte, Mont.—Nordberg Mfg. Co.

Nebraska. Wm. R. McKeen, 1222 Webster Ave., Omaha, Nebr.—Pres., McKeen Motor Car Co.

Nevada. James G. Scrugham, Reno, Nev.—Dean Eng. College, Univ. of Nev.

New Hampshire. Thomas W. Fry, Claremont, N. H.—Secy., Sullivan Mchy. Co.

New Jersey. H. L. Gantt, 2905 Singer Bldg., New York City.

New Mexico. L. J. Charles, Elephant Butte, New Mexico—C. E., U. S. Reclamation Service.

New York. W. H. Marshall, 30 Church St., New York City—Pres., American Locomotive Co.

North Carolina. Wm. S. Lee, Mercantile Bldg., Charlotte, N. C.—V. P. & Chf. Eng., Southern Power Co.

North Dakota. Calvin H. Crouch, University, N. D.—Dean Coll. Mech. & Elec. Eng., Univ. of N. D.

Ohio. Frank A. Scott, 5701 Carnegie Ave., Cleveland, Ohio—V. P., The Warner & Swasey Co.

Oklahoma. J. P. Fisher, Bartlesville, Okla.

Oregon. Bert C. Ball, Portland, Ore.—Pres. & Mngr., Willamette Iron & Steel Works.

Pennsylvania. Julian Kennedy, 1217 Bessemer Bldg., Pittsburgh, Pa.

Rhode Island. Henry D. Sharpe, Providence, R. I.—Treas., Brown & Sharpe Mfg. Co.

South Carolina. J. L. Coker, Jr., Hartsville, S. C.—V. P., Carolina Fiber Co.

South Dakota. M. W. Davidson, Vermillion, S. D.—Prof. M. E., Univ. of S. Dak.

Tennessee. N. Sanders, Chattanooga, Tenn.—Newell Sanders Plow Co.

Texas. W. B. Tuttle, 305 E. Houston St., San Antonio, Tex.—V. P., San Antonio Traction Co. & San Antonio Gas & Elec. Co.

Utah. Wm. Wraith, 618 Kearns Bldg., Salt Lake City, Utah—G. M., Internat. Smelting Co.

Vermont. James Hartness, Springfield, Vt.—Pres., Jones & Lamson Mach. Co.

Virginia. W. D. Mount, Saltville, Va.—G. M., Mathieson Alkali Works.

Washington. James V. Paterson, Seattle, Wash.—Pres., Seattle Constr. & Dry Dock Co.

West Virginia. Chas. E. Ward, Box 647, Charleston, W. Va.—Pres., Charles Ward Eng. Works.

Wisconsin. L. E. Strothman, Milwaukee, Wis.—Dept. Mngr., Allis-Chalmers Mfg. Co.

Wyoming. E. G. Heefer, Laramie, Wyo.—Head Dept. M. & E. Eng., Univ. of Wyoming.

The next step to be taken is the organization of each State Board of Directors for business, and the selection in each state of a corps of field aides from the membership of the five societies within that state, to assist the boards in carrying out the plan of the industrial census as published in the March issue of The Journal.

Howard E. Coffin, Mem.Am.Soc.M.E., is chairman of the Committee on Industrial Preparedness of the Naval Consulting Board, under the direction of which the State Directors will work and to which they will report, and W. S. Gifford, statistician of the American Telephone and Telegraph Company, is supervising director of the work of the committee.

TRIBUTE TO DR. WOODBURY

At a meeting of the Board of Government of The National Association of Cotton Manufacturers, April 24, 1916, the following resolution was unanimously adopted:

The Board of Government desires to express its profound sorrow at the death of the Secretary of the Association, Dr. Charles J. H. Woodbury.

This Association, and the cotton industry in general, owes to Dr. Woodbury a debt which is unmeasurable. Devoting himself in early life to the problems of mill construction and fire protection, he has, during all his official connection with the Association, of upwards of twenty-five years, been the leader in all movements tending to improve the processes and methods of textile mills. Under the guidance of his trained, scientific mind, the Transactions of the Association have recorded in the fullest degree the development of the cotton industry in its technical, historical, and social aspects; and they stand as a worthy monument to his memory.

To Dr. Woodbury more than to any one man is due the continued growth and prosperity of the Association, and its value as a representative of the textile trade. In spite of severe physical disabilities during the last period, he has served its interests with fidelity and devotion, and it may be said with truth that he laid down his life in its service.

As individuals, we shall miss him, with his kindly personality, his unfailing courtesy, his broad culture, and his remarkable fund of information.

The Board of Government of The National Association of Cotton Manufacturers hereby resolves, as a tribute of affection and gratitude, that this resolution be entered upon its records, and that copies be sent to the bereaved family, to affiliated associations, and to the daily press.

ERICSSON MONUMENT

The Society has received a copy of Hearings before the Committee on the Library, House of Representatives, Sixty-fourth Congress, reporting the hearing on March 13, 1916, on the bill recently introduced in Congress to erect a monument to the memory of John Ericsson.

As stated in The Journal last month, seven members were appointed to represent the Society at this hearing. Four of these were able to attend, and the following are the speeches in favor of the bill made by two of them, Erik Oberg and Casimir von Philp, and as reported in the hearings:

Statement of Mr. Erik Oberg, of New York, N. Y.

Mr. Chairman and gentlemen of the committee, while by accident of birth I come from the same country as John Ericsson I am here to-day to urge the passage of this bill, not in any way on that account, but simply to urge the passage of the bill as an engineer.

I am honored to be here to-day as the representative of one of the greatest engineering societies in the United States, The American Society of Mechanical Engineers. There are three other gentlemen in this group, who are here also representing that society. I am authorized by the Board of Directors of The American Society of Mechanical Engineers, an organization composed of 7,000 members, living in all parts of the United States, all of whom belong to the most prominent engineering societies in the country, to urge the passage of this bill.

The engineers of the country recognize that John Ericsson was one of the greatest engineering geniuses of the last century, irrespective of where he was born and irrespective of whatever his nationality may have been. He is recognized as one of the greatest, if not the greatest engineering genius of the nineteenth century, and it seems appropriate that the nation in which he carried out his greatest engineering inventions should erect a monument to him as well as to other men in other professions, who have done signal service to humanity. It seems fitting that a lasting monument should be erected to such a man.

There is no one in the city of Washington or in the United States whose convenience and whose every-day life is not influenced by the engineering inventions of John Ericsson. He has made life for humanity at large easier. The steamships that aptly plow the sea to-day, pass through the ocean much safer and easier because of the inventions of John Ericsson. Because of that fact, The American Society of Mechanical Engineers urges that this committee report this bill favorably to the Congress of the United States. [Applause.]

Statement of Mr. Casimir von Philp, of Bethlehem, Pa.

Mr. Chairman and gentlemen of the committee, I do not speak as a Swede, or as an American, or as representing any other nationality. I only speak as a mechanical engineer.

The engineer is considered the master of the mechanical arts. We will find monuments erected to prominent men of all professions, to lawyers and to warriors, but what have we done for the man who makes the warriors' tools? Is there a single monument to the inventor of the warriors' tools? There is none. The engineer is the inventor of the warriors' tools, but we have done nothing for him, and as an engineer I ask that this bill be favorably considered, so that the engineers will be represented at least to some extent in the monuments erected to prominent men.

I want now to call your attention to the rewards received by engineers. We have the United States Patent Office, which is the protector of the engineer's inventions. This Patent Office has received revenue from the engineers who have applied for patents. A part of the revenue received by the Patent Office can be used for the erection of a monument to an engineer, the master of the mechanical art.

As an engineer in the Bethlehem Steel Co., I am associated with the class of engineers represented by John Ericsson. If we take the *Monitor* we will find that the basic features of our modern battleships are found in the invention of John Ericsson as it appeared in the *Monitor*.

The *Monitor* was the most perfect invention of any kind of battleship construction. That vessel in its time was absolutely invulnerable. The guns were splendidly protected by the armament of the turrets, and the overhang of the armor prevented any vessel of that time ramming the *Monitor*, and those things made that ship one of the most prominent inventions of that time.

A modern battleship can be sunk easily, as has been shown during the present war, but at that time the battleship of John Ericsson was nonsinkable by any method in use at that time. There was nothing in the line of warships that could stand against it.

As an engineer and a follower of John Ericsson, I ask for the passage of this bill, in order that the engineers may be included in that class of prominent men who have bad monuments erected to their memory. [Applause.]

LECTURES ON MILITARY ENGINEERING

As anticipated, the movement inaugurated in New York by a committee of members of the national engineering societies for providing free lectures on military engineering subjects has spread beyond the metropolis.

In Detroit a course of five weekly lectures for engineers, by Col. M. M. Patrick and Major P. S. Bond, Corps of Engineers, U. S. A., was commenced on March 29.

In Chicago eleven weekly events, beginning on April 20, have been inaugurated. The first nine of these are Military Engineering lectures, and the remaining two excursions to a citizen's training camp to be established near Indianapolis. Correspondence courses and practical work in field engineering and maneuvers by members of the training camp are to be organized during the summer.

NOTES

The A.S.M.E. Boiler Code was presented by S. F. Jeter, Mem.Am.Soc.M.E., at the Annual Meeting of the National Association of Cotton Manufacturers, held in Boston, April 26 and 27. John R. Fordyce, Mem.Am.Soc.M.E., presented a paper on Cotton Handling in Southern Warehouses; Dr. S. W. Stratton, Mem.Am.Soc.M.E., presented a paper on Tests of Cotton Yarn and Fabrics, and Wm. D. Hartshorne, Mem.Am.Soc.M.E., presented a paper on The Washington Conference and Its Relation to Tire Fabric and Other Testing Requirements.

The Metropolitan District Student Branches are to be congratulated upon the success of their first joint meeting and smoker, which was held in the Engineering Societies Building on April 14, and an account of which is given elsewhere in this issue. The purpose of the meeting was announced to be "to bring the students into closer touch with the Society," but the real effect of this joint meeting was undoubtedly "to bring the students into closer touch, through the Society, with one another"—which was everything to be desired.

An informal discussion on the question "What relation should exist between the National Engineering Societies and the local section or association of their members; and, in the interests of the profession, what should be the attitude of both of the above to other local engineering societies or clubs?" was held by the American Society of Civil Engineers at their meeting of April 19. President D. S. Jacobus presented the subject from the standpoint of the experience of our Society. A report of the meeting which is of equal interest to all of our members will appear in a later issue of The Journal.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON JUNE 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third class under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. Unless objection is made by some member by June 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary about July 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Affleck, Myron H., Engr., Rumford Chemical Works, Providence, R. I.
Anderson, Arthur E., Supt., The Intermountain Rwy., Lt. & Pwr. Co., Laramie, Wyo.
Borge, John, Pres., Borge Incinerator Corp., New York City
Brown, Fred W., Vice-Pres., Associated Engineering Co., Somerset, Ky.
Brown, Percy, Efficiency Engr., American Graphophone Co., Bridgeport, Conn.
Clemons, Robert S., Constr. Engr., Ambler-Davis Co., Philadelphia, Pa.
Elliott, Newton R., Mech. Draftsman, The Portland Co., Portland, Me.
Finlay, Walter S., Jr., Constr. Engr., Motive Pwr. Dept., Interborough Rapid Transit Co., New York City
Fitzgerald, Walter L., Asst. Works Mgr., Edward G. Budd Mfg. Co., Philadelphia, Pa.
Foque, Theodore A., Genl. Mech. Supt., The Minneapolis, St. Paul & Sault Ste. Marie Ry. Co., Soo Line, Minneapolis, Minn.
Hays, Joseph W., Cons. Engr., 1778 Estes Ave., Chicago, Ill.
Hollis, Henry L., Cons. Mining and Metallurgical Engr., 1025 Peoples Gas Bldg., Chicago, Ill.
Hyde, Glenn C., Engr. and Vice-Pres., Electric Transmission Co. of Va., Lexington, Ky.
Jacoby, Henry E., Contr. Engr., 95 Liberty Street, New York City
Kane, Edmund J., Engr., Tractor Works, International Harvester Corp., Chicago, Ill.
Kempton, Herbert E., Prod. Mgr., Van Blerck Motor Co., Monroe, Mich.
Kittredge, John W., Development Dept., Firestone Tire & Rubber Co., Akron, Ohio
Leeds, Edward L., Genl. Sales Mgr., Niles-Bement-Pond Co., New York
MacBriar, Wallace N., Ch. Engr., Carnation Milk Products Co., Seattle, Wash.
MacFarland, D. H., Asst. to the Pres., The Atlas Portland Cement Co., New York City
Marrow, George P., Asst. Engr., Cons. Gas, Electric Light & Pwr. Co., Baltimore, Md.
Massey, Frank L., Mgr. and Treas., Massey Machine Co., Watertown, N. Y.
Mowat, J. F., M.M. of Blast Furnaces, Illinois Steel Co., Joliet, Ill.
Raybould, Frank J., Foreman Assembling Room, Winchester Repeating Arms Co., New Haven, Conn.
Stewart, Samuel, Mech. Engr. and Genl. Master Mech., Republic Iron & Steel Co., Thomas Sta., Birmingham, Ala.
Talkes, Ernest B., Master Mechanic, Federal Furnace Plant, By-Products Coke Corp., Chicago, Ill.
Titus, Warren H., Retired, Providence, R. I.
Vaughan, Lillian L., Asst. Prof. of Exper, Engrg., N. C. College of Agriculture & Mechanic Arts, W. Raleigh, N. C.
Wagner, Charles F., Mech. Engr., The J. B. McCrary Co., Atlanta, Ga.
Webster, Joseph S., Mech. Engr., New Haven Boiler Works, New Haven, Conn.
Wightman, George H., Mech. Engr., Gorham Mfg. Co., Providence, R. I.
Wilber, Dana W., Prin. Asst. Engr., to Mr. H. M. Wharton, M.E., New York City
Wilcox, Ralph M., Civil Engr., of Wilcox & Lucey, Middletown, Conn.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Ball, Herbert J., Instr. in Mech. Engrg. and Accounting, Lowell Textile School, Lowell, Mass.
Barbour, Robert, Pres., Barbour Flax Spinning Co., Paterson, N. J.
Bryan, Marcus K., Mech. Engr., with John A. Stevens, Cons. Engr., Lowell, Mass.
Carbone, Mario G., Mgr., Italian-Swiss Colony, New York City
De Florez, Luis, Chief Engr., Motor Petrol Co., Bayonne, N. J.
Disston, William D., 3rd Vice-Pres., Henry Disston & Sons, Inc., Tacony, Philadelphia, Pa.
Force, Henry H., Chief Engr. and Chief Electrician, The Stanley Works, New Britain, Conn.
Holmgren, Frederic C., Material Engr., Remington Arms & Ammunition Co., Bridgeport, Conn.
Kellogg, Charles D. H., Jr., with Bridgeport Brass Co., Bridgeport, Conn.
Lipsner, Benjamin B., Mech. Engr. and Supt. of Transportation, Albert Pick & Co., Chicago, Ill.
Lloyd, Sherman C., Asst. Ballistic Engr., Expr. Sta., E. I. du Pont de Nemours & Co., Henry Clay, Del.
Morrow, Lester, C., Inspector, Under U. S. Representatives of British Ministry of Munitions, Gisholt Mch. Co., Madison, Wis.
Nestler, Peter J., Asst. Engr., M. W. Kellogg Co., New York
Rogers, Frederick E., Jr., Cons. Engr., Good Housekeeping Inst., New York City
Sampson, Edwin M., Supt., Armored Cable Dept., National Metal Molding Co., Economy, Pa.
Starbuck, William D. L., 746 St. Nicholas Avenue, New York City
Vaniman, Roy L., Pres., Produce Terminal Corp., Union Stock Yards, Chicago, Ill.

FOR CONSIDERATION AS JUNIOR

Blackmer, Waldo H., Supvr. Inspection, American Ammunition Co., Worcester, Mass.

Blood, Laurence E., Supt. Factory B,
S. A. Woods Machine Co., Boston, Mass.
Bohn, Robert G., Draftsman,
Illinois Traction System, Peoria, Ill.
Brady, Charles V., Senior Student,
Washington University, St. Louis, Mo.
Brandt, Herman A., Student,
Polytechnic Institute of Brooklyn, Brooklyn, N. Y.
Brooks, Malcolm G.,
with M. S. Brooks & Sons, Chester, Conn.
Brown, Claude C., Asst. Boiler-room Chemist,
Pacific Gas & Elec. Co., San Francisco, Cal.
Center, Irving E., Asst. Engr., Turbine Research Dept.,
General Electric Co., West Lynn, Mass.
Doyle, William L. H. Engrg. Dept.,
Combustion Engineering Corp., New York City
Fairchild, Iler J., Computer-Draftsman,
Ordnance Office, War Dept., U. S. A., Washington, D. C.
Ge Bauer, Clarence H.,
with General Elec. Co., Cincinnati, Ohio
Glenn, Edward R., Shop Supt.,
Electro Bleaching Gas Co., New York City
Grobli, Walter A., Instr., Dept. of Descriptive Geometry and Mech. Drawing,
Stevens Inst. of Technology, Hoboken, N. J.
Hamilton, Kenneth D., Mech. Engr.,
Geo. E. Keith Co., Campello, Mass.
Haines, J. Edgar, Supervising Draftsman,
Duquesne Light Co., Pwr. Sta. Dept., Pittsburgh, Pa.
Keller, Clifford H., Engr.,
Rochester Trailer Co., Inc., East Rochester, N. Y.
Matthew, Robert M., Machine Shop Foreman,
Ohio Tool Co., Charleston, W. Va.
Mehard, Hugh R.,
with Ford Motor Co., Detroit, Mich.
Novotney, Thomas A., Engr.,
Dept. of Research, American Radiator Co., Buffalo, N. Y.
Penrod, Estel B., Draftsman,
Eclipse Motor Co., Cleveland, Ohio
Roland, Percy W., Mech. Engr.,
Gadabout Motor Corp., New York City
Ruth, Rowland W., Engrg Dept.,
American Well Works, Aurora, Ill.
Schmidt, Frank B., Asst. Supt.,
F. L. Schmidt Co., New York City
Seelbach, Earl H., Designer,
Pierce-Arrow Motor Car Co., Buffalo, N. Y.
Sharp, Ralph E., Chief Inspector,
Worth Brothers Co., Coatesville, Pa.
Sherwood, Herbert P.,
with The Kennicott Co., Chicago, Ill.
Smith, Carroll W.,
with C. A. Smith Lumber & Mfg. Co., Oakland, Cal.
Spearman, John M., Steam Engr.,
Mining Div., Tennessee Coal, Iron & R.R. Co., Blockton, Ala.
Strahlmann, Otto E., Aeronautical Mech. Draftsman,
U. S. Signal Corps Aviation School, San Diego, Cal.
Voos, Frederick W.,
with Remington Arms & Ammunition Co., Bridgeport, Conn.
Welling, Lindsay H.,
with Henry R. Worthington, New York City
Westbrook, James R., Student Apprentice,
Westinghouse Air Brake Co., Wilmerding, Pa.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

Ashley, Edward E., Jr., Mech. and Elec. Engr.,
c/o Starrett & Van Vleck, Architects, New York City

PROMOTION FROM JUNIOR

Anderson, Howard L., Master Mech.,
American Sheet & Tin Plate Co., Vandergrift, Pa.
Avnsoe, Thorkild, Genl. Supt.,
Texas Portland Cement Co., Dallas—Houston, Tex.
Hallock, Homan F., Mech. Engr.,
The Diamond Match Co., Oswego, N. Y.
Murphy, Benjamin S., Asst. Engr.,
Hudson & Manhattan R. R. Co., New York City
Naess, Ragnvald, Engr.,
American Trading Co., Manila, P. I.
Oakley, Walter W., Standardization of Mfg. Practice,
The Pittsburgh Plate Glass Co., Works No. 8, Kokomo, Ind.
Shenberger, George H., Draftsman,
The Goulds Mfg. Co., Seneca Falls, N. Y.
Withington, Sidney, Asst. Engr.,
New York, New Haven & Hartford
R. R. Co., New Haven, Conn.

SUMMARY

New Applications	81
Applications for change of grading:	
Promotions from Associate-Member	1
Promotion from Junior	8
Total	90

GEOGRAPHICAL INDEX

(Applications for promotion from any grade will be indicated by the initials of that grade.)

Alabama
Birmingham—Stewart, S.
Blockton—Spearman, J. M.
California
Oakland—Smith, C. W.
San Diego—Strahlmann, O. E.
San Francisco—Brown, C. C.
Connecticut
Bridgeport—Brown, P.
Holmgren, F. C.
Kellogg, C. D. H., Jr.
Voos, F. W.
Chester—Brooks, M. G.
Middletown—Wilcox, R. M.
New Britain—Force, H. H.
New Haven—Raybould, F. J.
Webster, J. S.
Withington, S. (J.)
Delaware
Henry Clay—Lloyd, S. C.
District of Columbia
Washington—Fairchild, I. J.
Georgia
Atlanta—Wagner, C. F.
Illinois
Aurora—Ruth, R. W.
Chicago—Hays, J. W.
Hollis, H. L.
Kane, E. J.
Lipsner, B. B.
Sherwood, H. P.
Talkes, E. B.
Vaniman, R. L.
Joliet—Mowat, J. F.
Peoria—Bohn, R. G.
Indiana
Kokomo—Oakley, W. W. (J.)
Kentucky
Lexington—Hyde, G. C.
Somerset—Brown, F. W.
Maine
Portland—Elliott, N. R.
Maryland
Baltimore—Marrow, G. P.
Massachusetts
Boston—Blood, L. E.
Campello—Hamilton, K. D.
Lowell—Ball, H. J.
Bryan, M. K.
West Lynn—Center, I. E.
Worcester—Blackmer, W. H.
Michigan
Detroit—Mehard, H. R.
Monroe—Kempton, H. E.
Minnesota
Minneapolis—Foque, T. A.
Missouri
St. Louis—Brady, C. V.
New Jersey
Bayonne—de Florez, L.
Paterson—Barbour, R.
Hoboken—Grobli, W. A.
New York
Brooklyn—Brandt, H. A.
Buffalo—Novotney, T. A.
Seelbach, E. H.
East Rochester—Keller, C. H.
New York City—Asbley, E. E., Jr. (A.M.)
Borge, J.
Carbome, M. G.
Doyle, W. L. H.
Finlay, W. S., Jr.
Glenn, E. R.
Jacoby, H. E.
Leeds, E. L.
MacFarland, D. H.
Murphy, B. S. (J.)
Nestler, P. J.
Rogers, F. E., Jr.
Roland, P. W.
Schmidt, F. B.
Starbuck, W. D. L.
Welling, L. H.
Wilber, D. W.
Oswego—Hallock, H. R. (J.)
Seneca Falls—Shenberger, G. H. (J.)
Watertown—Massey, F. L.
North Carolina
W. Raleigh—Vanghan, L. L.
Ohio
Akron—Kittredge, J. W.
Cincinnati—Ge Bauer, C. H.
Cleveland—Penrod, E. B.
Pennsylvania
Coatesville—Sharp, R. E.
Economy—Sampson, E. M.
Philadelphia—Clemons, R. S.
Disston, W. D.
Fitzgerald, W. L.
Pittsburgh—Haines, J. E.
Vandergrift—Anderson, H. L. (J.)
Wilmerding—Westbrook, J. R.
Philippine Islands
Manila—Naess, R. (J.)
Rhode Island
Providence—Affleck, M. H.
Titus, W. H.
Wightman, G. H.
Texas
Houston—Avnsoe, T. (J.)
Washington
Seattle—MacBriar, W. N.
West Virginia
Charleston—Matthew, R. M.
Wisconsin
Madison—Morrow, L. C.
Wyoming
Laramie—Anderson, A. E.

PERSONALS

THIS department is intended for items about members of the Society, their professional work and incidents concerning them which may be of interest to the membership in general. Items are solicited upon important engineering developments in which members have been associated, and also newspaper clippings or manuscripts of addresses delivered by members at meetings of any kind are desired. It is hoped that every member of the Society will furnish an interesting item occasionally for publication in The Journal.

H. L. Gantt is the author of a new book entitled Industrial Leadership.

C. B. Langstroth has become associated with the Ross Rifle Company of Quebec, Canada.

James I. Emery has been appointed chief engineer of the National Projectile Factory, Lancaster, England.

An article on the Lethbridge Municipal Power Plant by A. G. Christie is published in the April 4 issue of *Power*.

Robert B. Brownlee is co-author with Frederick G. Keyes of a book entitled The Thermodynamic Properties of Ammonia.

George H. Houston has become associated with the American Can Company in a consulting capacity, with headquarters in New York.

Willard F. Rockwell has contributed an article on The Organization of a Modern Foundry to the April 6 issue of *The Iron Age*.

Dr. Miller R. Hutchison, chief engineer of the laboratory of Thomas A. Edison, addressed the Jovian League of New York City on April 5.

George C. Olmsted, manager of the Minnesota Radiator Company of Duluth, Minn., has changed his headquarters to Minneapolis, Minn.

James A. Moyer and James P. Calderwood are co-authors of a book entitled Engineering Thermodynamics which has recently been published.

Charles P. Steinmetz spoke on general problems of illuminating design at the April 6 meeting of the Illuminating Engineering Society, New York.

An address on The Manufacture of Pulp and Paper by Lucien Buck was given at the March 17 meeting of the Rochester Engineering Society.

L. R. Pomeroy is the author of an article on Diameter of Driving Axle Journals, which appears in the April issue of *Railway Mechanical Engineer*.

W. F. Freund, formerly with the India Rubber Company of New Brunswick, N. J., has become a member of the staff of Gibbs and Hill of New York.

Arthur C. Scott is the author of an article on Lubrication of Station and Industrial Machinery which appears in the April 8 issue of *Electrical World*.

J. E. Johnson, Jr., has contributed an article on The Operation of the Blast Furnace to the April 1 issue of *Metallurgical and Chemical Engineering*.

A. Lewis Jenkins contributed an article on a Chart for Ratios for Speeds in Geometric Progression to the April 13 issue of the *American Machinist*.

George F. Swain, professor of civil engineering, Harvard University, Cambridge, Mass., is the author of a book entitled Conservation of Water by Storage.

C. T. Myers, engineer for the Timken-David Brown Company, Detroit, manufacturers of worm-driven truck axles, has been promoted to manager of the company.

Herman Jakobsson, consulting engineer of Washington, D. C., has become affiliated with the Midvale Steel Company of Philadelphia, Pa., as artillery engineer.

Wm. H. Wood is the author of a brief article entitled Safety First Railroad Rail System, which appears in the April issue of *Railway and Locomotive Engineering*.

F. B. and L. M. Gilbreth are authors of an article entitled Conserving the Worker's Health and Energy, which is published in the April 6 issue of *The Iron Age*.

H. M. Estabrook, president of the Barney and Smith Car Company, Dayton, O., has become affiliated with the Malm Machine Company of Dayton, O., as treasurer.

Dr. Alex. C. Humphreys, Past-President, Am.Soc.M.E., presented a paper entitled Reform and Regulation at the April 21 meeting of the Boston Society of Civil Engineers.

Herbert R. Davis is now connected with the Dominion Gas Company of Buffalo, N. Y. He was until recently in the employ of the Quapaw Gas Company of Bartlesville, Okla.

Arthur R. Carlyle, engineer with the Union Oil Company of California, San Francisco, has been transferred to Los Angeles, Cal., as engineer of the marine department.

Bradley Stoughton, Secretary of the American Institute of Mining Engineers, addressed the Philadelphia Foundrymen's Association, April 5, on Melting with Crude Oil in the Cupola.

Welles H. Sellew is now associated with the Canadian Car and Foundry Company, Kingsland, N. J. He was formerly in the employ of the Otis Elevator Company of New York, N. Y.

Harry E. Smallbone, president and superintendent of the Smallbone Manufacturing Company, Chicago, Ill., has become associated with the King Sewing Machine Company, Buffalo, N. Y.

Walter C. Beckjord has become affiliated with the Madison Gas and Electric Company of Madison, Wis. He was formerly in the employ of the St. Paul Gas Light Company, St. Paul, Minn.

Howard B. Howie, until recently associated with the Oriskany Ore and Iron Corporation, Reusens, Va., has become identified with the Canadian Copper Company, Cunickel, Ontario.

Oscar Segalowitz, formerly with the American Paper Goods Company, Kensington, Conn., has entered the employ of the Aetna Explosives Company, New York, in the engineering department.

Forrest W. Manker has accepted a position with the B. F. Sturtevant Company, Cleveland, O. He was until recently connected with the Moulton Engineering Corporation of Portland, Me.

S. S. Wyer is the author of an article on Principles of Natural Gas Leasehold Valuation which appears in the April issue of the Bulletin of the American Institute of Mining Engineers.

F. L. Gilman, assistant general superintendent of the Western Electric Company, Chicago, Ill., has been appointed one of the assistant chief engineers of the company, with headquarters in New York.

William H. Shirey, formerly connected with Smith, Hinchman and Grylls, Detroit, Mich., as draftsman, has entered the employ of McMeans and Tripp, consulting engineers of Indianapolis, Ind.

George S. Wilson has contributed an article to the April 4 issue of *Power* on Sawmill Waste in Suction Producer Plant which gives results of test with hogged mill waste, fir bark and Douglas fir cubes.

Walter J. Bitterlich has been appointed plant engineer of the Hood Rubber Company, Watertown, Mass. He was formerly connected with this company in the capacity of assistant master mechanic.

W. Clement Brooke, until recently inspector of the East Orange Water Department, has accepted the position of assistant construction engineer with the Interborough Rapid Transit Company.

Burton C. Fonda, until recently in the employ of the Thomas Crimmins Contracting Company, New York, has become associated with the General Electric Company of Schenectady, N. Y., in the turbine department.

L. Guy Long, until recently affiliated with the Fairbanks-Morse Electric Manufacturing Company, Indianapolis, Ind., as mechanical engineer, has accepted a position with The Gibson Company of the same city.

P. A. Beaman has been appointed assistant superintendent of George W. Prentiss and Company, Holyoke, Mass. He was formerly with the Manufacturers Equipment Company, Boston, Mass., as mechanical engineer.

Archibald Johnston, vice-president of the Bethlehem Steel Company, a graduate of the class of '89 of Lehigh University, was given a dinner April 7 at the Machinery Club, New York, by the members of the New York Lehigh Club.

Walter C. Lange has resigned his position of engineer's assistant with the Consolidated Gas Company of New York, and has accepted the position of superintendent of the Schmitt Manufacturing Company, Homestead, N. J.

J. W. F. Macdonald, until recently connected with the International Engineering Works of Framingham, Mass., as chief draftsman, has accepted the position of mechanical engineer with the Merrill Process Company, Boston, Mass.

Alonzo B. See, president of the A. B. See Electric Elevator Company, New York, has been elected vice-president of the Machinery Club of the City of New York, to succeed the late John A. Hill, publisher of the American Machinist.

Marcus B. Rascovich has accepted a position with the Mineral Products Corporation of Marysvale, Utah. He was until recently associated with the Jualin Alaska Mines Company, Jualin, Alaska, in the capacity of mechanical engineer.

Russell J. Neagle is now connected with the Condit Electrical Manufacturing Company of South Boston, Mass., in the capacity of salesman. He was formerly in the employ of the Edison Electric Illuminating Company of Boston.

Ross Anderson has resigned his position of factory superintendent with the Flannery Bolt Company, Bridgeville, Pa., and has accepted the position of factory manager with the Poole Engineering and Machine Company, Baltimore, Md.

Howard B. Clark has resigned his position as eastern representative of the McNaull-Boiler Manufacturing Company of Toledo, O., to accept the position of engineer of operation and maintenance with the National Carbon Company of Cleveland, O.

The city of Philadelphia, acting on the recommendation of The Franklin Institute, has awarded the John Scott Legacy Medal and Premium to Clement F. Street, vice-president of the Locomotive Stoker Company, for the Street locomotive stoker.

Theodore B. J. Merkt, until recently connected with the Pyrene Manufacturing Company, New York, as experimental engineer, has become associated with Westinghouse, Church, Kerr and Company, New York, in the capacity of assistant engineer.

A. C. Brown has been elected general manager of the Brown Hoisting Machinery Company of Cleveland, O., succeeding Richard B. Sheridan. Mr. Brown is also vice-president of the Brown Hoisting Machinery Company and has been assistant manager.

William L. Wotherspoon has become consulting mechanical and electrical engineer to the International Nickel Company, New York. He was until recently associated with the Canadian Mining and Exploration Company, New York, in the same capacity.

Walter Castanedo, for many years New Orleans representative of the Harrisburg Foundry and Machine Works, has been appointed district manager for the Ames Iron Works of Oswego, N. Y., with headquarters in the Hennen Building, New Orleans, La.

Charles A. R. Haynes has resigned his position as assistant engineer with the New York Steam Company, New York, to accept a position as supervisor of scheduling of the plant department of the Winchester Repeating Arms Company, New Haven, Conn.

Frank R. Wheeler, for the past ten years associated with the C. H. Wheeler Manufacturing Company on the Pacific Coast and Chicago, has returned to Chicago, as district manager of the Middle Western territory, with office in the Marquette Building.

M. R. Hull has resigned his position as superintendent of construction at the Washoe Reduction Works of the Anaconda Copper Mining Company, Anaconda, Mont., to accept the position of chief engineer of the Arizona Copper Company, with headquarters at Clifton, Ariz.

A. L. G. Fritz has accepted the position of superintendent of construction with Ford, Bacon and Davis at Kingsport, Tenn. He was until recently superintendent of construction of the New Burlington Power Station of the Public Service Electric Company, Burlington, N. J.

Axel C. V. Malm has resigned his position of superintendent with the Egry Register Company, Dayton, O., which position he held for the past four years, and has formed a new company under the name of The Malm Machine Company, Dayton, O., for the working out of a rotary punch press designed by Mr. Malm.

James McIlvrid, who for years was manager of the Cockburn Company and its successor, The Standard Gas Power Corporation, has retired from the latter concern and has opened a machine shop in Jersey City under the name of The Mutual Iron Works, where he is building a complete line of special machinery.

Charles L. Edgar, president of the Edison Electric Illuminating Company of Boston, and J. B. McCall, president of the Philadelphia Electric Company, have been appointed to represent the central-station industry on the campaign executive committee for the "America's Electrical Week" celebration next December.

Dr. Charles E. Lucke presented a paper before the Independent Oil Men's Association at a meeting held in New York on April 14, in which he advocated the use of kerosene as fuel for automobiles. His idea in general terms was to pre-heat the air and the kerosene to 300 degrees, the initial heat to come from a kerosene lamp.

Frederick Sargent, of the firm of Sargent and Lundy, Chicago, Ill., sailed from New Orleans, La., for Chile, S. A., on April 5. Mr. Sargent is making this trip in behalf of the Chile Exploration Company, a firm which is identified with the Guggenheim copper interests. He expects to return to Chicago in about two months.

Arthur Falkenau, vice-president of the Hooper-Falkenau Engineering Company, industrial engineers and architects, New York, has become acting consulting engineer of the Canadian Car and Foundry Agency, which is carrying on the production of munitions for Russia in eighty or more plants in the United States and Canada.

Reid Jones has resigned his position as designing engineer for Bartlett and Ranney, Inc., consulting engineers of San Antonio, Tex., and has formed a partnership with C. S. Thomas, Jr., of St. Louis, under the firm name of Thomas and Jones. This firm is under contract to construct the new $1,750,000 terminals of the M., K. and T. R. R. at San Antonio, Tex.

Carl M. Hansen, secretary and chief engineer of the department of accident prevention, inspection and merit classification of the Workmen's Compensation Service Bureau has resigned. Mr. Hansen has been with the Bureau for three years and in that time has developed and put into successful application the system of schedule rating in practically every compensation state in the Union.

E. C. De Wolfe is the author of an article on the Application of Correct Methods which appears in the April 1 issue of *Coal Age*. This article outlines the advantage realized from the use of a top cutter in a mine where both floor and roof are uneven and top coal must be left. Both wide and narrow work is performed by this machine and the expense of timbering is practically eliminated.

Richard B. Sheridan, general manager of the Brown Hoisting Machinery Company, Cleveland, O., has announced his resignation and has accepted a position with the American International Corporation whose offices are at 120 Broadway, New York. Before his departure from Cleveland to New York, Mr. Sheridan was tendered a banquet by former associates who presented him with a loving cup.

Henry Souther, vice-president of the Ferro Machine and Foundry Company, Cleveland, O., and past-president of the Society of Automobile Engineers, has severed his connection with that firm. His new affiliations have not yet been announced. Mr. Souther joined the Ferro organization in 1914, having been consulting engineer to the Standard Roller Bearing Company, Philadelphia, for the previous four years.

H. G. Stott, superintendent of motive power of the Interborough Rapid Transit Company, New York, has been retained as consulting engineer in connection with the large steam plant which the Buffalo General Electric Company is building to supplement its hydro-electric energy from Niagara Falls. This new plant will embody many advanced features, including a steam pressure of 275 lb. and an exceptionally high boiler rating.

George W. Martin, vice-president of the New York Service Company, and Jay G. De Remer, formerly manager of the general engineering department of the American District Steam Company at North Tonawanda, N. Y., have formed a partnership under the firm name of Martin and De Remer, with offices at 100 Broadway, New York, for general practice in public utilities and industrial plants. Mr. Martin will retain his interest in the New York Service Company as its vice-president.

NECROLOGY

HENRY WICK

Henry Wick was born in Youngstown, Ohio, on May 13, 1846. He received his early education in the schools of Youngstown and later spent two years at the preparatory school of Western Reserve College at Hudson, Ohio. He returned to Youngstown and after a very short time spent in his father's bank, he became manager of the Packard Coal Company which was then opening a mine about two miles west of Youngstown.

In 1877, Mr. Wick became treasurer and active manager of the Youngstown Rolling Mill Company. He later took the lead in purchasing the rolling mill at Warren on the failure of the pipe works there and became the head of the company which undertook its operation. Up to that time, Youngstown had had no steel plant, but in the summer of 1892 a determined effort was made by the leading manufacturers to establish one there. As a result of this, the Ohio Steel Company was formed and Mr. Wick was chosen as its head. In 1899, the Ohio Steel Company with several plants in other places joined in forming the National Steel Company of which Mr. Wick became the first vice-president with headquarters in Chicago, Ill. A year later the offices were moved to New York City and early in 1901, Mr. Wick was elected president. He resigned this position shortly afterwards, however, and returned to Youngstown to take up some enterprises in which he was particularly interested.

Mr. Wick became a member of this Society in 1893. He died at his home in Youngstown after a short illness on December 22, 1915.

ALASTAIR ROSS

Alastair Ross was born in Aberdeen, Scotland, on July 1, 1888. He received his early education in the High School and at Gordon's College at Aberdeen and at the West of Scotland Technical College in Glasgow. He served a four years' apprenticeship with Messrs. J. Abernethy and Co., Engineers, in Aberdeen, in fitting and erecting marine engines, in general mill work and one year in the drafting room. From 1910-1911, he was a draftsman with the Harvey Engineering Company in Glasgow, sugar machinery specialists. He left this firm to become chief draftsman for Messrs. Catton, Neil and Co. in Honolulu, Hawaii. In 1913, he became head of the Engineering Department of Findlay Richardson & Company of Manila, Philippine Islands, and the next year went to Cuba as chief engineer for The Guantamo Sugar Company. He left Cuba in August, 1915, to take part in the War and obtained a Commission as Second Lieutenant in the Royal Flying Corps. He was killed in an aeroplane accident in Catterick, Yorkshire, on January 17, 1916. He became a member of this Society in 1915.

ROBERT ALLISON

Robert Allison was born at Middletown, Durham County, England, on December 25, 1827, but was brought to this country by his parents when very young. He received his early education in the schools of Shamokin, Northumberland County, Pa., which were taught by farmers for four months during the year.

At the age of 15, Mr. Allison was appointed an assistant engineer at the Shamokin furnace and the next year, he was apprenticed to the firm of Haywood & Snyder, Pottsville, Pa., to learn the trade of machinist. For about two years follow-

ing the completion of his apprenticeship, he worked as a journeyman, following which he accepted a position as foreman in the shops of T. H. Wintersteen, Port Carbon, Pa., where he introduced and developed many improvements in the shops, one in particular being a tool for boring car wheels. This machine did five times as much work as that done by the old method.

About 1863, Mr. Allison in partnership with F. B. Bannan of Pottsville, Pa. started the Franklin Iron Works of Port Carbon which had been idle several years. One of the most important inventions of this company was the Allison Cataract Steam Pump which revolutionized the system of freeing the underground mines from water. Another important invention was the hydraulic feed for diamond drilling machinery.

In 1878, Mr. Allison purchased Mr. Bannan's interest in the works and operated them alone until the time of his retirement in 1901.

Mr. Allison was a member of several Masonic lodges, a member of the Historical Society of Schuylkill County, the Schuylkill Motor Club and the American Institute of Mining Engineers. He became a member of this Society in 1884. He died at his home in Port Carbon on February 3, 1916.

THOMAS I. STEPHENSON

Thomas I. Stephenson was born in Lenoir City, Tennessee, November 5, 1863, and received his early education in the schools of Knoxville. He began work with the Knoxville Iron Company in 1880 and in 1891 was made its secretary. He was elected vice-president and general manager in 1895 and president and general manager in 1910. He was elected president of the Cross Mountain Coal Company in 1914. Mr. Stephenson became a member of this Society in 1915. He died at his home in Knoxville on January 18, 1916.

EDWARD I. LEIGHTON

Edward I. Leighton was born in Birmingham, England, on March 8, 1850. He moved to this country with his parents when about six years old, settling in Cleveland, where he attended the public schools. Prior to 1880 Mr. Leighton was employed in the steel mills of Cleveland. In that year, with Fred W. Bruch, he started the Cleveland Punch & Shear Works Company, first operated under the firm name of Leighton and Bruch. About 1890 Mr. Leighton purchased his partner's interest and later the business was sold. Although he retired from business 15 years ago, he had been director up to the time of his death in the following concerns: Acme Machinery Company, the Forest City Live Stock and Fair Company, the Van Dorn & Dutton Company, the Van Dorn Electric Tool Company and the Reliable Machine Company.

Mr. Leighton became a member of this Society in 1892. He died at St. Augustine, Fla., on February 26, 1916.

GEORGE W. K. TAYLOR

George W. K. Taylor was born in New York City on December 18, 1856. He received his early education in the public schools of Brooklyn and later attended Cooper Union from which he received a B.S. degree in 1877 and a degree in mechanical engineering in 1907. From 1874-1893 he was employed by the Eaton, Cole & Burnham Co. at New York and Bridgeport, Conn., in charge of the designing, manufacturing and superintending the production of special valves, fittings, etc., especially adapted to high pressure steam work for power stations. In 1893, he formed a partnership with Mr. McMann, and this firm made a specialty of designing, manufacturing and superintending work for power plants. In 1894, he equipped the steam power plants of the Baltimore, Md., traction system, and the Columbus, O., Edison Electric Light Co. This firm was incorporated in 1910 as the McMann & Taylor Company, designing and manufacturing wrought and cast iron pipes, boiler tubes, fittings, valves, tools, etc., and all goods pertaining to steam, water, gas, etc.

Mr. Taylor was a member of the Machinery Club of New York, the Society of Old Brooklynites, the Chamber of Commerce, the Merchants' Association, the Old Union League Club of Brooklyn, Director of Greenwich Bank, Trustee of St. John's Methodist Episcopal Church of Brooklyn, and was a 32nd degree Mason. He became a member of this Society in 1906.

He died at his home in Brooklyn, March 7, 1916.

WM. H. FRANCIS

Wm. H. Francis died in Philadelphia on March 16, 1916.

GEORGE NEWBOLD COMLY

George Newbold Comly was born at Byberry, Philadelphia, Pa., on August 6, 1851. He was educated at the Friends' School at Byberry and also at the Friends' Central School in Philadelphia, and served an apprenticeship in the machine shop of Wm. B. Bement & Sons in Philadelphia for four years. Following this, he was foreman of the machine shop at the Edge Moor Iron Works and later was put in charge of the drawing room.

In 1890, Mr. Comly started an engineering business for himself, doing considerable business for the Newport News Ship Building and Dry Dock Company.

In 1896, he became connected with the Solvay Process Company of Syracuse where he was in charge of the engineering department for fourteen years. For two and one half years preceding his death, he was Deputy Commissioner of Buildings for the city of Syracuse.

Mr. Comly was a member of the Citizen's Club, The Technology Club, the Syracuse Country Club, and the Social Literary Club, all of Syracuse. He was also a director of the Society for the Prevention of Cruelty to Children. He became a member of this Society in 1880. He died at his home in Syracuse on March 22, 1916.

HAROLD B. KIRKUP

Harold B. Kirkup was born on September 14, 1887. He received a degree of mechanical engineering from Cornell University in 1912. In September, 1912, he entered the employ of the Cambria Steel Company of Johnstown, Pa., doing general power plant work, including steam engine testing, indicating and valve setting. For two years preceding his death he was with the Ice Manufacturing Company of New York City as testing engineer. Mr. Kirkup became a member of this Society in 1914. He died in New York on March 23, 1916.

CLAUDE M. DUGAN, JR.

Claude M. Dugan, Jr. was born in Philadelphia, Pa. on February 3, 1877. He received his education at the Boys' Manual Training School and at the University of Pennsylvania, from which he graduated in 1898.

In 1899 he entered the employ of the Vulcanite Portland Cement Company as a chemist. Following this, he was employed by Wm. Krause Son Cement Co. and by the Bureau of

Filtration in Philadelphia. In 1905, he became assistant superintendent of the Kosmos Portland Cement Co. at Kosmosdale, Ky. and later manager of the manufacturing department. In 1911 he became general manager of this company. In 1913, he became president of the Dugan Engineering Company which was afterwards absorbed by the Hunt Engineering Company. For this latter company he was vice-president.

Mr. Dugan became a member of this Society in 1913. He died on April 11, 1916.

JAMES F. WALSH

James F. Walsh was born in Cleveland, Ohio, on March 29, 1857. He received his education in the parochial schools and Spencerian College of Cleveland. In 1871 he began railroad work as machinist apprentice on the Cleveland, Columbus, Cincinnati and Indianapolis Ry. and was successively locomotive fireman, engineer, and roundhouse foreman and general foreman.

In 1892 Mr. Walsh became associated with the Galena Signal Oil Company as mechanical expert and in 1902 he was appointed superintendent of motive power, Chesapeake and Ohio Railway, at Richmond, Virginia. In May, 1910, he became general superintendent of motive power for the Chesapeake and Ohio lines. He retired from active service in July, 1912.

At the time of his death, which occurred on April 13, 1916, at Roanoke, Virginia, Mr. Walsh was doing special mechanical work for the Galena Signal Oil Company. He became a member of this Society in 1913.

SOCIETY MEETINGS

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office, before the 18th of the month.

NEW YORK, MARCH 29

The first social event to be held by the New York section, at which no effort was made to combine business with pleasure, took place at the Machinery Club on March 29. There was an attendance of nearly 200 members and ladies. A dinner was served, followed by dancing. Edwin J. Prindle, chairman of the Entertainment Committee, was toastmaster, and brief speeches were made by F. R. Low, Editor of Power, Spencer Miller, member of the Naval Consulting Board, and Secretary Calvin W. Rice. The speakers all entered into the spirit of the occasion, which called for story-telling rather than more serious discussion, and the whole affair was one of enjoyment and a delightful entertainment for all. By means of this meeting, the New York members, who usually have to rush for a train at the close of their evening meetings, became much better acquainted than has heretofore been possible, and the affair afforded so much pleasure that it is likely to become at least an annual event, and will, undoubtedly, lead to other social occasions in the way of smokers or excursions.

BUFFALO, MARCH 29

A meeting of the Engineering Society of Buffalo was held on March 29 at which Major L. V. Frazier of the United States Corps of Engineers gave a stereopticon lecture on The Engineering Arm of Our Army. Major Frazier said that the United States has about 2000 engineers to an army of approximately 80,000 men. In Europe, he said, the proportion of engineers is about twice that of the United States. He described the duties of the engineering corps as construction and demolition, and illustrated his points with figures. It builds and operates railways, mines bridges, trenches and fortifications; the participation of engineers in warfare is not limited to actual work with the fighting forces. Major Frazier said that examinations were open to junior and assistant engineers and to graduates of recognized engineering schools, and showed with a series of slides the training that they receive in preparation for them. Some of the views were of actual work at West Point, in Philadelphia and in Russia. A raft made of barrels to take the place of pontoons he referred to as a common expedient. The paper was discussed by Col. Charles Wolf of the 74th Regiment, who said that the country is talking too many kinds of preparedness, it should decide on one kind and go ahead with it, and Capt. W. E. Welsh of the 30th United States Infantry, who said that to go into war without a trained army, we should have to put 2,000,000 men in the field to secure suitable training for 1,000,000.

Two resolutions were carried unanimously. The first was presented by D. C. Howard, Mem.Am.Soc.M.E., and demanded that our representatives in Congress "act in accordance with the views expressed" in it which were that the country should be put in a condition of defense both on the Atlantic and Pacific coasts. The other was introduced by F. A. Lidbury of Niagara Falls, former president of the Electro Chemical Society of the United States. His resolution provided that this nation should so permit and foster development of its water power as to prevent further exportation of the electro chemical industry, on which military preparation fundamentally depends. There were about 250 members present.

BOSTON, APRIL 5

A meeting of the Boston Section of the Am.Soc.M.E. was held on April 5 at the Franklin Union. The subject of the meeting was The Shoe Industry, which was presented by Joseph J. Gillespie. The lecture was illustrated with lantern slides and moving pictures which showed the shoes of the primitive man and of the various countries and centuries, and also methods of shoe manufacture and the progress that has been made up to the present time.

NEW HAVEN, APRIL 5

The Spring Meeting of the New Haven Section held on April 5, was a joint meeting with the Civil, Electrical and Mining Engineers of New Haven. The meeting consisted of an afternoon session, held in the Mason Laboratory of the Sheffield Scientific School, dinner at the Yale Dining Club Hall, and an evening session in North Sheffield Hall. About 150 were present in the afternoon and about 300 in the evening.

Dr. L. P. Breckenridge, Mem.Am.Soc.M.E., presided in the afternoon, when H. I. Harriman, C.E., of Boston, Mass., presented an interesting paper on The Water Powers of New England. The paper was illustrated with numerous lantern

slides showing recent examples of drains, impounding reservoirs and hydro-electric plants in various parts of New England.

This paper was followed by a general discussion, which was opened by R. J. S. Pigott, Mem.Am.Soc.M.E. John W. Lieb, Mem.Am.Soc.M. E.; S. F. Ferguson, Mem.Am.Soc.M.E.; Prof. C. F. Scott, Mem.Am.Soc.M.E.; C. R. Harte, W. S. Huson, Mem.Am.Soc.M.E., Professor Breckenridge, and others took part in the discussion.

Calvin W. Rice, Secretary Am.Soc.M.E., was present and spoke for a few moments upon the work that the Society is doing in coöperating with the other national engineering societies toward the welfare of the country.

Following this session, a dinner was served in the hall of the Yale Dining Club. The evening session was opened by President Arthur T. Hadley of Yale University. President Hadley introduced Samuel Insull, president of the Commonwealth Edison Company of Chicago, who presented a comprehensive paper on The Progress of Economic Power Generation and Distribution. Mr. Insull reviewed the history of the business of electric power generation and distribution, from its inception in the early ages to the present time. His paper was illustrated by numerous lantern slides showing the evolution of electric power station machinery.

A more complete account of this meeting is given elsewhere in this issue.

PHILADELPHIA, APRIL 10

On April 10 a joint meeting of the Philadelphia Section of The American Society of Mechanical Engineers and of the American Institute of Electrical Engineers was held at the Engineers' Club, at which Joseph Tracy, Chairman of the Philadelphia Section of the A.I.E.E., and Prof. R. H. Fernald, Mem.Am.Soc.M.E. and Chairman of the Philadelphia Section of the Am.Soc.M.E., presided jointly. The general subject of the evening was Some Prime Movers Now Under Development. The first paper given was The Uniflow Engine, which was presented by Allan D. Skinner, Mem.Am.Soc.M.E., of the Skinner Engine Co., Erie, Pa. The second paper, on Future Possibilities of the Large Steam Turbine Generator in electric generating service, was presented by W. C. Eglin, Mem.Am. Soc.M.E., vice-president and chief engineer of the Philadelphia Electric Co. His paper was discussed by George R. Henderson, Mem.Am.Soc.M.E.; Carl Hering and R. H. Fernald, Mem. Am.Soc.M.E. The last paper, on The Diesel Engine, prepared by L. B. Harris, of the Southwark Foundry & Machine Co., was presented by W. B. Piersol, of the Southwark Foundry & Machine Co., as Mr. Harris was unable to be present. This paper was discussed by J. Woodbridge, T. M. Chance, Mem. Am.Soc.M.E.; H. P. Liversidge, H. T. Moore, Mem.Am.Soc.M. E.; Prof. Fernald and others. There were about 240 members present.

On behalf of Mr. Harris, Mr. Piersol extended an invitation to all present to visit the Southwark Foundry & Machine Co. to see the Southwark Diesel engines under construction.

BUFFALO, APRIL 12

A meeting of the Engineering Society of Buffalo was held on April 12 at which Fred Kent, works manager of the Lodge & Shipley Company of Cincinnati, Ohio, spoke on Bringing a Shop Up-to-Date.

Mr. Kent's talk was very practical and dealt with the establishment of a proper drafting room system, planning department, proper means for training of men and a means for routing work through the shop. He dealt in considerable detail with the question of when it paid to make jigs and when it did not; also, with the points of advantage of automatic lathes or plain engine lathes to the small shop man. About 250 members were present.

NEW YORK, APRIL 20

The New York Local Section held a joint meeting with the Metropolitan Section of the Society of Automobile Engineers in the Auditorium of the Engineering Societies Building on the evening of April 20. About 350 were present.

H. R. Cobleigh, chairman of the Am.Soc.M.E. Section, opened the meeting and invited Leonard Kebler, chairman of the S.A.E. Section to take the chair.

The topic of discussion was the four-cylinder vs. the multi-cylinder motor. Finley R. Porter, Mem.Am.Soc.M.E. and M.S.A.E., read a paper on Internal Combustion Motors: The Four-Cylinder Motor of To-day and Future Possibilities, and J. Edward Schipper, M.S.A.E., read a paper on Automobile Applications of Four-Cylinder Motors, prepared by F. E. Watts, M.S.A.E., who was unable to be present.

The keynote of Mr. Porter's paper was that the increase in number of cylinders of an engine has been the result of a demand in advance of the art, and that the determining factor of number of cylinders is thermal efficiency.

Mr. Watts' paper considered the requirements of performance, durability and maintenance cost of the motor of pleasure automobiles and pointed out how the four-cylinder motor met these requirements.

The case of the four-cylinder motor having been presented in the two papers, the chairman called for discussion of the other side of the question, and several members responded with interesting observations.

Preceding the meeting an informal dinner was held, at which members of both societies were present.

STUDENT BRANCHES

JOINT MEETING OF METROPOLITAN STUDENT BRANCHES

For the first time in the history of the Society a joint meeting of Student Branches was held at the headquarters of the Society on Friday evening, April 14, 1916. Five Student Branches located at the following institutions participated:

Columbia University
New York University
Pennsylvania State College
Polytechnic Institute of Brooklyn
Stevens Institute of Technology

More than 250 undergraduates and members of the Faculty of the various colleges were in attendance.

The meeting opened with an address of welcome by Past President and Honorary Secretary F. R. Hutton, who is also Chairman of the Committee on Student Branches. Professor Hutton pointed out the importance of the occasion and the fact that future joint meetings would be governed in a sense by the precedents formed on the occasion of the initial affair. The object of the meeting was to bring the students of the different engineering schools into closer touch with the parent Society and at the same time foster the habit of forming new acquaintanceships and friends among those in the engineeriing profession. In turn this develops the coöperation which is of paramount importance to the continued progress of the profession.

It is planned to make this joint meeting of the Student Branches located in the Metropolitan District an annual affair, and further that whenever possible the branches in other sections of the country will arrange to hold occasional joint meetings. This can be done either where several branches are conveniently located to one another, as is the case in New York,

or on occasions when one or more groups of engineering students are visiting other cities for trips of inspection or other purposes. The student members at Pennsylvania State College were in New York on a trip of inspection and the committee in charge of the meeting invited them to be their guests. It is planned to organize the meeting sufficiently early next year to make it possible for some of the other out of town Student Branch members to join in the meeting.

The manufacture of steel, tin plate, and tin products was shown by motion pictures loaned by the United States Steel Corporation. A motion picture showing the welding of a broken rudder plate followed with an actual demonstration of thermit welding of two pieces of pipe. This was most spectacular and was described by Mr. Hurlbert of the Goldschmidt Thermit Company.

All those in attendance were provided with cards showing the college they attend and with space for each to write his name. These were attached to the coat lapels.

A smoker and refreshments followed in the rooms of the Society and all joined in college songs led by the members of the glee clubs of the schools. Good fellowship prevailed generally and the following members of the committee in charge felt well repaid for the efforts which they put forth to make a success of the undertaking:

Lawrence H. Nielsen, Columbia University, Chairman
Herman Brandt, Polytechnic Institute of Brooklyn.
Charles A. Pines, New York University
James A. Wilcox, Stevens Institute of Technology.

ARMOUR INSTITUTE OF TECHNOLOGY

The Armour Institute of Technology Student Branch held a meeting on March 16, 1916, and Prof. Geo. F. Gebhardt, Mem.Am.Soc.M.E., carried out a novel plan. At his suggestion, the members considered themselves as consulting engineers and he acted as a client who was bringing several specimens of apparatus to be tested. A pair of small gears made of a special alloy were tested for failure. Other specimens were an automatic sprinkler and a piece of rubber hose. Many interesting points about the thoroughness with which the articles are tested were brought out.

Plans were discussed for conducting a meeting in the form of a court trial in which the defendants and plaintiffs would be composed of the students, the subject of the suit being the failure of some article with which engineers have to deal.

A meeting of the Student Branch was held on April 12 at which the following officers were elected for the coming year: L. A. King, president; Geo. Fritze, vice-president; E. W. Haines, secretary; H. S. White, treasurer. Plans were discussed for a banquet to be held on April 29. Following the speeches given by the new officers, a talk on Boiler Room Efficiency was given by G. F. Wetzel, a Senior who is employed by the International Filter Company of Chicago.

BUCKNELL UNIVERSITY

A meeting of the Bucknell University Student Branch was held on April 10. The speaker of the evening was unable to be present and the meeting was given over to an impromptu discussion of the subject of Safety Devices. The paper on Standardization of Safety Principles by Carl M. Hansen, published in the April issue of The Journal, was referred to in a number of instances and many instructive points were brought out by the students.

COLORADO AGRICULTURAL COLLEGE

The Colorado Agricultural College Student Branch held a meeting on February 28. Mr. Courey gave a detailed and instructive talk on the Diesel Engine mentioning the advantages of the engine and its construction, and also giving an account of the discovery of the Diesel principle.

The meeting on March 13 was visited by members of the local branch of the A.I.E.E. and several sophomore engineering students. President Lory was the speaker of the evening and discussed the subject of Strengthening the Engineering Departments of the Land Grant Colleges. He said that in the early years of these colleges the engineering department threatened the life of the agricultural work. This fact caused considerable agitation and brought about the organization of the National Association of Agricultural Colleges and Experiment Stations. This movement surprisingly strengthened the standing of the agricultural departments and after several years the engineering department lost favor and seemed to be rapidly declining. This state of affairs continued to exist until only a few years ago an attempt was made to do away with the engineering department in the Land Grant Colleges through legislation. This led to protective measures on the part of that department and through organization, great strides have been made toward strengthening its stand. It is now planned to establish engineering experiment stations at these schools and thereby increase materially the value and usefulness of the engineering courses. Dr. Lory pointed out several important phases of the matter which should be followed up and spoke of the work already done by some of the larger institutions. In conclusion he painted a very bright picture of the future of engineering in the Colorado college.

At a meeting of the Branch on March 27, a series of four films were shown entitled From Ore to Finished "National Pipe." These pictures very clearly illustrated the mining, shipping and handling of the iron from the fields to the finished product of steel pipes. One reel was devoted to the welfare work of the National Tube Co.

LEHIGH UNIVERSITY

At a meeting of the Student Branch of Lehigh University held on March 23, William D. Reese spoke on Exhaust Steam Turbines. Mr. Reese explained that steam turbines are divided into two classes, those that take steam at boiler pressure and those that take steam from the exhaust of some type of reciprocating engine. Due to the increased cost of fuel and labor, engineers have turned their attention to devising some way by which more of the heat which the burning of a pound of coal generates can be used. There are ways of using a part of this latent heat, such as heating the feed water to a fairly high temperature by the exhaust steam, but these are not very satisfactory as not much of the heat can be recovered. For this reason engineers have tried to devise some form of engine which will use this latent heat in the exhaust steam, and of all the devices up to the present time the exhaust steam turbine has proved to be the most successful.

Mr. Reese gave a brief history of the exhaust steam turbine and presented data indicating the saving realized from its use. He said that an idea of the cost of these turbines may be gained from the cost equations given in *Power* for December, 1913. It has been found that where more power has been needed, that the cost of installation of the low pressure turbine system including the condenser to a reciprocating engine is less than that of an additional engine and boiler to generate the extra power, not counting the saving in fuel by the former. Although this turbine has not been developed to any extent in this country, there seems to be a great future for it in the extension of existing power plants.

G. P. Nachman, M.E., '14, who is in charge of the Heating and Ventilating department for S. B. Austin Sons & Co., of Cleveland, Ohio, spoke on Heating and Ventilating. Mr. Nachman first discussed the heating and ventilating of schoolhouses and enumerated the several methods of heating a building: namely, hot water either gravity or forced method, direct steam, either vacuum or return pipes, gas heaters, or the blower system.

Mr. Nachman said that it is advisable to heat large houses by the blower system. Therefore a one-unit system has been devised which not only heats the house but also ventilates it. A device is on the market consisting of a small motor which can be put out of a window and will draw air in the room over a radiator. The blower system is also used in mines and in the drying room. It was pointed out that the blower system has an advantage over the steam system in that the ordinary height of a window sash above the floor is 4 ft.; if steam is used, this space is taken up by steam coils, while if the blower system is used this space is clear and work benches, etc., may be placed there. The blower system is usually considered to be superior to any other form of heating or ventilating.

LELAND STANFORD JR. UNIVERSITY

The Student Branch of Leland Stanford, Jr., University held a meeting on March 1 at which H. C. Parker read a paper

describing the San Bernardino Precooling Plant, operated by the Santa Fé Railroad for cooling oranges before shipment. The packed oranges are cooled from a temperature of 60 to 90 deg. down to about 44 deg. This is accomplished by passing air refrigerated to a temperature of 8 to 10 deg. through the car packed with oranges. Eight thousand cubic feet per minute is the volume used and the cooling is continued for four hours. The balanced system is used with a pressure of ½ in. of water applied to one end of the car and ½ in. of vacuum to the other end. The flow is reversed every few minutes for uniform cooling.

The cooling system comprises three 350 h.p. Stirling boilers supplying steam to two cross compound engines, each direct connected to a 300 ton, 17 x 34 in. duplex, double acting Vilter refrigerating machine. The ice boxes of the cars are also filled with ice to maintain a low temperature during shipment.

The plant uses eight double inlet sirocco fans, each about 10 ft. in diameter. Each set of four fans is driven by an 80 h.p. motor. The eight fans will handle 260,000 cu. ft. of air per minute. The capacity of the plant is 32 cars every four hours.

The plant was erected by the Santa Fé Railroad in 1910 at a cost of $900,000. Since its installation over 30,000 cars of oranges have been precooled for shipment with the result that damage claims have been practically eliminated.

At the same meeting H. R. Hammett gave a paper on The Uses and Properties of Aluminum Alloys. The aluminum magnesium alloys were spoken of in particular, because of their present and future use in the automobile industry.

At a meeting of the Branch on March 15 an illustrated paper on Hydraulic Power Plant Engineering was presented by J. W. Swaren of the Pelton Water Wheel Co. of San Francisco. The history of the development of water wheels and turbines was first considered and then illustrations of modern practice were given. The lecture was generously illustrated with slides showing representative examples of modern installations.

OHIO STATE UNIVERSITY

A meeting of the Student Branch of the Ohio State University was held on February 16. It was decided to hold weekly meetings at which one member of each thesis group should give a short talk on his thesis subject, explaining the object of same and method of attaining it.

Steam Consumption from Indicator Cards was discussed by H. H. Brooks with special reference to more recent ways of improving the accuracy of this method.

PENNSYLVANIA STATE COLLEGE

The Student Branch of the Pennsylvania State College held a meeting on March 16, at which Professor Canan gave an illustrated talk on The Combustion of Fuels, showing the progress made in raising the efficiency of fuel utilization.

Prof. Frank A. Burr, Mem.Am.Soc.M.E., followed with an interesting and thorough discussion on Spray Pond Systems, giving costs and much valuable data on systems which have been installed.

UNIVERSITY OF CALIFORNIA

The University of California Student Branch held a regular meeting on the evening of March 21, at which K. Potts, '17, presented a paper on The Electric Drive on the Battleship *California*. He discussed the various possibilities of the electric method of ship propulsion and cited tests that have been carried out on the collier *Jupiter*.

Prof. J. N. LeConte, Mem.Am.Soc.M.E. and Honorary Chairman of the Branch, discussed the subject of Skin Friction on Centrifugal Pump Runners and Runner Balancing. He referred to tests which have been carried out in the laboratory in an endeavor to obtain the foregoing and noted how close the theory involved agreed with the experimental results obtained.

At a meeting of the Branch on April 4, C. P. Kenville, '17, gave a talk on The Present Tendencies in the Design of Ship Hulls in which he discussed the recent experiments that have been carried out at Washington, D. C., relative to the resistance of ships of various designs. Prof. H. B. Langille, Mem.Am.Soc.M.E. and Professor of Machine Design at the University, spoke along the same lines, his subject being Ship Resistance and Propeller Design. He explained the methods used to calculate the resistance of ships and the present drafting room practice relative to propeller design.

An illustrated lecture on Gold Dredging and Dredger Construction was presented by H. G. Oliver. Mr. Oliver outlined the methods of dredging in California and showed views of the world's largest gold dredger during construction and in operation in the field after its completion.

UNIVERSITY OF COLORADO

At a meeting of the Student Branch of the University of Colorado on March 16 the following officers were elected: Harlow Platts, president; Guy Kurtz, vice-president, and Robert F. Hamilton, secretary and treasurer. Following this Prof. John A. Hunter, Mem.Am.Soc.M.E., and Professor of Mechanical Engineering in the University, spoke on the advantages of an organization such as the A.S.M.E. Student Branch to the school and also to the members of the organization.

At a meeting of the Branch on March 30 Thomas Cleary of the Westinghouse Electric & Manufacturing Co. spoke on the Westinghouse Under-Feed Stoker. After explaining the operation and use of the three kinds of mechanical stokers, the over-fed, the under-fed, and the chain grate, Mr. Cleary took up the Westinghouse stoker in detail, and pointed out that with the mechanical stoker less labor and less fuel are required, and the boiler capacity is increased, this increase in capacity being limited only by the amount of fuel fed in.

UNIVERSITY OF ILLINOIS

At a meeting of the University of Illinois Student Branch on March 23 Miss S. Harbarger of the English department of the University addressed the members on Rhetoric and the Engineer. Miss Harbarger asserted that rhetoric is important to the engineer because it is a means of recreation, of efficiency and of preparedness. Rhetorical work gives confidence in one's ability to create a desirable impression on others and is therefore a necessary tool for the engineer. The speaker pointed out that the attitude of the engineering student toward rhetoric is likely to be his attitude toward his profession and therefore should be a healthful one.

UNIVERSITY OF KANSAS

The University of Kansas Student Branch held its seventh annual meeting on March 9. Professional sessions were held both in the morning and afternoon, and at seven o'clock in the evening a banquet was served at Marvin Hall.

UNIVERSITY OF KENTUCKY

The members of the Student Branch of the University of Kentucky returned from an instructive inspection trip through Chicago, in time to start thesis work on April 4. The regular program of the Branch was suspended and talks by eminent engineers substituted.

On April 5, a comprehensive lecture was given by J. N. Breckenridge on the Manufacture of National Pipe by the National Tube Company. His lecture was illustrated by moving pictures showing the whole process of manufacture from the raw material to the finished pipe.

Willis H. Carrier, Mem.Am.Soc.M.E., and President of the Carrier Engineering Corp. of New York City, visited the Branch on April 10 and presented an illustrated lecture regarding the great variety of problems which the air engineer has to solve.

An interesting talk on The Boiler of 1916 was given by F. C. Bitgood of the Babcock & Wilcox Co. This is a boiler of the water-tube type carrying 350 lb. of steam at a superheat of 250 deg. Mr. Bitgood stated that the present tendency of boiler manufacture was for high pressure with just enough superheat to prevent initial condensation, and that the boiler for 1917 will have a pressure of 500 lb. steam at a superheat of 100 deg. He also said that a boiler with a steam pressure of 1000 lb. is the ultimate desire of his Company and that it will probably be realized in the 1918 boiler.

UNIVERSITY OF MICHIGAN

At a joint meeting of the Student Branch of the A.S.M.E. and of the A.I.E.E. was held on March 31, at which G. W. Lunn of the Commonwealth Edison Co., Chicago, gave an interesting lecture on Central Stations. Mr. Lunn sketched briefly their history and took as an example of the latest developments the three plants of the Edison Co. at Chicago, which he described at length. The site, buildings, prime movers, boilers, electric machinery, auxiliary apparatus, tests, and safety provisions were dealt with, and the welfare work of the company outlined. The lecture was illustrated by slides.

UNIVERSITY OF MINNESOTA

The Student Branch of the University of Minnesota held a meeting on March 25, at which Mr. John Corser, '16, gave an interesting talk on Alaska. Mr. Corser was employed by the Copper River and Northwestern Railroad Company during the construction of their two hundred miles of railroad from Cordova, on the sea coast, to Kennicott, which is located in the rich mining and timber lands of Alaska. He spent 3½ years in this region and is familiar with the commercial conditions there.

Mr. Corser said that the Copper River and Northwestern Railroad is the first railroad ever built in Alaska that has been a success, and in spite of the many difficulties and unexpected problems encountered, it paid for itself during construction. This can be explained by the fact that the passenger fare was 20 cents per mile and the freight rates accordingly high.

Unexpected problems were encountered in the rock cuts along the banks of the Copper River and in the large dirt cuts. The strata formation along the Copper River is such that the layers of rock form an angle sloping toward the river and when a cut was made through the rock the lower part of the cut would gradually slide away and that above would come down upon the roadbed. In some cuts, it was found necessary to remove four times as much rock as had been intended. In the dirt cuts, the ground was frozen to a depth of from 18 in. to 2 ft., and after making a cut the sun would thaw out the ground at the top of the bank and it would slide down in the form of a large mass of mud. This made it necessary to widen all the cuts to a greater width than had been anticipated.

During the winter months the road is closed a great part of the time, and when it is open there is no scheduled running time as the snow often makes it impossible for the trains to make any progress. Snow sheds and rotary snowplows have improved the winter conditions considerably during the last two or three years.

Each spring the Kennicott end of the railroad is closed due to washouts and one of the bridges across the Copper River near Kennicott has been washed out every spring. The greatest flood occurred in the spring of 1913 when large sections of the road were washed away.

The speaker, in closing, compared Alaska with the United States as to size and climate. Although Alaska is only one-fifth as large as the United States, it has a population of nearly 10,000 white people and about five or six times as many natives, mostly Indians. The climate varies along the southern coast; the summers are similar to those of our western coast, but cooler, due to the warm water currents of the Pacific Ocean; the winters are cold, the temperature falling as low as 60 deg. below zero. Further inland, the climate is extremely cold and the summers are very short.

UNIVERSITY OF MISSOURI

A meeting of the Student Branch of the University of Missouri was held on April 6, at which the following new officers were installed: F. P. Hutchison, president; Louis Seutter, corresponding secretary; R. B. Warren, secretary and treasurer; and a governing board consisting of J. W. Haney, Mem.Am.Soc.M.E., R. M. Lotz and F. N. Westcott.

E. J. McCourtland, Dean of the Engineering School of the University, gave an illustrated lecture entitled Sanitary Engineering, dealing with community and personal sanitation.

UNIVERSITY OF NEBRASKA

The Student Branch of the University of Nebraska held a meeting on March 15, at which O. R. Martin, Professor of Business Accounting of the University of Nebraska, presented a detailed definition and description of a corporation and of a partnership, explaining the distinction between the two. He said that a corporation is considered as an individual inasmuch as it is responsible for its actions, as a whole body, but the members, separately, are not responsible. In a partnership, however, each individual is responsible for the firm. When Professor Martin had concluded his remarks on this subject, he gave a brief outline of the different kinds of stocks.

On April 4, Prof. G. E. Barber, who is the head of the Department of Roman History and Literature, gave a talk on Engineering in Ancient Rome. The speaker gave an outline of the materials used in Ancient Rome—natural stones, both chiseled and rough; concrete, brick, and stucco work. He said that the Roman roads were from two to three feet thick and consisted of natural stone cemented and pounded together. Interesting lantern slides of the old temples, theaters, walls and public buildings followed the talk, showing in considerable detail the Roman methods of building.

VIRGINIA POLYTECHNIC INSTITUTE

On April 8, a meeting of the Virginia Polytechnic Institute Student Branch was held at which a paper on Injectors by H. M. Harris and F. C. Holton was presented. The principles of the various types of injectors were discussed and the talk was illustrated by blackboard sketches.

H. A. Coddington, Engineer of Tests of the Norfolk and Western Railway presented a paper at a meeting held on April 12 on Superheated Steam and Superheaters as Applied to Locomotives. The lecture was supplemented by lantern slides, showing the method of construction and installation of superheater units on modern locomotives.

A meeting of the Branch was held on April 15 at which two papers were presented. The first was on the subject of Feed Water Heaters by A. T. M. Rust and A. J. Bopp, who discussed the several types of heaters now on the market and illustrated their talk with black-board sketches. The second paper was presented by G. F. Minor and H. L. Dodson entitled Centrifugal Pumps. Black-board sketches were used to illustrate this paper, and the subject was treated from its historical side as well as from a mechanical standpoint.

WORCESTER POLYTECHNIC INSTITUTE

At a meeting of the Worcester Polytechnic Institute Student Branch, James F. Howe, '99, Mem.Am.Soc.M.E., of the American Steel and Wire Rope Company, addressed the members on Wire Rope and Its Relation to Engineering. The speaker first called attention to the disadvantages possessed by chains, namely, their bulk and low tensile strength, and explained that a rope of one-quarter the cross sectional metal area of the chain would be of equal strength. Cold working of the metal after heat treatment was given as one reason for the great reliability of wire rope material. Mr. Howe stated that flexibility, durability, and efficiency are the three desirable qualities which the manufacturers strive for, and each particular use to which the rope is put requires individual consideration and design. This is necessary because of the fact that the maximum flexibility, durability and efficiency cannot be found in any one case, but one or more of these qualities must suffer at the expense of another. Numerous slides were shown which illustrated the various uses of wire rope as well as the many shapes, styles and sizes of rope and fastenings.

YALE UNIVERSITY

The Yale University Student Branch held a meeting on January 21, at which F. L. Low addressed the students on the Panama-Pacific Exposition. Mr. Low spoke mainly of the lighting effects of the exposition and showed slides which were loaned by the National Electric Light Association.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices now appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications. Those not members of the Society are required to file a letter of reference or introduction from a member before applications will be forwarded.

7 PROFESSOR OF ELECTRICAL ENGINEERING of high grade technical capacity, vigor, personality, experience in practice and teaching ability. A man of high standing among engineers and recognized as an authority. Location Middle West.

40 DESIGNER; good opportunity for high grade designer with chiefly drawing office experience on heavy machine tools and similar machinery. Location, Pennsylvania.

44 DESIGNERS experienced in automobile work. Location New York.

164 DRAFTSMAN, thorough technical training with at least 5 to 6 years practical experience as draftsman and designer of heavy high speed machinery, as steam turbines, centrifugal pumps and herringbone gears. Must be neat, quick and accurate, and possess such characteristics as would justify promotion to chief or assistant chief engineer in one to two years time. Salary to begin moderate until ability is proven. Location Maryland.

167 RECENT GRADUATES in mechanical engineering from schools of recognized standing, desired for testing work in large steam operated electric power plants. Applicants with experience in testing work will be given preference. State particulars of education, experience and salary desired. Location New York.

180 INSPECTOR, for interchangeable parts on fine balances. Young man with tool making experience preferred. Eastern location.

185 TOOL DESIGNER who is resourceful and can follow work through to completion. Technical man with practical shop experience. Location Connecticut.

187 DRAFTSMAN with blast furnace and rolling mill experience. Location Pennsylvania.

188 DRAFTSMAN with at least ten years drafting office experience, competent to take charge of a number of men and capable of doing his own calculating. Location Pennsylvania.

192 SUPERINTENDENT to take charge of foundry and scrap reclaiming department, handling all kinds of non-ferrous metals, employing 250 men; must be good executive with business ability and sound knowledge of metallurgy of non-ferrous metals; give full details of experience and qualifications. Location Western Pennsylvania.

193 TOOL DESIGNER accustomed to heavy machine tool work, for manufacturers of milling machines and their equipment. Location, Illinois.

197 CHIEF INSPECTOR for large valve and gage manufacturing concern; plant employs about 1500 men and women; requires man of wide experience of at least ten years, in interchangeable manufacturing field. Location, New England.

198 CHIEF INSPECTOR, up-to-date, well versed in drill press practice in fine interchangeable work, with at least 10 years experience.

201 VALVE AND FITTING DESIGNER and checker with large firm; good future to man with experience who is willing to hustle and work hard. Others need not apply. State experience in full, salary expected and references. All correspondence will be strictly confidential.

202 INSPECTOR OF MATERIAL AND SUPPLIES to work under the supervision of the head of bureau of tests of New York concern manufacturing paper products, to accumulate data which will form basis for research work leading to standardization of grades of paper and other materials used in manufacturing processes. One or two years experience in paper industry would be especially helpful.

203 ASSISTANT TO SUPERINTENDENT OF EMPLOYMENT; young university graduate to develop a systematic plan for engaging, training and recording progress of employees; one who has made a study of psychology or at least with clear conception of the requirements of such a position. Location New York.

205 SALES ENGINEERS. It is desired that applicants be young men between the ages of 25 and 30 years, graduates of some approved engineering college, preferably M.E. degree and of good appearance; would be expected to undergo a period of probation and training in the various offices of company before being given more responsible and higher positions in sales work. If a call cannot be made, application may be made by letter in the applicant's own hand writing, stating age, education, previous business training if any, salary desired, etc. Location, New York.

212 SALES ENGINEERS for the following territories: Central Pennsylvania, New Jersey, New England, Tennessee, North Carolina, Minnesota, North and South Dakota; must show excellent past record and be familiar with boiler plant practice; must be men of good personality. Apply by letter.

213 DESIGNER—experienced in design of machine tools; resourceful and capable of doing original work. Salary dependent upon man.

214 SUPERINTENDENT OF SHOP, to have charge of shop covering repair work, erection of machinery, general repairs on buildings and furnaces, millwrighting, etc., employing about 150 men. Name confidential. Location, Eastern States.

216 DRAFTING ROOM SUPERINTENDENT. Good position open in large flour milling machinery factory. Preferred qualifications; technical, mechanical education, executive capacity, experience in mechanical transmission machinery layouts, the producing of flour and cereal milling machinery and machinery installation plans. Permanent position for right man. Give full particulars of experience, also salary expected.

217 ENGINEER to take charge of manufacturing operations of work in machining in iron and brass, copper, smithing, etc., necessitating working closely to dimensions. Prefer technically trained man. Essential qualifications are knowledge of the trade, shop organization, cost keeping, etc., with personality to control men. Salary about $2500. Location, New York.

218 ENGINEER to take charge of drafting room; output consists of coal handling apparatus, hoisting engines, special heavy machinery and tools, locomotive and overhead cranes. Salary $150 per month, with good prospects of a permanent position and advancement to right man; technical graduate preferred. Give age, reference, and state where last employed. All replies will be held strictly confidential.

219 RECENT GRADUATE with some experience in making boiler tests, to train into work of inspection of boiler plants and steam engine installations in connection with refrigerating and ice making machinery. Location East. Apply by letter. Name confidential.

220 INSTRUCTOR IN MECHANICAL ENGINEERING. Salary $1000 to $1200. Location Middle West.

222 Executive Superintendent for elevator repair and supply company. Location New Jersey.

224 Engineer experienced in testing and installation of steam turbines and turbine driven apparatus. Must be capable of intelligently running and witnessing tests on apparatus, both in buying and selling and handling general engineering details. In application give experience, salary expected, etc.

230 Works Manager wanted at once; thoroughly trained and experienced mechanical engineer as manager of large shop having many departments (principally machine) and making a complicated product of small parts. Only applications from those who have had successful experience in handling such a proposition will be considered. Give full particulars including age, nationality, where and in what lines experience was gained and approximate salary expected. Name strictly confidential. Apply by letter.

231 Detail Draftsman on structural and mechanical work. State experience and salary expected. Location Kansas.

232 Agents to handle sales of products in own territory, for firm specializing in manufacture of crushers, adapted for road building, contracting, mining, rock crushing, for pulverizers, gravel plants, block and tile plants.

237 Engineer experienced in time study work on machine operations. Salary depends on man. Location New Jersey. Apply by letter.

238 Mechanical Engineer to take charge of research department in the development and manufacture of underfeed mechanical stokers. Must have had experience in designing, construction and operation. Good opportunity for the right man with old established corporation. State age, experience, when at liberty, salary expected, etc. Apply by letter.

240 Assistant to general power plant engineer; work would cover power design, construction, testing, etc., in large industrial plant. Salary $900. Location, New Jersey.

243 Efficiency Engineer; American under 30, technical graduate preferred with practical experience. Will for several years act as understudy for ultimate position of efficiency engineer. Salary to start $100 per month. Send postal card with name and address for further particulars.

244 Mechanical and Electrical Engineer to handle the various engineering problems of power generation, distribution and installation of new equipment, maintenance, etc., exclusive of operation of plant; preference given to man not over forty, but ability and experience in industrial plant work must be unquestioned. Name confidential.

245 Manager of Advertising Department for concern in Middle West, manufacturing line of boiler specialties.

246 Superintendent of factory engaged in the manufacture of oil and gasoline engines. Must be familiar with modern methods of manufacture, active, tactful, a close student of human nature and a natural leader. Exceptional manufacturing men even though not actively engaged in gas engine work are encouraged to reply. Position offers a splendid opportunity for one who can qualify. Give complete experience. Name confidential. Apply by letter.

248 Designer for special machinery and labor-saving devices capable of following work through shop to completion. Location, New York State.

250 Manager for firm in India manufacturing clay products, as drainage pipes, tile floors, bricks and wall tile. Correspondence will be handled through New York firm.

252 Production Superintendent, as assistant superintendent in charge of production, in a high class engine and machinery building plant; preferably a man who has had experience in planning and carrying on production according to sales and stock requirements. State qualifications and salary expected. Applications will be treated in strict confidence.

253 Graduate Technical Mechanical Engineer, as assistant to factory executive; young, energetic man. State age, education, past positions, if any, and salary expected at start.

255 Draftsman, American or English, familiar with tool design. Location, Philadelphia.

256 Technically Trained Mechanical Engineer who has had several years' experience in shop methods and costs, wanted, to increase the applications of a new metal working process. Exceptional opportunity for right man. State salary, experience and references.

258 Works Manager for company manufacturing heavy chemicals; position is one of responsibility and demands high order of executive ability; one educated as a chemical engineer or chemist who has demonstrated executive ability. Location Western Pennsylvania.

259 Special Agent for South American Markets for construction materials and machinery. Examination in May (date not yet assigned) to be held under the direction of the Department of Commerce. Application to take the examination should be made direct to the Bureau of Foreign and Domestic Commerce, Washington, D. C., and should set forth applicant's education and experience in the subject of the investigation.

MEN AVAILABLE

Only members of the Society are listed in the published notices. Notices are not repeated in consecutive issues of the Bulletin.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

E-161 Engineer on large steam turbine, power plant installation, operation and efficiency investigations; 10 years experience in charge.

E-162 Sales Engineer among building trades, preferably in New York. Acquainted with leading architects and engineers throughout East and Middle West. Six years successful experience as engineer and salesman for prominent New York manufacturing concern and at present holding responsible position.

E-163 Assistant to President, Manager or Superintendent: Member, 39, M. E. 18 years experience in design and manufacture of steam and hydraulic machinery; twelve years in design, construction and operation of large industrial plants successively as assistant superintendent, superintendent and general superintendent; expert in organizing, cost, statistical and production work. Present position general superintendent of large manufacturing plant; salary $6000 per year.

E-164 Mechanical Engineer at present chief draftsman of large manufacturing concern, desires change. 20 years experience general engineering, automatic labor saving machinery, resourceful, hustler; looking for opportunity to advance. Salary $3000 to start.

E-165 Expert on power plant work and equipment with valuable patents in that line; strong personality, excellent executive and salesman desires to invest several thousand dollars in established engineering enterprise or to form partnership with consulting engineer. Advertiser is also ready to act as consulting engineer to engineering concerns.

E-166 Mechanical Engineer with manufacturing plant, central station or consulting engineer; member, 34, married, technical education, experienced in design, erection and efficient operation of power plants, as principal assistant to consulting engineer; specialized in up-to-date boiler room management and efficiency use of exhaust steam. Eastern states preferred.

E-167 Columbia Graduate in mechanical engineering, with drafting room, power plant and shop experience, seeks position offering opportunity for advancement. At present employed as assistant foreman inspector in large arms plant.

E-168 Vacation Position, June-September, desired by instructor in mechanical drawing in large eastern university; six years practical experience in estimating and designing machinery.

E-169 Metallurgical and Mechanical Engineer; member, age 34, married, specialist in the design and construction of mining, crushing, milling, smelting and acid plants. Ex-

pert on oil-flotation concentration, fine grinding, blast furnace and reverberatory furnace smelting. Thirteen years with mining, milling and smelting companies and manufacturers, wishes responsible executive or engineering position in which broad engineering experience together with ability to handle men will be required. Now in South America, but will go any place. Wire "The Journal" for letter giving complete experience and references.

E-170 Manager, Superintendent or Sales Engineer. Member, graduate M. E., Lehigh University, several years in management of mechanical and purchasing departments of railroad, coal mining, and industrial corporations; extensive experience as sales engineer in railroad equipment. Organizer and executive, qualified to fill position of manager of an industrial plant or coal mining company, or superintendent of motive power of a railroad. Can successfully represent manufacturers of machinery, power plant equipment, iron and steel.

E-171 Machine Shop Superintendent or Master Mechanic with wide range of experience in large steel plants, thirty-two; technical graduate, desires to make change of position with future; best of recommendations; interview is preferred.

E-172 Sales Engineer, age 33, technical graduate, member, seven years sales experience machinery and steel. At present employed. Wishes better opportunity for advancement with high class firm.

E-173 Assistant Works Manager, mechanical engineer or similar capacity, automobile industry preferred. Junior member, age 31, married, technical graduate, experienced in power plants, testing and investigations, general mill engineering.

E-174 Technical Graduate, experienced in general power station design, also engineering and construction, administrative and sales departments of manufacturing corporations, desires connection with manufacturing company with eventual investment of capital; member, age 37, married, eleven years practical experience in U. S. and abroad.

E-175 Chief Engineer, Power Engineer or Plant Engineer, graduate mechanical and electrical engineer, age 33; 13 years extensive experience in designing, constructing, erecting and testing power plants, sub-stations, etc., desires to locate with large firm where conscientious ability will be appreciated. Salary $2500. At present holding responsible position. Location Eastern States.

E-176 Student Member, will graduate this June, desires a position with an engineering firm promising an opportunity for advancement.

E-177 Student Member, five years experience as a machinist before entering university, desires a position with consulting engineers, or in efficiency work with manufacturing firm. Will graduate in June.

E-178 Plant Engineer, member, Cornell graduate with eleven years experience in design, construction, maintenance and operation of industrial and power equipment for three of the largest concerns in this country, desires to make a change. An efficient executive who obtains results. Salary $3600.

E-179 Student Member, graduating from course in mechanical engineering at Worcester Polytechnic Institute in June, wishes position with manufacturer of automobiles, or manufacturer of marine or automobile motors. No drafting. References if desired.

E-180 Mechanical Engineer or Master Mechanic, age 31, graduate M. I. T., five and one-half years experience in design, construction and maintenance of power plants for textile mills; experienced as master mechanic of textile mills; can handle men and get results. At present employed; desires advancement.

E-181 Superintendent, technical graduate, broad experience in general manufacturing in lines usually associated with an establishment whose output is of specialties and general engineering products. Tactful, resourceful and energetic. At present employed. Desires executive position which would be an advancement.

E-182 Sales Engineer or Manager; graduate engineer with sound practical experience and thoroughly acquainted with the best business practice.

E-183 Sales Engineer, Manager or Manufacturers' Representative. Worcester Polytechnic Institute graduate in mechanical engineering, age 36. Thirteen years broad practical experience selling and managing sales or pumping machinery, air compressors and internal combustion engines with their auxiliary equipment, in New York City. Good business record with leading concerns in these lines and is now available.

E-184 Sales Engineer, Manager or Superintendent with technical education and 16 years splendid engineering experience. Six years as draftsman, estimator and chief draftsman, five years chief mechanical engineer large shops manufacturing special machinery, and last five years sales-engineer large power plant contractors. Available on short notice.

E-185 Experimental Engineer or Assistant to Executive. Junior Member, Stevens 1911 Graduate, age 28 years, varied experience in power plant, field and office. Last three years in successful executive and experimental work. Possesses initiative, good personality, unusual mathematical ability. At present employed in Pennsylvania. Desires to locate with concern where ability and energy will win advancement.

E-186 Assistant to Engineer or Instructor in Mechanical Engineering, would like permanent position as test engineer, assistant to consulting or mechanical engineer or instructor in mechanical engineering. Junior Member, college graduate, age 25, practical experience in drafting, testing and design in steam, hydraulic, electrical and gas engineering; also experience on appraisal work and teaching.

E-187 Sales Engineer, M. I. T. graduate, age 29, Associate Member, with three years shop and designing and five years sales engineering experience on pumping machinery and power plant equipment, desires position as sales engineer in New England with headquarters in Boston. Capable salesman with ability to develop business, also careful engineer. Would consider a New England agency.

E-188 Engine Specialist in stationary gasolene, kerosene and high speed engine design. Age 27, seven years experience in design, lay-out, jigs and tools, foundry equipment and general shop superintendence.

E-189 Efficiency Engineer. Cornell, M.E., age 33, understands human nature, capable of handling men diplomatically and to advantage. Experience gained in over twenty different organizations of a very large concern, desires position where traveling is not required, or will consider position as head of employment department.

E-190 Factory Manager, Works Office Manager or Assistant to executive of large organization. Member, age 34, experienced in the manufacture and design of water tube boilers and general plate work. At present employed.

E-191 Publicity Advertising Manager or similar position of responsibility desired by Associate Member with over seven years experience in technical publicity work (advertising, catalogs, editorial, engineering papers and articles). Experience mainly in power plant and general machinery fields. Graduate M.E., age 34, married. At present employed.

E-192 Mechanical Engineer, teaching or commercial position; technical graduate, age 33, four years practical experience as designer and as experimental engineer; five years experience in teaching mechanical engineering subjects including a large amount of experimental work. At present employed. Can furnish best reasons for desiring to change.

E-193 Efficiency, Plant or Sales Engineer: Associate member, graduate mechanical engineer, 32, married. Practical shop man with American and British experience; design and construction of buildings, also structural and mechanical equipment of hydro-electric plants, sugar factories, conveying and elevating machinery, foundry and machine shops.

E-194 Engineer on Oil Engines, desires position as executive, chief engineer, manufacturing superintendent, engineer of tests, or assistant with a concern producing or intend-

ing to take up the manufacture of oil engines. Member, University training with extensive experience in the design and construction of marine and stationary four and two-cycle Diesel engines; has held position with a leading German firm as co-worker in the development of the marine commercial type.

E-195 Works Engineer or Assistant Superintendent; Member, graduate in mechanical engineering, age 35, married; drafting room, erecting, installing, testing and industrial plant design experience, and some sales experience; two and one-half years in executive capacity—operating plant costing $300,000. Immediately available.

E-196 Manager or Superintendent of office building or apartment house or head of service and maintenance department of manufacturing concern or industrial plant. Associate Member, technical graduate, age 30. At present mechanical assistant to manager of large office building. Previous industrial plant experience.

E-197 Materials Testing Laboratory Engineer; wishes to install and operate laboratory for manufacturing or experimental plant and to push commercially some specialty with a future. Experience includes five years as machinist; technical graduate; executive and production work in U. S., Germany and England; charge of materials testing laboratory for one of leading universities in this country and for the U. S. Government; thorough teaching experience in mechanics and the strength of materials. American, unmarried, age 39.

E-198 Factory Manager or General Superintendent. Location must be with a live progressive growing concern, or with a concern that recognizes need of improvement and requires a man who has years of experience with large manufacturing companies and is capable of dictating policies that will bring satisfactory results. Leaving responsible position for larger field. Open for engagement May or June.

E-199 Production Engineer and Automobile Designer; Member, desires position as purchasing or shop engineer; sixteen years experience in U. S. A. and in France; can offer exceptional references.

E-200 Student Member, practical experience in machine shop one year, desires opportunity with some manufacturing concerns. Graduate in mechanical engineering in June, can furnish excellent references.

E-201 Student Member; M.I.T., 1917; desires position during Summer from middle of June until September.

E-202 Student Member, will graduate in June in the Mechanical Engineering course, Bucknell University; three years practical experience in general repair shops, desires a position with chances for advancement. Age 24; can give references and recommendations.

E-203 Student Member, expecting to graduate in June, desires a position. One year electrical work before entering college; nine years experience working at driving and overhauling automobiles during vacations.

E-204 Student Member will graduate in June in mechanical and electrical engineering, desires employment in the South in utility, oil or phosphate work. Will go to Central or South America.

E-205 Student Member, technical graduate, one year's experience in costs, stores and efficiency, wishes to make a change at once.

E-206 Superintendent or Assistant Superintendent of a large concern employing approximately 1500 men and girls and engaged in the manufacture of war munitions as a side line, wishes to connect with some large concern in a similar capacity. Twenty years experience in interchangeable work. Prefer a commercial proposition to munition work. Technical education. Present salary $3000.

E-207 Assistant Manager or Chief Engineer. Fifteen years experience in design and manufacture of pumping and hydraulic machinery. For many years connected with large concern as head of the engineering department; thoroughly familiar with production methods, shop organization, routing of material, and accounting system. Connection with smaller concern preferred, specially centrifugal volute and turbine pumps.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

Affidavit of Samuel S. Wyer, consulting engineer, on Present Situation of the Kansas Natural Gas Company. In the District Court of the United States. No. 136-N. John M. Landon and R. S. Litchfield vs. The Public Utilities Commission of the State of Kansas. Gift of S. S. Wyer.

Air in Compression and Expansion, Chart. C. K. Bennett. *1916.* Gift of author. Price $1.00.

American Society of Mechanical Engineers. Journal vol. 37. (2 vol.) *New York, 1915.*

Brake Performance of Modern Steam Railroad Passenger Trains; a discussion of the Pennsylvania Railroad Brake Tests, 1913, S. W. Dudley. *Pittsburgh, 1914.* Gift of A. S. M. E.

Caisson as a New Element in Concrete Dam Construction a Proposal Made in Connection with the Columbia River Power Project, O. G. Aichel. *New York-London, 1916.* Gift of author.

Electric Automobile Charging Stations in New York City and Vicinity, with route maps, 1916. *New York, 1916.* Gift of New York Electric Vehicle Association.

Electrical Railways, H. M. Hobart, being the "James Forrest" lecture, 1915, delivered at Institution of Civil Engineers. *London, 1915.* Gift of James Forrest.

Engineering Thermodynamics. By J. A. Moyer and J. P. Calderwood. *New York, 1915.* Gift of J. Wiley & Sons. Price $2.00.

This is written to fill the need for a brief and concise text book to be used in technical schools. The authors consider the other text books in use to have too much duplication of subject matter.

W. P. C.

Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface. *New York, Babcock & Wilcox Company, 1916.* Gift of Babcock & Wilcox Company.

General Society of Mechanics and Tradesmen of the City of New York. Annual Report, 1915. *New York, 1916.* Historical Sketch and Government, 1785-1914. Gift of General Society of Mechanics and Tradesmen.

New York City, Board of Water Supply. Contract 120, information for bidders, forms of proposal, contract, etc. for construction of two superstructures for the Hudson and Croton Lake Drainage chambers in the towns of Fishkill, Dutchess county, and Yorktown, Westchester county, N. Y. *1916.* Gift of Board of Water Supply.

Sperry Gyro Stabilizer for Ships. Gift of Sperry Gyroscope Co.

Springfield, Mass. Water Commissioners, 42. Annual Report, 1915. *Springfield, 1916.* Gift of Springfield Water Commissioners.

Frederick W. Taylor, Revolutionist, Frank B. Copley. Privately printed, 1916. Gift of Frederick W. Taylor Co-operators.

U. S. Lighthouse Service, Dept. of Commerce. General information, 1915. *Washington, 1916.* Gift of U. S. Department of Commerce.

Use and Abuse of Coal Specifications. *New York, 1916.* Gift of Fuel Engineering Company.

Web of Steel. Cyrus Townsend Brady, Father and Son. *New York, Fleming H. Revell Company, 1916.* Gift of Publisher.

GIFT OF WASHINGTON SOCIETY OF ENGINEERS

Estrada de Ferro Central do Brazil. Noticia sobre a Duplicação da Linha na Serra do Mar. *Rio de Janeiro, 1914.*

Avenida Central. 8 de Março de 1903, 15 de Novembro de 1906. (Portfolio of views.)

Mensagem offerecida ao exmo snr. Dr. André Gustavo Paulo de Frontin. *Sept. 1912.*

Sessao Magna do Conselho Director no dia 24 de Dezembro de 1914, 34° Annversario da Fundacao do Club de Engenharia. *Rio de Janeiro, 1915.*

Sessao Solemne Commemorativa ao 32° Anniversario da Fundacao do Club de Engenharia em 24 de Dezembro de 1912. *Rio de Janeiro, 1913.*

EXCHANGES

Institution of Gas Engineers. Transactions, 1915. *London, 1916.*

Master Car Builders' Association. Proceedings. vol. 48, pt. 1-2; vol. 49, pt. 1-2. *Chicago, 1914-1915.*

National Association of Cotton Manufacturers. Transactions no. 99. *Boston, 1916.*

TRADE CATALOGUES

Bristol Co. *Waterbury, Conn.* Bulletin 230. Bristol's recording pressure gauges. *Sept. 1915.*

Chain Belt Co. *Milwaukee, Wis.* General Catalog no. 56. *1915.*

Comstock, L. K., & Co. *New York, N. Y.* The E O E formula.

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. *March 1916.*

Ingersoll-Rand Co. *New York, N. Y.* Form 3036. Turbo Blowers. *March 1916.* 9023. "Imperial" tie tamping outfits. *March 1916.*

International Motor Co. *New York, N. Y.* Motor trucking above the clouds.

Kingsford Foundry & Machine Works. *Oswego, N. Y.* Bulletin 17. Boiler of merit.

Leschen, A., & Sons Rope Co. *St. Louis, Mo.* Leschen's Hercules. *April 1916.*

Nelson Valve Co. *Philadelphia, Pa.* Extra heavy steel gate valves.

Texas Company. *New York, N. Y.* Lubrication. *March 1916.*

Under-Feed Stoker Co. *Chicago, Ill.* Publicity Magazine. *March, April 1916.*

Universal Motor Co. *Oshkosh, Wis.* Bulletin no. 20. De Luxe. 4 K. W. Generator set.

Walworth Mfg. Co. *Boston, Mass.* Walworth Log. *March, April 1916.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

Abstracts of Current Decisions on Mines and Mining, reported from May-September, 1915. U. S. Bureau of Mines. Bulletin 113. *Washington, 1916.*

Aero Engines, G. A. Burls. ed. 3. *London, 1916.*

Altitudes in the Dominion of Canada, James White. ed. 2. *Ottawa, 1915.*

American Electric Railway Association. Studies in the cost of urban transportation service, F. W. Doolittle. *New York, 1916.*

Ardlethan Tinfield, Report on. New South Wales. Dept. of Mines. Mineral Resources, no. 20. *Sydney, 1915.*

Automobile Repairing Made Easy, V. W. Pagé. *New York, 1916.*

Die Brauneisenerzlagerstätten Oberschlesiens, Friedrich Raefler. Sammlung Berg u, Hüttenmännischer Abhandlungen, pt. 155. *Kattowitz.*

Cartridge Manufacture, D. T. Hamilton. *New York, 1916.*

Central Station Management, H. C. Cushing, Jr., and Newton Harrison. *New York, 1916.*

Clauses and Precedents in Electricity, Gas and Water Legislation. Compiled by Jacques Abady. *London, 1915.*

Color and Its Application, M. Luckiesh. *New York, 1915.*

Color Standards and Color Nomenclature, R. Ridgway. *Washington, 1912.*

Composition and Porosity of the Intake Beds of the Great Australian Artesian Basin. *Sydney, 1915.*

Compressibility of Natural Gas at High Pressures. U. S. Bureau of Mines. Technical Paper 131. *Washington, 1916.*

Data of Geochemistry. ed. 3. U. S. Geological Survey. Bulletin 661. *Washington, 1916.*

Developers and Development. *New York, 1912.* Gift of Arthur Worischek.

Diemaking and Die Design, F. D. Jones. *New York, 1915.*

Discovery of Phosphate of Lime in the Rocky Mountains, F. D. Adams and W. J. Dick. *Ottawa, 1915.*

Early Days on the Yukon, William Ogilvie. *Ottawa, 1913.* Gift of Mrs. Wm. Ogilvie.

Economic Methods of Utilizing Western Lignites. U. S. Bureau of Mines. Bulletin 89. *Washington, 1915.*

Economies in Brickyard Construction and Operation, Ellis Lovejoy. *Indianapolis, 1913.*

II. Eigenschaften und Eignung der verschiedenen Systeme elektrischer Traktion. B. Allgemeiner Vergleich der Eigenschaften und Eignung der verschiedenen Systeme. *Zurich, 1915.*

Einiges über den Wert von Rauchgasuntersuchungen, H. Winkelmann. Sammlung Berg u. Hüttenmännischer Abhandlungen, pt. 156. *Kattowitz.*

Electric Railway Engineering, C. F. Harding and D. D. Ewing. ed. 2. *New York, 1916.*

Electrical Ignition of Petrol Engines, J. W. Warr. *London, 1910.*

Electrical Measurements and Meter Testing, D. P. Morton. *Chicago, 1915.*

Elementary Manual of Radiotelegraphy and Radiotelephony for Students and Operators, J. A. Fleming. ed. 3. *New York, 1916.*

Elementi di Scienza Vera. Giovanni Danieli. *New York, 1916.* Gift of author.

Das Erdöl, C. Engler and H. v Höfer. *Leipzig, 1916.* IV Band.

Erfahrungen bei der Herstellung von Eisenbetonsäulen. Deutscher Ausschuss für Eisenbeton, pt. 34. *Berlin, 1915.*

Essentials of Electrical Engineering, John F. Wilson. *New York, 1915.*

Furnace Efficiency, combustion and flue gases, J. C. Peebles. *Chicago, 1914.*

Gas Works Directory and Statistics, 1915-16. *London, 1915.*

Geologic Atlas of the United States. Folio 196—Philipsburg, Montana; 195—Belleville-Breese, Illinois; 197—Columbus, Ohio; 198—Castle Rock, Colorado. *Washington, 1916.*

Gold Regions of South Eastern Africa, Thomas Baines. *London, 1877.*

Graphic Studies of Ultimate Analyses of Coals, U. S. Bureau of Mines. Technical Paper 93. *Washington, 1915.*

Ground Water in the Waterbury Area, Connecticut, U. S. Geological Survey. Water Supply Paper 397. *Washington, 1916.*

High Explosive Shell Manufacture, D. T. Hamilton. *New York, 1916.*

Historical Inquiry into the Production and Consumption of the Precious Metals, William Jacob. vols. 1-2. *London, 1831.*

History and Economics of Transport, A. W. Kirkaldy and Alfred D. Evans. *London-New York.*

How a Miner Can Avoid Some Dangerous Diseases, U. S. Bureau of Mines. Miners' Circular 20. *Washington, 1916.*

How to Conduct a Radio Club, E. E. Bucher. *New York, 1916.* Gift of Wireless Age.

How to Pass U. S. Government Wireless License Examinations. 118 actual questions answered, E. E. Bucher. ed. 2. *New York, 1915.* Gift of Wireless Age.

Interior Ballistics, Jas. M. Ingalls. ed. 3. *New York, 1912.*

International Engineering Congress. Panama Canal, vols. 1-2, Municipal Engineering, vol. 3. *San Francisco, 1915.*

International Military Digest. Annual for 1915. *New York, 1916.*

Irrigation Practice and Engineering. Vol. III—Irrigation structures and distribution system. *New York, 1916.*

Jahrbuch der Elektrotechnik. Dritter jahrgang, 1914. München, *1915.*

Leather, from the raw material to the finished product, K. J. Adcock. *London.*

Manual of Federal Trade Commission, R. S. Harvey and E. W. Bradford. *Washington, D. C., 1916.*

Manufacture of Gasoline and Benzene toluene from Petroleum and Other Hydrocarbons. (U. S. Bureau of Mines. Bulletin 114.) *Washington, 1916.*

Mechanical Equipment of Federal Buildings under the Control of the Treasury Department, N. S. Thompson. ed. 3. *New York, 1915.*

Mechanics' Institute. Mechanics-Mercantile Library. Books added during 1915. *San Francisco, 1916.* Gift of Institute.

Metal Mine Accidents in the United States During 1914, U. S. Bureau of Mines. Technical Paper 129. *Washington, 1916.*

Moody's Manual of Railroads and Corporation Securities. 1916. vol. 1, Railroad Section. *New York, 1916.*

Muret-Sanders. Enzyklopadisches English-Deutsches und Deutsch-Englisches Wörterbuch. *Berlin.* 4 vols.

National Association of Railway Commissioners. Proceedings of 27th Annual Convention, 1915. *New York, 1915.*

National District Heating Association. Proceedings of Annual Convention. 6th-7th, 1914-15. *1914-15.* Gift of Association.

Naval Ordnance. A text book prepared for the use of the Midshipmen of the United States Naval Academy, R. I. Curtin and T. L. Johnson. *Annapolis, 1915.*

New York State Museum. 67th Annual Report, 1913. *Albany, 1915.* Gift of New York State Library.

New Zealand. Geological Survey Branch. 8th Annual Report. *Wellington, 1915.*

Nova Scotia. Department of Mines. Annual Report, 1915. *Halifax, 1916.*

Oil Fuel Equipment for Locomotives and Principles of Application, A. H. Gibbings. *London, 1915.*

Overhead Transmission Lines and Distributing Circuits, Their Design and Construction, F. Kapper; translated by P. R. Friedlaender. *New York, 1915.*

The Plumber and Sanitary Engineer (now Engineering Record). vols. 1-3. *New York, 1877-80.*

Pole and Tower Lines for Electric Power Transmission, R. D. Coombs. *New York, 1916.*

Practical Exporting, B. Olney Hough. *New York, 1915.*

Practical Forging and Art Smithing, Thos. F. Googerty. *Milwaukee, 1915.*

Probebelastung von Decken. Deutscher Ausschuss für Eisenbeton, pt. 32. *Berlin, 1915.*

Rifles and Ammunition and Rifle Shooting, H. Ommundsen and E. H. Robinson. *London-New York, 1915.*

Schwellung und schwindung von zement und zementmörteln in wasser und luft. Deutscher Ausschuss für Eisenbeton, pt. 35. *Berlin, 1915.*

Scientific Management. A history and criticism, H. B. Drury. *New York, 1915.*

Service of Coast Artillery, F. T. Hines and F. W. Ward. *New York, 1916.*

Shrapnel Shell Manufacture, D. T. Hamilton, 1915.

Some Engineering Problems of the Panama Canal in Their Relation to Geology and Topography. U. S. Bureau of Mines, Bulletin 86. *Washington, 1915.*

Specifications for High Explosive Shells and Fuses. Abstract of the Official British, French and Russian Government specifications. *New York, 1915.*

Steam Engine Theory and Practice, Wm. Ripper. ed. 7. *New York, 1914.*

Steel Ships, Thomas Walton. ed. 4. *London, 1908.*

Stratigraphy of the Pennsylvania Series in Missouri. Missouri Bureau of Geology and Mines. vol. XIII, 2d ser. *Jefferson City, 1915.*

Surface Water Supply of the United States, 1913. Part IX—Colorado River Basin. U. S. Geological Survey. Water Supply Paper 359. *Washington, 1916.* Purchase.

——— 1914. Part V—Hudson Bay and Upper Mississippi River Basins. U. S. Geological Survey. Water Supply Paper 385. *Washington, 1915.*

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Testing of Machine Tools, G. W. Burley. *London, 1915.*

Theory and Calculation of Electric Currents, J. L. LaCour and O. S. Bragstad. *New York, 1913.*

Theory of Machines, R. F. McKay. *London, 1915.*

Tonindustrie Kalender 1916, pts. 1-3. *Berlin, 1916.*

Torrens Registration System in New York, J. J. Hopper. *1916.* Gift of Bureau of Municipal Research.

Torrens System of Land Title Registration and Its Application in Other Countries and Especially in the State of New York, a sketch, John J. Hopper. Gift of author.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the February 1916 issue of The Journal.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

Arranged in the Order of Their Appearance in the Survey.

Experimental Fan in the Laboratory.
Flow of Air through Nozzles.
Heat Treatment and Physical Properties of Steel.
Thickness and Tensile Strength of Steel Plates.
Markings of Sawings on Metal Bars.
Powdered Coal in Open-Hearth Furnace.
Open-Hearth Furnace Without Regeneration.
Powdered Coal Burners.
Powdered Coal Drying.
Surface Combustion Furnace. Tests.
Hot-Blast Mains, Losses.
Lead-Joints, Leakage.
Valves in Water Works.
Solid-Wedge Valves.
Double-Disc Valves.
Kline Rotary Valve
Frederickson Two-Cycle Engine.
Brown-Boveri Gas Turbine.
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Liquid-Fuel Engine Exhaust.
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Spring Suspension, Automobile.
Chisels.
Dynamometer for Tractors.
Freight Brake, Empty and Load.
Steam Turbine Blade Fastening.
Lovekin Blade Fastening.
Blade Fastening on U. S. S. "Nevada."
Oil Cooler on U. S. S. "Nevada."

Notices from German publications have reached the Library to the effect that the German Government has, for military reasons, prohibited the exportation of certain classes of technical literature.

THIS MONTH'S ARTICLES

Data on the use of experimental fans in a mining laboratory, together with the results of some tests on the determination of the coefficient of the *vena contracta,* are presented in an article abstracted from the *Transactions of the Institution of Mining Engineers.* An abstract of Thomas B. Morley's paper on the flow of air through nozzles, read before the Institution of Mechanical Engineers, is given in this issue. The abstract of the very interesting discussion which followed the reading of this paper will be given in an early issue of The Journal.

From the German paper *Ferrum* is abstracted a paper on tests concerning the influence of heat treatment on certain physical properties of steam. While the tests have failed to obtain any strikingly new results, they are valuable in confirming certain theories not sufficiently proved previously. An interesting series of tests on the influence of thickness on the tensile strength of steel plates have been made by G. B. Waterhouse. Particular attention is called to the results obtained with Bessemer steel plates.

An installation using powdered coal in the open hearth furnace is described on the basis of a paper read by C. J. Gadd before The Franklin Institute of Philadelphia. It describes an open hearth furnace from which the regenerative principle has been entirely eliminated, while it does not yet appear that the apparatus has been sufficiently developed. The present installation, both because of its size and ingenuity of design, certainly merits attention.

E. Schramm and J. R. Cain present data of some tests made on a surface combustion furnace, giving the highest temperatures reached and a curve showing the ideal conditions of perfect combustion without any excess of oxygen. Of practical interest are the facts shown by the test that first, a temperature of about 3000 deg. fahr. was reached in a little over half an hour with a gas consumption of 3 cu. ft. per minute, and second, that the rate of cooling of the furnace is very slow.

In a series of tests on hot blast mains at the plant of the Bethlehem Steel Company, R. J. Wysor determined the average thermal loss due to cooling water from each hot blast valve, and arrived at certain conclusions of general interest with respect to loss of heat in hot blast mains. Among other things, he believes that insufficient insulation in the hot blast main is a cause of serious temperature and heat losses.

The question of leakage from lead joints in cast iron water pipes in city mains is discussed on the basis of some tests by Arthur H. Smith. In these tests a leakage of 1.58 gal. per day per linear foot of lead joint has been found, and the author believes that as long as pipe lines are built in the present manner leakage must be reckoned with, and further, that if leakage of new work can be limited to one gallon per day per foot of joint under 100 lb. pressure, the performance can be called good and acceptable.

Two articles of a somewhat controversial nature on valves for use in water works are abstracted from *The Journal of the New England Water Works Association.* One champions the use of the solid wedge type because of the experience had with it by the Boston Water Department. Another presents reasons in favor of the double disc type of valve.

In the section internal combustion engineering, besides a description of a new rotary valve and a two stroke cycle aeronautical engine, attention is called to two abstracts on gas turbines. One of these is the Detroit gas turbine, of which, however, no mention of any tests can be found.

The composition of the exhaust from liquid fuel engines is discussed in a paper by Robert W. Fenning before the Institution of Mechanical Engineers. The author introduces the use of exhaust gas charts, which may prove of advantage in engine testing.

Prof. G. B. Upton presents a system for plotting and cross-fairing results in lubrication testing.

The discussion of the metal used for chisels and standardization of their shapes forms the subject of a paper before the Institution of Mechanical Engineers.

A dynamometer for determining the horse power of tractors is described and a chart reproduced.

The empty and load train brake is described, and some data on the comparative efficiency of this type of equipment are given from a paper before the St. Louis Railway Club.

Vickers-Ferranti, Brown-Boveri and Lovekin methods of turbine blade fastenings are compared.

Air Engineering

The Value of the Experimental Fan in the Mining Laboratory, David E. Thomas

The object of the paper is to call attention to the value of the experimental fan installation in a mining laboratory, and in general to indicate the nature of the work which can be successfully carried out in mining schools and the possible economic value of this work in mining engineering.

In setting up a mine fan for purely experimental work it is obvious that a reproduction of the conditions of the actual mine is practically impossible, but the construction of lengthy ducts may be obviated by using an orifice in a thin plate to represent the resistances of the mine.

The installation described (Gamble Institute, St. Helens Mining School) consists of a Keith single inlet type fan with a runner 12½ in. in diameter driven by a continuous-current 220 volt motor on the same shaft, with a regulator giving a speed variation from 870 to 1600 r.p.m. The article fully describes the particulars of the installation and methods of obtaining the various quantities such as quantity of air passing, maximum static water gage, etc., and indicates some of the results obtained with the experimental fan. The data presented in the paper show the value of the experimental fan. Among other things, the determination of the coefficient of the *vena contracta* shows the importance of the Murgue and Rateau formulae, particularly in their application to finding the value of the area of a regulator in the mine.

The value of the coefficient of the *vena contracta* is much higher than the generally accepted value 0.65. It may be possible that this value is a little higher than would be obtained in the ordinary mine, owing to the comparatively high velocity of the air in the fan duct of the experimental fan; still, there is no evidence in the experiments on this fan which confirm such a conclusion, and the writer is of the opinion that the value of the coefficient would be more correctly expressed by the value 0.70. The general acceptance of this value would, besides simplifying calculations, result in a closer agreement between the formulae of Murgue and Rateau. The discrepancy already noted between the theoretical deductions and the practical results recorded in the experiments on the water gage obtained with varying inlets, the fan speed remaining constant, is worthy of closer investigation. (*Transactions of the Institution of Mining Engineers,* vol. 50, part 3, February 1916, p. 482, 18 pp., 3 figs. *d.*)

The Flow of Air Through Nozzles, Captain Thomas B. Morley

The paper describes experiments the primary object of which was to compare various forms of nozzles with regard to their effectiveness for the production of jets of air having as high a mean velocity as possible. These data made possible a comparison of the discharge and the velocity attained with those calculated from the ordinary theory in which reversible adiabatic expansion is assumed. This investigation was further extended to cover the nature of the impact produced by a jet upon a flat plate, and its relationship to the reaction of the jet. The article describes in detail the nozzles tested. There were six of them. The features the influence of which was investigated were the entrance curves, the rate of divergence after the throat, and the length. The following measurements are described in detail: Measurement of discharge and discharge coefficient, measurement of velocity, the impact apparatus, reaction apparatus, the calculation of velocity, and accuracy of impact reaction and velocity results.

It has been found that nozzles with a larger inlet curve give a higher velocity. Nozzles with a rapid taper are much less effective than those in which the taper is gradual. In the case of some of the nozzles good results were obtained with a length of 1.2 and 0.6 in. respectively, but experiments show that the best results are obtained when the nozzles are even shorter than these lengths; also the comparative efficiency of the nozzles over a very considerable range of pressure seems to be independent of the pressure. Considering the absolute values of the velocities obtained with the best nozzle forms, it has been found that those based upon the reactions are practically equal to the theoretical values, while the impact experiments lead to figures some 12 per cent higher. The efficiency of the best nozzle forms is practically unity. The author comes to the following conclusions as to the flow of air through nozzles and orifices.

In the flow of air through an orifice, it is evident that a *vena contracta* exists, the size of which depends upon the pressure of the air supply, so that the discharge coefficient is variable, increasing as the pressure increases.

A convergent nozzle with a rounded inlet may have a discharge coefficient of 0.98 if it is short; and, so long as there is no sharp change of curvature, alterations in the form of the entrance curve have very little effect upon the coefficient. The addition of a divergent part after the throat slightly reduces the coefficient unless the taper is very gradual.

The efficiency of nozzles and orifices, as measured by the mean velocity of the jet produced, is very high indeed, becoming practically unity if they are of the proper form. For pressures up to 50 lb. per square inch, orifices and convergent nozzles are practically equally good. It may be remarked that Rosenhain found that in the case of steam up to 80 lb. per square inch an orifice was better than a nozzle.

While the addition of a short and very gradually divergent part to a nozzle may slightly improve its efficiency, it appears that in general, and within the pressure limits of the experiments, a divergent part added to an air-nozzle is not an advantage, and if such a part has more than a gradual taper, it reduces the efficiency of the nozzle very seriously.

The effect of extra length is not so deleterious as that of a rapid rate of divergence. In the case of divergent nozzles, an entrance curve of about 0.5 in. radius gives an appreciably higher efficiency than one of 0.1 in. radius.

As regards the impact and reaction of jets the author believes that there are two points that call for explanation, when the reactions of the air jets with the forces recorded on a flat plate placed normally to the jets are compared, namely, the variation of the impact with the position of the plate and the relationship between the true momentum per second of the jet and the reaction and impact results.

The paper describes the methods of carrying on the tests and to a certain extent the theory of the impact and reaction action of the jets. The tests showed the expansion of the air is complete at or extremely near to the exit from the nozzle and that while the impact changes considerably between points at distances varying from 2 to 14 in. from the nozzle, the pressure between these points remains nearly constant. The variation of the impact is not therefore due to changes of pressure with corresponding velocity changes in the free jet.

Further experiments carried out by displacing the pressure tube from the axis showed that the smallest perceptible effect on the water gage was indicated at a radius of 0.75 in. at 1.5 in. from the nozzle, and this radius increases in accordance with an approximately parabolic law up to 2.5 in. at 20 in. from the nozzle. These observations, though rough, are in

tolerable agreement with the conclusions of Parenty and others that the jet is a paraboloid in form. Further experiments with a Pitot tube placed in the axis of the jet at various distances from the nozzle have confirmed this conclusion, that the jet is paraboloidal in form and have indicated that the cross-section of the jet is about proportional to the distance along the axis. It is worthy of notice that when the Pitot tube was just at the exit from the nozzle the pressure recorded by the gage to which it was connected was equal to that in the reservoir. This confirms the conclusion previously reached that the efficiency of the nozzle is practically unity.

The parabolic form of the jet has a bearing upon an hypothesis propounded by the author. He believes that an "energy system" of circulating air is set up round about the jet, the external air flowing in nearly normally to the jet until it comes near the boundary of the jet, when it is rapidly accelerated, and, flowing along with the jet, is deflected with it at the impact plate. The remainder of the path of the circulating air is completed in the atmosphere. The "energy system" derives the energy required to initiate it during the establishment of the jet when the flow is first started, but once set up it makes a very small energy demand upon the jet. Hence the induced air derives but little of its momentum at the expense of the original jet with the result that the momentum of the total air deflected by the impact plate is augmented.

While a complete mathematical expression for the system of stream lines set up together with the effect of frictional losses and the consequent effect of the impact plate seems to be impossible, the author gives an expression for the total added momentum per second at any point neglecting friction, as follows:

$$M' = \int -Kx - \frac{3}{2} dx = C - \frac{D}{\sqrt{x}}$$

Where x represents the distance measured along the axis outwards from the nozzle and k a coefficient. M' increases as x increases but its rate of increase, while remaining positive, decreases. On the above hypothesis the observed impact should approach the value M of the true impact of the original jet (the momentum per second of the jet as it leaves the nozzle) as x decreases. As there seems to be no reason why the reaction of the jet should not represent the true value of M, this means that as the plate opproaches the nozzle, the impact should approach the value of the reaction. Among other things, the writer calls attention to the fact that in view of the high efficiency with which the expansion of air in nozzles may be carried out, and the advantages in many circumstances of the turbine over the reciprocating motor, there appears to be a field in which, where power is transmitted by compressed air, the reciprocating motor might with advantage be replaced by an air turbine. (*Journal of the Institution of Mechanical Engineers*, Nos. 2, 3, February and March 1916, pp. 51 and 93, 70 pp., 32 figs. *etA.*)

Engineering Materials

Influence of Heat Treatment on Certain Physical Properties of Steel, A. Pomp

The article presents data on tests, the purpose of which have been to establish the influence of heat treatment on the various physical properties of iron having a low content of carbon. These investigations covered, *first*, material heated and slowly cooled; *second*, heated and immersed rapidly in cold water; and *third*, overheated and regenerated material.

In order to test the homogeneity of the material as it was before the beginning of the test, a number of test pieces were subjected to microscopic investigations with respect to segregation of sulphur, phosphorous and carbon, and it was found that the material was entirely free from segregation phenomena.

The article reports data previously obtained in the same connection by Heyn, and describes in detail the methods of testing used in the present instance. In the series of tests with heated and slowly cooled material, the heat treatment was

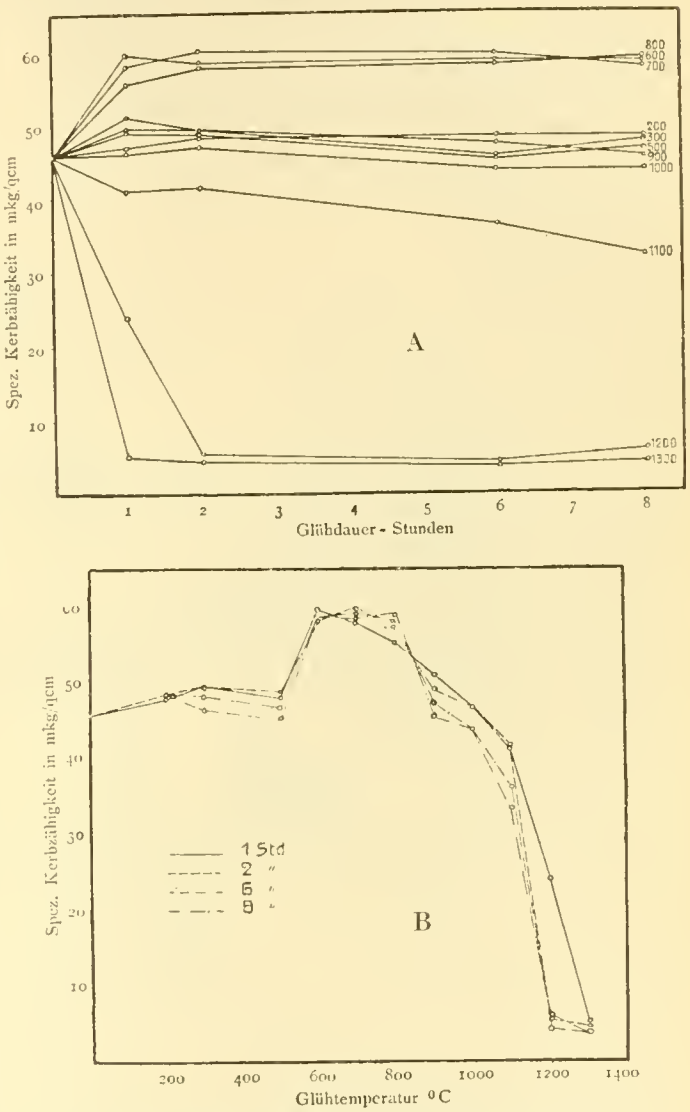


Fig. 1 A, Relation between Tenacity and Heat Treatment; B, Relation between Tenacity and Temperature of Heating

(Ordinates: specific tenacity under shock in mkg/qcm: 1mkg/qcm = 46.58 ft.-lb. per sq. in.; abscissae: temperature of heating in deg. cent.; in B, *Std.* = hours)

carried out in the following manner: Eight test bars were placed in a cold muffle and heated to the desired temperature, which took, in accordance with the temperature desired, from 15 to 45 minutes. The final temperature was then maintained constant for a period of 8 hours. At the end of the first hour two test pieces were taken out from the furnace and slowly cooled in infusorial earth. At the end of the second hour, two more pieces were taken out, likewise at the end of the sixth and eighth hours, and all cooled in infusorial earth down to room temperature. The complete cooling took up to twelve hours.

The data obtained in the notch-shock tests are presented in the original article in the form of tables and graphical curves. Only the latter are here reproduced. Fig. 1A shows that the

tenacity under shock varies quite widely as a result of heat treatment. These variations become particularly noticeable during the first two hours of heating, as one can see from the sharp fall of the curve between "zero" and "two" hours. The minimum variation is produced by heating at 1000 deg. cent., while the fall of tenacity is very sharp for 1200 and 1300 deg. cent.

At first glance it might appear as if after a certain period of heating, say one to two hours, there is established some sort of a state of equilibrium which would explain the nearly horizontal course of some of the curves. This assumption is, however, contradicted by the way the curves for 900, 7000 and 1100 deg. cent. run, since with an increase in duration of heating there appears to be a continuation of the fall of tenacity. As a rule the heat treatment produces either an increase or a decrease of tenacity under shock. An increase may be expected at all temperatures under 1000 and a decrease at those above 1000 deg. cent.

When heat treatment produces an increase in tenacity under shock, the maximum value of the latter, characteristic for the given temperature, is reached after one, or at most, after two hours of heating. In the case of heating at temperatures above 1000 deg., there is a continuous decrease of tenacity beginning with the start of heating and increasing with the duration of heating, and this decrease of tenacity occurs more rapidly the higher the temperature of heating is. A separate series of tests were carried out in this connection running the duration of heating up to 30 hours, and these tests fully confirm the above conclusion.

Fig. B shows the relation between tenacity under shock and the temperature of heating. The fully drawn lines correspond to a duration of heating of one hour, the broken lines to that of two hours, the dash lines to a duration of six hours, and those broken in by two points to a duration of eight hours. If one considers the four curves as a whole, one can see that the lines rise slightly from zero to 300 deg. cent., then from 300 to 500 deg. there is a slight decrease of tenacity under shock. From the minimum reached at 500 deg. cent., there is a strong rise of the bundle of curves until at temperatures varying from 600 to 800 deg., a maximum of tenacity is reached, after which there is a rapid fall beginning at 800 to 900 deg. cent., and a new minimum is reached at about 1200 deg. cent. These data do not materially differ from those previously obtained by Heyn.

As regards the variation in the dimension of the granular structure, it was found that when iron with a low content of carbon is heated at temperatures from zero to 1100 deg. cent., the increase in the duration of heating produces a slight growth in the ferrite crystals. At temperatures above 1100 deg. cent., the crystals materially increase with increase of temperature and duration of heating. At the same time, the formerly uniform ferrite polygons change at temperatures above 1100 deg. cent. into structural forms with rough edges and irregular surfaces. (*Einfluss der Wärmebehandlung auf die Kerbzähigkeit, Korngrösse und Härte von kohlenstoffarmem Flusseisen,* A. Pomp, *Ferrum,* vol. 13, No. 4, p. 49, January, 1916, article not finished. *e.*)

Influence of Thickness on Tensile Tests, G. B. Waterhouse

Data of an investigation showing how variations in thickness affect the static properties of open-hearth and Bessemer plate. The work described was carried out in connection with some comprehensive tests on steel plates, and throws some light on the influence of thickness on the results of tensile tests, besides giving comparative results on basic open-hearth and acid Bessemer steel. A brief review of previous literature on this subject is given.

The work done by the writer was on the material known as sheet bar, 8 in. wide and of various thicknesses. The results are given in tables and figures.

The results on the open-hearth steel agree in general with previous conclusions. The ultimate stress decreases as the thickness increases up to about 0.6 in., but after that it is practically uniform and does not show the steady decrease that might be expected from Webster's table. The curve for the elastic limit descends at about the same rate of speed as the ultimate stress, as the thickness increases, but when about 0.6 in. is reached, instead of remaining constant, it steadily descends as the thickness rises. The elongation remains practically constant for all the thicknesses tested, but the reduction of area after remaining comparatively uniform until about 0.6 in. is reached, then descends somewhat rapidly as the thickness increases.

The results on the ordinary Bessemer steel are quite different. The ultimate stress decreases somewhat as the thickness increases, but the decrease is very slight. This is also true of the elastic limit, but here the influence of the thickness is a little more marked. The reduction of area is practically constant until a thickness of about 0.55 in. is reached, and then sinks as the thickness increases.

These results on the Bessemer steel are confirmed by tests made on steel slightly higher in carbon.

On the whole it has been found that acid Bessemer steel is noticeably "stiffer" than basic open-hearth. Further, this comparison brings out clearly the comparatively small effect of the increase in thickness on the tenacity of the Bessemer steel. Some other factor evidently has a greater influence on this property than the change in gage, and this factor may probably be the residual phosphorus of the Bessemer steel. (*The Iron Age,* vol. 97, no. 15, p. 896, April 13, 1916, 3 pp., 3 figs. *e.*)

Peculiar Appearance of Some Sawn Bars

An article showing micro-photographs of a sample of sawn steel bars.

Three illustrations are given, one showing wavy lines appearing as slight irregular ridges in the surface. The bar in question was 3½ in. in diameter, and the sample was cut by a power hacksaw with reciprocating blade. The peculiar markings appear on both sides of the sample and are so located that all centers appear to be on a common plane.

The editor sent it to several metallurgists and chemists and, in addition to the editorial proper, reproduces their answers. The consensus of opinion is that these markings had nothing to do with either the composition or heat treatment of the steel, but were produced by the forces acting on the metal during the process of power sawing.

A power driven hacksaw when in operation is subjected to several forces. One is a force bearing down, while the other principal one is a horizontal or pulling force in the direction of the blade travel. These two forces tend to set up vibrations in the saw blade. There is also some lateral motion of the machine itself introducing a third component in the vibration while the teeth are constantly wearing thinner through abrasion. The combined efforts of these forces would tend to keep the cutting blade bent into a series of corrugations resulting in the oval markings on the specimen under consideration.

Geo. O. Loeffler states that he sawed a piece of shrapnel

bar on a small machine which gave a smooth cut and the waves showed quite clearly and uniformly. He also noticed that the areas intersected at the top and bottom of the bar or at right angles to the blade. He then gave the bar a half turn and made another cut and found the same condition. (*The Blast Furnace and Steel Plant*, April 1916, p. 157, 3 pp., 5 figs. *dt.*)

Fuel and Firing

Powdered Coal in the Open-Hearth Furnace

A report of a paper read by C. J. Gadd, Chief Engineer of the American Iron & Steel Manufacturing Company, on April 6, before The Franklin Institute of Philadelphia.

3. By reason of their high radiating capacity, the infinite number of minute incandescent particles in the powdered coal communicate the heat by radiation, and not by convection, thus eliminating the necessity of bringing the surrounding air to the temperature of the coal particles;
4. All the heat in the waste gases is conserved and used in the production of steam.

The extra fuel consumed, due to the use of cold air, is offset by:

1. The elimination of all loss in the gas producer process;
2. The elimination of all loss due to frequent reversals;
3. The elimination of all loss in waste heat taken up by the regenerative chambers;

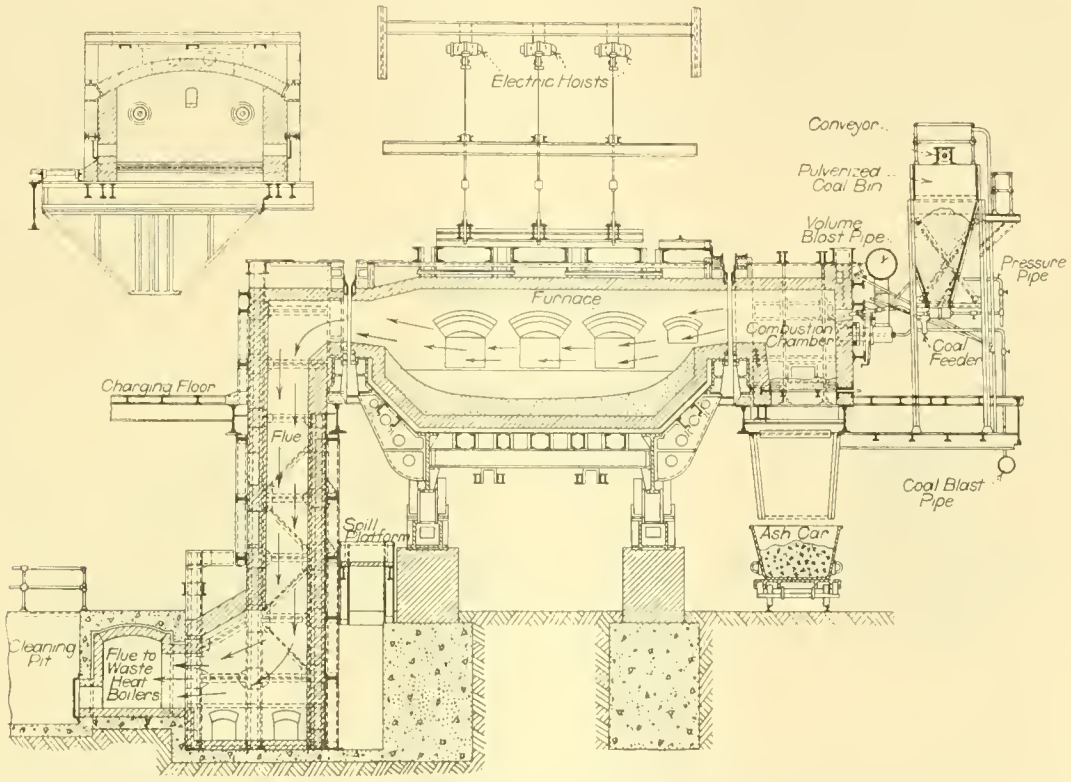


Fig. 2 A, Open-Hearth Furnace Heated by Powdered Coal

The author recounted briefly the experiments with different forms of burners applied to open-hearth furnaces and showed the cross section of an open-hearth furnace fired at one end and operated without generators (Fig. 2A). With this furnace is connected an interesting arrangement of waste-heat apparatus, involving two steam boilers and an economizer, both arranged so that they can be by-passed when necessary for repairs, so as not to shut down the furnace plant. Other applications of powdered coal burning in iron metallurgy were shown. The installation represents a somewhat radical departure from the old time theories of open-hearth furnace practice. The burners are arranged at only one end of the furnace and the path of the flame is always in one direction. The theory underlying this method of applying powdered coal in the open-hearth furnace is given by the author as follows:

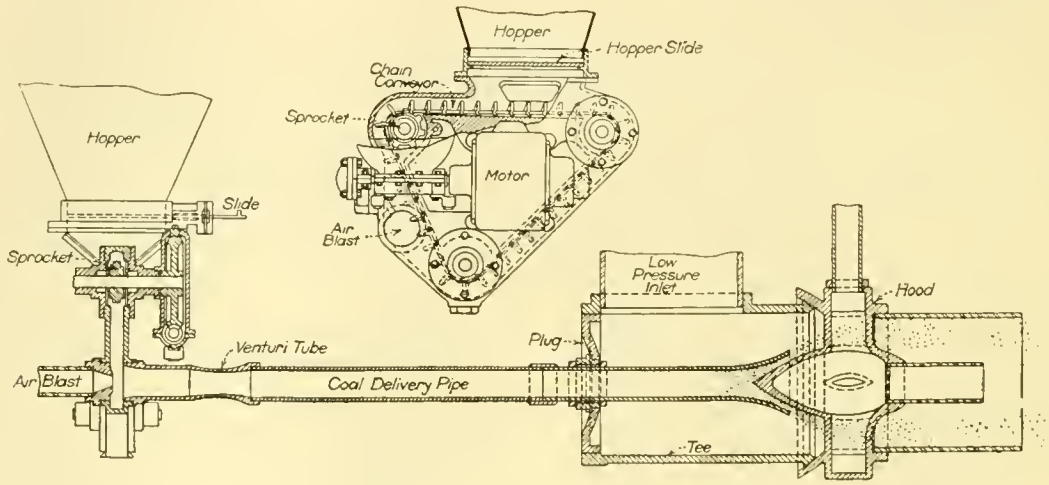
1. The fuel is burned above the bath, and all the heat contained in the coal is instantly developed in the furnace;
2. As the path of the flame is in one direction all parts of the furnace are maintained at the same temperature;
4. The elimination of the expensive maintenance cost of producer plant and regenerative chambers;
5. The greatly reduced first cost of installation.

The article describes in detail the methods of distributing and storing powdered coal and the methods of preparation of the fuel. In the latter connection the author calls attention to the fact that it is easier to dry coal to one half per cent moisture or less than it is to maintain it in this state. He explains it as follows:

The moisture driven off from the coal in the process of drying saturates the hot air contained in the dryer cylinder. In this highly saturated condition the air follows the dried coal through the dust-proof conveying system to the enclosed storage bin. As the coal and air cool, moisture is precipitated and the volume of the air diminished with the result that more warm saturated air is drawn from the dryer. The precipitation of moisture resulting from the cooling process of the coal and air may be almost entirely overcome by placing ventilating shafts on the storage bin and the high points of the con-

veying system connected with the outside air. However, in the process of drying through the medium of heat a small quantity of the expelled moisture will find its way back in the coal after cooling, and for this reason it is good practice to gage the dryer so that the resultant product leaving the dryer will contain less than one half per cent of moisture.

One of the most interesting parts of the paper is that concerned with the burners. Fig. B shows a low pressure powdered coal burner with its feeding apparatus. An endless flight conveyor chain is used for feeding a stream of powdered coal in a continuous shower across the air blast ports. The excess fuel is automatically returned to the hopper by the endless flight conveyor chain. The air blast inlet nozzle connected with one side of the feeder case is reduced, the outlet side being flared, beyond which is a venturi tube used to induce higher velocity of the mixture leaving the feeder, thereby causing a slight vacuum or pull throughout the case. The cone extension on the hood of the burner enters the flared end of the coal delivery pipe, breaking the solid shaft of coal and air and deflecting it around the inner periphery of the burner pipe. The mixture takes the form of a hollow ring, in the center of which an auxiliary blast is discharged giving a thorough atomization of the fuel particles as they enter the furnace.



B, Low-Pressure Powdered Coal Burner

Sectional elevations of mechanically operated high pressure powdered coal feeding apparatus are likewise given. Feeders and burners of the high pressure type produce a long flame through progressive combustion and can only be used where the form of the furnace and the character of the work demand that an elongated cutting flame be developed in close proximity to the work done. This method of application is adapted to open-hearth furnace practice. In the type of feeders and burners described, the results obtained are equally good whether the powdered coal is injected into the furnace from the burners at a velocity of 1500 ft. per minute, or of 25,000 ft. per minute.

The author puts the personal equation forward as the important factor in the operating part of the apparatus as developed thus far. In fact, he says that it is necessary to depend too greatly upon this uncertain element. In the drying process the operator may at any moment upset the complete equilibrium of a plant either by overheating the coal or by not drying it enough. In the furnace operation three or four separate adjustments are required depending on the burner used, each adjustment bearing a fixed relation to the others. These adjustments are the control of the coal feed, the control of the coal blast, the control of the volume blast and the control of the furnace draft where mechanically operated by low pressure feeders and burners are employed. (*The Iron Age*, vol. 97, no. 15, p. 890, April 13, 1916, 6 pp., 9 figs. *dA.*)

A Test of a Surface Combustion Furnace, E. Schramm and J. R. Cain

Description of some tests made on a surface combustion furnace to determine its performance and best conditions of operation.

The article fully describes and illustrates the methods of testing. The furnace was operated without a charge. A cover was placed so as to almost close the top of the muffle, thus reproducing normal operating conditions and avoiding loss by radiation from the incandescent bed. In a preliminary run it was established that at high temperatures the furnace reaches steady conditions after about half an hour run. The same tests have shown that a temperature of about 1650 deg. cent. (3000 deg. fahr.), was reached in a little over half an hour and maintained for ten minutes with a gas consumption of 3 cu. ft. per minute. It has been further found that the rate of cooling of the furnace is very slow because of the heat storage of the incandescent bed and the efficient insulation of the walls, a property which makes this type of furnace convenient for certain laboratory operations.

A curve is plotted with the ratio of air to gas in the mixture against the percentage of oxygen in the flue gases. This curve, together with the flue-gas analyses given in the article, established that a ratio of air to gas of 5.5 gives most nearly the ideal conditions of perfect combustion without any excess of oxygen, and this ratio gives also the highest temperature for any given gas consumption. From comparison of data of gas consumption for mixtures in the ratios 5.5 and 6.5 it has been found that a 20 per cent excess of air causes a lowering of furnace temperature of about 100 deg. cent. (180 deg. fahr.)

The highest furnace temperature reached during the tests described was 1675 deg. cent. (3045 deg. fahr.), but the temperature of the porous mass must have been considerably higher. It should, however, be pointed out that the refractories ordinarily obtainable will not permit the operation of a furnace above, or indeed, for any length of time, as high, as 1650 deg. cent. (*The Journal of Industrial and Engineering Chemistry*, vol. 8, no. 4, p. 361, April, 1916, 5 pp., 6 figs. *e.*)

Heating

Loss of Heat in Hot-Blast Mains, R. J. Wysor

In making efficiency tests on the hot blast stove at the Bethlehem Steel Company's plant, the author found a marked difference in temperature as indicated by a pyrometer inserted near a stove on blast and the regular recording instruments situated near the bustle pipe. Hence a special hole was provided at the junction of the hot-blast main and the bustle pipe and portable pyrometers with bare fire ends were used, both at this point and in the stove necks. Similar experimental work has been also done by H. A. Brassert, superintendent of blast furnaces, South Works, Illinois Steel Co., who found temperature drops of the same order of magnitude.

In the course of this investigation, the author determined the average thermal loss due to cooling water from each hot-blast valve with an average blast temperature of 1360 deg. fahr. and a volume of about 33,000 cu. ft. free air per minute under standard conditions, to be approximately 10,000 B.t.u. per minute. The general conclusions arrived at by the author are as follows:

First.—Between the stoves and the blast furnace there is a very marked drop in the temperature of the hot-blast, which is not only serious as to temperature, but signifies also a thermal loss. It is affected by many variables, such as size and length of hot-blast mains and connections, thickness of fire brick linings, volume and initial temperature of air passing per unit of time, temperature and wind velocity of the outside air, extent of water cooling, etc. It is probable that, at a great many furnace plants in the country, these losses are of sufficient magnitude to justify an attempt at their reduction. The present tendency is toward higher blast heats on furnaces carrying large percentages of Mesabi ores in their mixtures; and high heats have always been desirable in smelting hard, coarse ores, such as the magnetites so generally used in the east. In the manufacture of spiegel and ferromanganese, the maintenance of high blast temperatures is of particular importance. This is particularly important in all plants where economy in the use of blast furnace gas must be practiced, owing to large consumption in gas engines or under boilers.

Second.—Insufficient insulation in the hot-blast main is the cause of serious temperature and heat losses. It seems logical and practicable to prevent a large percentage of these losses by means of one of the methods of insulation suggested in this paper. With such insulation, other operating conditions being normal, we would expect higher available blast heats with resulting fuel economy, or a smaller quantity of fuel gas necessary for heating the stoves. It is believed that blast-furnace managers and superintendents generally will be interested in a study of better insulation of the hot-blast main and stoves. (*The Iron Trade Review*, vol. 58, no. 8, p. 435, February 24, 1916, 4 pp., 4 figs. *e.*)

Hydraulics

Leakage from Lead Joints in Cast-Iron Water Pipes, Arthur H. Smith

Discussion of the leakage from water pipes in city mains and their connections.

The leakage losses from a water works system may be due to the following three causes: (*a*) Leaking of underground mains; (*b*) broken or abandoned service pipes; (*c*) defective plumbing fixtures. It is of interest to note that the amount of leakage due to all causes combined is usually surprisingly high. The general experience of water works men who have studied this particular phase of leakage seems to be that from 30 to 40 per cent of the total supply which enters the system is unaccounted for, that is, only 60 to 70 per cent is delivered for legitimate purposes, the rest being lost as leakage.

A test for leakage has been conducted on a small new public water works system at Medway, Mass. There the sources of supply are driven wells from which water is pumped through the distribution system to a stand pipe 30 ft in diameter by 80 ft. high whose capacity per foot in height is thus 5288 gal. The distribution system is made up of cast iron pipes 6 in. to 12 in. in diameter, class E. New England Water Works Association specifications. The lead in the 6 in. sockets is 2 in. deep and in the 8 in., 10 in., and 12 in. sockets, 2½ in. deep.

At the time of the test the system had been entirely completed with the exception of service connections, none of which had been put in. With the stand pipe filled and with pumps stopped, the observation for leakage was made for a 24 hr. period by simply noting the rate of lowering of the water level. A careful inspection of the entire route of the pipes revealed no evidence of much leakage and it is believed that practically all was at lead joints.

The total loss in 24 hours was found to be 22,400 gal., which with proper corrections showed a net loss in the underground mains of 20,800 gal. or 1.58 gal. per day per linear foot of lead joint. The possible errors in determination ought not to exceed 5 per cent. These results are fairly representative for the size of pipe and class of work.

So long as pipe lines are built in the present manner, leakage must be reckoned with. In the endeavor to reduce it to a minimum, two general lines of action are possible: *first*, the substitution of some more satisfactory material than lead, and *second*, an improvement in the design and construction of the lead joint. The author believes that if leakage on new work can be limited to *one* gallon per day per foot of joint under 100 lb. pressure, the performance can be called good and acceptable. (*Journal of the New England Water Works Association*, vol. 30, no. 1, p. 1, March 1916, 19 pp. *pe.*)

VALVES FOR USE IN WATER WORKS

Reasons for Adopting the Solid-Wedge Type of Valve in the Boston Water Department, George H. Finneran

Discussion of the solid-wedge type of valve for use in water works.

The Boston Water Department manufactures its own gates, hydrants, bronze fittings, etc. In determining what type of valve to adopt it decided in favor of the solid-wedge type as compared with the loose double disc, because 67 years of experience has developed no convincing reasons why the solid wedge type should be discontinued.

In considering the merits of the respective types, the engineers of the Water Department were impressed by the fact that there is practically but one seat to a valve in operation and that is the seat opposite to the side on which the pressure acts; hence the superfluousness of the second disc in the double seating plug of the expansion type. Further the engineers took into consideration the uncertainty of the double-disc type of valve in overcoming rust and other solid matter that is generally encountered between the seats of valves infrequently operated, as against the ability to dislodge with the solid-wedge an amount of such matter sufficient to allow of tight closing valve by manipulating, that is, raising and lowering the wedge and crushing and washing out the obstructing material. The horizontal movement of the expanding disc is more apt to

drive the matter against the seats with such force as to adhere and prevent tight closing.

As a point against double-disc valves, also, the opportunity was considered for rust or other matter to accumulate between the discs and adhere to the various knuckles, hinges, wedges, trunnions, etc., of the operating mechanism, clogging them and interfering with their action. In waters of heavy lime content or those with corrosive constituent, the effect would tend practically to put the valve out of commission. Generally in a large city where a gate is frequently operated by unskilled and indifferent men, a plain rugged type of valve is almost a necessity.

Reasons for Using the Double-Disc Type of Valve, J. M. Diven

This paper presents reasons in favor of the double-disc type of valve although the author states that he had no recent experience with solid-wedge valves but has used the double or parallel disc type of valve.

He gives a brief history of valves, starting from the solid wedge type imported from England in the early days of water works construction. The next was the Peet valve, a taper seat type, of the wedge principle. Various devices have been contrived for expanding the discs to their seats, but the writer believes that while the discs are free to adjust themselves to their seats there should be as little lost motion as possible between the discs and seats so that when operated, the discs are in practical contact with the seats, thus shearing off an accumulation of rust, sediment, or foreign substance.

An objection to the solid-wedge type is the fact that the gates always seat in the same place and when foreign substance is trapped between the gate and the seats, the seats would become so damaged that the gate would leak. In parallel-seated or double-disc valves, the gates do not seat twice in exactly the same place. Therefore, should solid matter be caught between the gate and the seats, the marring will not cause serious damage as the dent in the disc will not come opposite the corresponding one in the seat and the compensating feature of the parallel seat valve permitting a certain amount of give, takes care of some irregularities in the contact parts. (*Journal of the New England Water Works Association*, vol. 30, no. 1, pp. 101 and 106, March 1916, 18 pp. and 1 fig. *dcp.*)

Internal Combustion Engineering

Kline Rotary Valve

Description of a new rotary valve construction patented by H. J. Kline.

By using an automatic auxiliary exhaust valve in conjunction with the main or rotary valve, the former, controlled by the piston, may be so designed that it will carry away a large part of the heat of the exhaust. At light loads when the throttle is only slightly open, the exhaust pressures within the cylinder are such that the automatic valve is supposed to barely lift, but at full loads where the exhaust pressure is very high, the valve should be forced wide open to carry away at the lower end of the cylinder, the larger part of the exhaust gases and consequently the major portion of the heat.

A further problem is created by the necessity of securing a proper fit of the valve and to maintain a gas-tight joint after some wear has occurred. The Kline valve rotates toward the cylinder so that when pressure is applied by way of the ports leading to the combustion chamber the valve will be placed against the opposite side of the casing.

The packing is used only as a safeguard. The packing rings do not revolve with the valve but creep slowly around, due to the cylinder pressure forcing them against the sides of the grooves in the valve. It is claimed that this creeping action will slowly wear the ends of the packing strip so that it will gradually settle as the valve wears and will still continue to keep this point sufficiently tight. (*The Automobile*, vol. 34, no. 11, p. 500, March 16, 1916, 1 p., *d.*)

The Frederickson Engine

Description of a two-stroke cycle aeronautical engine. By means of an oscillating base valve operated by the connecting rod the engine practically does away with crank case compression. The operating principle is as follows:

Gas from the carburetor or mixer enters the crank case. At the inner dead center of the piston, the valve between the crank case and inner half of the cylinder is opened; during the outward stroke of the piston, gas from the crank case is drawn through this valve into the inner half of the cylinder and at the outer dead center the valve is closed. This valve is operated entirely by the side motion of the connecting rod. There are no gears, eccentrics, chains or cams.

During the inward stroke of the piston the gas in the inner half of the cylinder is compressed until the piston nears the end of its stroke, when the compressed gas is released into the combustion chamber, forcing out the burnt gas from the previous explosion through an exhaust valve or port, the opening and closing of which is so arranged that while practically all the burned gas is expelled, all of the unburned is retained. The piston on its outward stroke compresses this gas in the combustion chamber, at the same time drawing another charge of gas from the crank case into the inner half of the cylinder, which in this case forms the primary or low compression chamber. Near the outer dead center, the gas in the combustion is ignited, forcing the piston toward the center.

No data as to tests or performances of this engnie, or speed and power output are given. The article is illustrated by two section diagrams and a view of the engine as installed on an aeroplane. (*Aerial Age Weekly*, vol. 3, no. 4, p. 120, April 19, 1916, 2 pp., 3 figs, *d.*)

A Gas Turbine

Some information concerning the work done at the plant of the Brown-Boveri Co. in Baden. According to the article recent correspondence indicates that their work on the gas turbine has finally been brought to a state of practical working efficiency. The turbine is designed and operated on the impulse principle. (*The Gas Engine*, vol. 18, no. 4, p. 191, April, 1916, 1 p. *gd.*)

The Detroit Gas Turbine

Some data concerning a gas turbine said to be built in Detroit, Mich. According to the article it consists of a gas compressor with eight compressing cylinders for supplying the compressed gas to the firing chambers. Each cylinder supplies complete charge at each revolution in all eight impulses at each turn of the driving shaft. Since the speed of this driving shaft will ordinarily be 3000 r.p.m., this will mean approximately 24,000 explosions per minute upon a 23 in. rotor; each explosion or impulse directs its energy upon 7.75 sq. in. of rotor surface at a constant pressure of about 115 lb. per sq. in. No precise data of the construction or of tests are given in the article. It is only stated that the 200 h.p. turbine will weigh 345 lb. complete and that at present time it is proposed to furnish only three models, of 100, 200 and 300 h.p. units. (*The Gas Engine*, vol. 18, no. 4, p. 193, April, 1916, 2 pp. 2 figs. *d.*)

The editor has secured a catalogue of the corporation handling these turbines and this catalogue describes the operation of the turbine in the following manner (Fig. 3).

As the compressor piston moves downward the gas is drawn into the compressor cylinder and as it starts to move upward the gas is passed into the firing chamber of the follower valve. This action is controlled by the ports and passages.

As the compressor piston moves downward, the follower valve moves upward until the intake port comes opposite the cylinder port. The follower valve has moved upward to its highest position while the compressor piston is moving to its lowest point of travel. As the compressor piston commences its upward movement the follower valve is moved down until the top edge of the gas transfer port is in the same plane with the cylinder port.

When the compressor piston has reached its highest point of travel the follower valve moves upward, carrying the compressed charge of gas in the firing chamber at a pressure of about 90 pounds per square inch.

As the follower valve moves upward, the gas transfer port

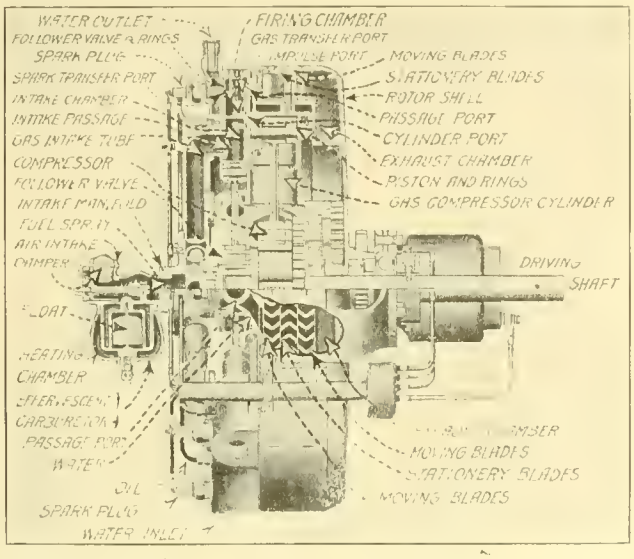


Fig. 3 Detroit Gas Turbine

and cylinder port are closed to each other and at a predetermined distance of the impulse port below the passage port the ignition of the charge of gas takes place by directing an electrical spark through the spark transfer port. At the moment of complete combustion and when the exploding gas has reached its point of greatest expansion, the impulse port is opened instantly directly opposite the passage port and the charge is directed through the channel and nozzles onto the first row of moving blades.

As the gas is driven at high pressure upon the first row of moving blades, their form is such that they absorb and transmit a large percentage of the power to the rotor, while the gas is deflected to another set of stationary blades which in turn directs the still expanding gases upon the second row of moving blades, also attached to the rotor and moving in the same direction as the first.

The catalogue gives the following principal dimensions for a 100 h.p. turbine: Diameter of rotor, 22 in.; weight complete, 286 lb.; speed of rotor limited to 12,000 r.p.m.; permissible speed of driving shaft, 4000 r.p.m.; mean effective pressure of exploding gas on rotor vanes, 115 lb. per sq. in.

The catalogue of the company does not make any mention of any tests of the turbine and does not state whether any have been so far practically used.

The Composition of the Exhaust from Liquid-Fuel Engines, Robert W. Fenning

The paper has a two-fold object: *first*, to describe a method of constructing exhaust-gas charts for suitable fuels *without the use of an engine* and to set forth the results of numerous experiments relating thereto; and *second*, to increase the evidence as to the composition of exhaust gases, especially with reference to the combustible products obtained when using strong mixtures. In the course of the investigation several exhaust-gas charts have been prepared.

The author gives the name *exhaust-gas chart* to the set of curves obtained by plotting on a strength-of-mixture base the percentages of carbon dioxide (CO_2), cabon monoxide (CO), and oxygen (O_2) in the exhaust gases, the strength of the mixture being expressed as the ratio of air to fuel by weight. The author did not use an actual engine in the majority of his experiments which consisted mainly in the preparation of mixtures of air and vaporized fuel in known proportions, the explosion of some of the mixture in a small explosion vessel, and the complete analysis of the resulting products of the combustion. Exhaust samples were, however, also taken from an engine fitted with Dr. Watson's apparatus for measuring air and fuel, and these samples were analyzed. Comparisons

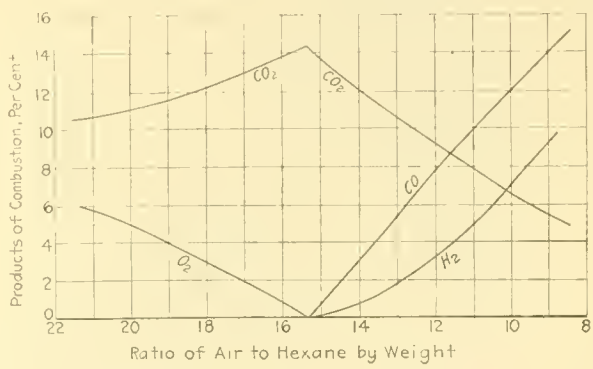


Fig. 1 Hexane "Exhaust-Gas Chart" Explosion-Vessel Tests

were then made between the composition of the products of combustion resulting from explosions in a small explosion vessel and in an actual engine.

The fuels used were hexane (C_6H_{14}), benzene (C_6H_6), gasoline and commercial benzol. The article fully describes the methods of preparation of air-fuel mixture, explosion of mixture, and analysis of products of combustion, as well as gives a general discussion of results. A sample of an exhaust-gas chart from explosion vessel tests on hexane is given in Fig. 1. The conclusions from the experiments above referred to are expressed by the author as follows:

a With volatile fuels there is but little difference in the composition of the products of combustion resulting from air-fuel mixtures in a small explosion-vessel or in an engine cylinder, in spite of the conditions being so dissimilar. In fact, the agreement between the CO_2, O_2, and CO values in engine and explosion-vessel tests is so close that an exhaust-gas chart prepared from explosion-vessel tests can be used to estimate the strength of mixture supplied to an engine.

b A very small quantity, if any, of unsaturated or saturated hydrocarbons is present in engine-exhaust gases. Taking a particular instance, methane is almost entirely absent.

c The hydrogen constituent in exhausts from strong mixtures

is an important item, and increases in value rapidly with increase in mixture strength.

d The ratio of air to fuel in the original mixture can be calculated with a considerable degree of accuracy from the composition of the exhaust gases.

e The reliability of Dr. Watson's method and apparatus for measuring the air and fuel supplied to an engine is once more demonstrated.

Exhaust-gas charts such as described in this paper may prove useful in engine testing both for estimating the mixture strength and for determining the waste of heat due to incomplete combustion. Likewise they may prove useful for setting carburetors and thus promoting fuel economy. (*The Institution of Mechanical Engineers*, Advance Paper C, read March 17, 1916, 38 pp., 9 figs. *eA*.)

Lubrication

A System for Plotting and Cross-Fairing Results in Lubrication Testing. Professor G. B. Upton

Description of a method of plotting the results of lubrication testing which makes possible cross checking of values for both relative and absolute accuracy. The tests were made with hard bronze bearings in a Thurston lubrication testing machine.

The main plot is shown in Fig. 5A. The kind and supply of lubricant and speed of shaft were kept constant throughout a series of tests, among which the only impressed variable was the load on the bearing. For each load there is plotted a curve such as *MNO*. The curves in the figure are labeled with their appropriate bearing loads in pounds.

One variety of cross plotting and fairing of the curves is possible by taking the values of the intercepts of the varion load lines on a vertical line of constant temperature such as *AB* or *A'B'*. The resultant curve of *friction vs. load* at constant temperature has a small positive intercept of friction for zero load, then increases about in proportion to load until the seizing load for the bearing is approached, and the curve turns abruptly upward. Another cross plot comes from dividing each friction value by the corresponding load, that is, obtaining the coefficient of friction and plotting that against load as in curves *AA* and *BB* in Fig. B, *AA* being for constant temperature of 60 deg. fahr. and *BB* for 100 deg. fahr. in the bearing metal.

The much more important curve is *ANFC* which is the locus of "equilibrium temperatures," or temperatures at which a balance is reached between the gain and loss of heat due on the one side to the bearing getting hotter, and on the other side to decrease of friction as the temperature rises. For the curve *ANFC* the temperature intercept at zero friction must be the room temperature. The locus of equilibrium temperatures is independent of the curves of *friction vs. temperature* at various constant loads such as *MNO*, Fig. A. It is superimposed upon those curves.

To find the curve of equilibrium temperatures, two series of constant load runs were made, the first series with loads increasing from one run to the next and the second series with load decreasing. Equilibrium is reached when the ratio of friction times speed to difference of temperature between bearing and room becomes constant. The dotted curve *DQFF'E*, Fig. A, is the locus of minima of the constant load curve.

The real criterion of safety of the bearing comes from the relations of the constant load curves, the locus of equilibrium temperatures and the locus of minima of constant load curves. If a constant load curve cuts the locus of equilibrium temperatures while the constant load curve is descending, the bearing will come to equilibrium and be entirely safe as it will have no tendency to get hotter. If the room temperature be raised and the new equilibrium temperature curve is different, the safe loads for the bearing are greatly changed.

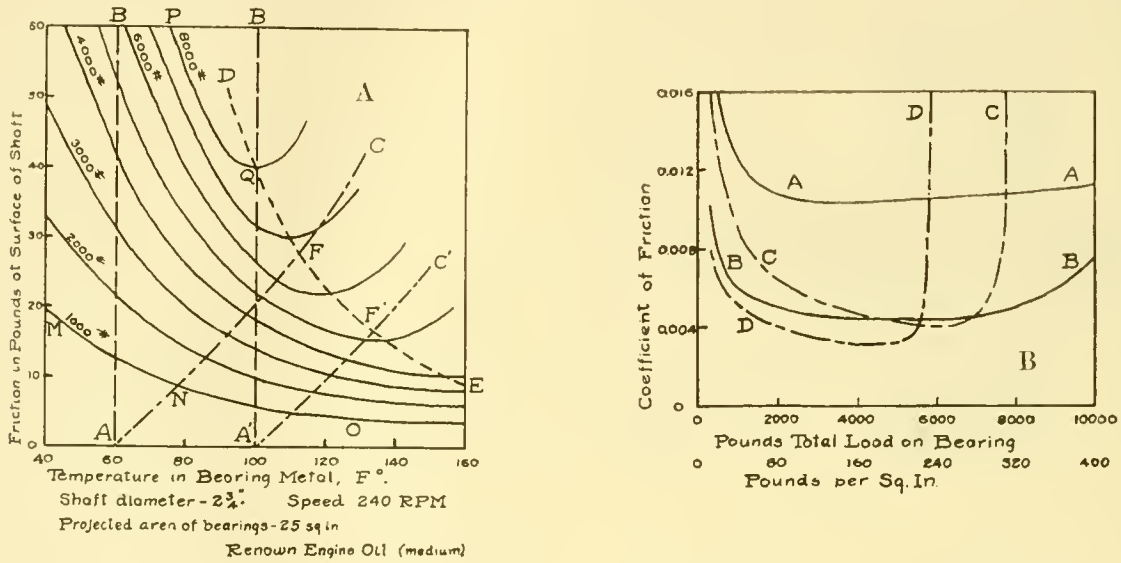


Fig. 5 Plots of Lubrication Tests

In chart B, the bearing temperature constants are, 60 deg. fahr. for curve *AA*, 100 deg. fahr. for curve *BB*. Bearing warming to equilibrium, room temperature constant to 60 deg. fahr., curve *CC*, 100 deg. fahr. curve *DD*.

The effect of the environment on the coefficient of friction of a plain bearing has generally received less attention than it should. The curves *CC* and *DD* of Fig. B have as their only cause of difference the change of room temperature from 60 deg. to 100 deg. fahr. The higher room temperature gives a lower coefficient of friction at the expense of load carrying capacity. The author points out that a study of the curves of Fig. B and comparison with Fig. A will show the unreasonableness of quoting coefficients of friction in lubrication or bearing tests without the most complete statement of all the conditions under which the test was made. (*The Sibley Journal of Engineering*, vol. 30, no. 6, p. 194, March 1916, 3 pp., 2 figs. *et*.)

Machine Parts

Special Spring Suspension for Trucks and Automobiles. M. C. Krarup

The article presents data from an exceptional installation where by larger flexibility and range of action of the spring suspension, an increased load capacity has been gained. A construction of this particular spring (rear suspension) is shown in Fig. 6 (in the original article another figure is given showing the front suspension).

The rear end of each leaf spring supports the frame of the vehicle through the intermediation of a large supplementary helical spring of the railroad truck spring variety. The movements of the leaf spring as well as of the coil spring are guided by means of a 15-in. lever, with bar and shackle connection, and these levers on opposite sides of the vehicle are tied together with a cross-bar and, therefore, the cross-bar forms the pivotal axis for the turning movement of the two parallel levers. The arrangement is such that one-sided shocks can be compensated by the choice of the spring dimensions, and the cross-bars almost equalize the forces acting upon the two helical springs of a pair whether they are at the ends of a cross-bar or closer together. The supplementary helical springs add to the flexibility of the suspension. With the range of action in one of these coil springs of 6 in., the additional range of action produced by the axle is about 3 in. if the action is at the middle of the leaf spring, but the slight angularity of the whole spring movement, especially in front, modifies this relation only a trifle.

If plain leaf springs of a flexibility corresponding to that of the suspension described were used, the results, as far as undesirable large movements are concerned, would be acceptable. One factor to which the writer calls particular attention is that the arrangement by which the guide levers enter between the two spring elements on one side in such a manner that the compression of both leaf and coil springs on one side causes only the compression of the coil spring on the other side but not that of the leaf spring; on the contrary, it tends to extend the latter. (Results from a Special Spring Suspension Developed for Brewery Trucks and Applicable to Automobiles, Marius C. Krarup, *The Automobile*, vol. 34, no. 11, p. 493, March 16, 1916, 5 pp., 3 figs. *dc.*)

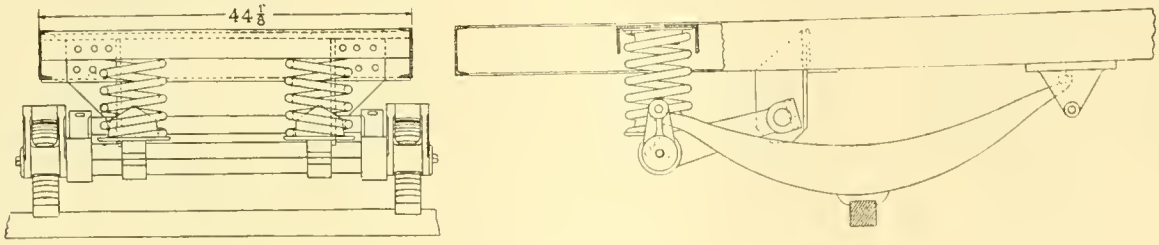


Fig. 6 Williams Rear-Axle Suspension for Brewery Truck

Machine Shop

Chisels. Henry Fowler

Discussion of the metal used for chisels and standardization of their shapes.

In the Chief Mechanical Engineer's department of the Midland Railway (England), after considerable experiment, it was decided to order chisel steel to the following specifications: "carbon, 0.75 to 0.85 per cent, the other constituents being normal" (manganese, 0.30, silicon, 0.10, sulphur, 0.025, phosphorous, 0.025 per cent).

Fig. 7 shows the most important forms of chisels used in the locomotive shops. They are made to stock orders in the smithy and forwarded to the heat treatment room where the hardening and tempering is carried out on batches of fifty. Since the chemical composition is more or less constant, the chief variant which causes the temperatures to be varied slightly, is the section. The chisels are carefully heated in the gas furnace to a temperature of from 730 to 740 deg. cent. (1346 to 1364 deg. fahr.) according to section, and then quenched to a depth of ⅜ in. to ½ in. from the point, in water, after which the whole chisel is immersed and cooled off in a tank containing linseed oil. This is followed by tempering in an oil bath. (*The Institution of Mechanical Engineers*, Advance Paper D read on February 18, 1916, *dp.*)

Measuring Apparatus

Dynamometer for Determining Horsepower of Tractors

To determine the horsepower delivered at the drawbar of a tractor it is necessary to take into consideration three factors, namely, pull, distance and time. The ordinary commercial dynamometer records only the element of pull, which makes it difficult to obtain a net result in terms of horsepower owing to the liability of error in measuring the distance and elapsed time. Another difficulty with recording spring dynamometers is that the recording mechanism must be mounted directly on the dynamometer. The dynamometer is then subjected to very severe usage which interferes with the accuracy of the recording mechanism and sometimes puts it out of commission entirely.

To overcome these difficulties, the Hyatt Roller Bearing Co. has developed a special recording dynamometer for traction engine testing. It consists primarily of an hydraulic pressure unit which is hitched between the tractor and the load being pulled, and a recording pressure gage connected to the hydrostatic unit by means of a flexible tube. The dial of the recording gage is driven by a gear reduction connected by means of a speedometer shaft to a trailer wheel which runs on the ground. To obtain the elapsed time an accurate clock is provided having a recording arm which checks the time intervals on the margin of the pressure gage chart. Hence the three factors for obtaining the delivered horsepower are all automatically recorded on one chart so that it is unnecessary to take any measurements as to the distance or observations as to the elapsed time.

The article contains an illustration showing the dynamometer set up for testing a tractor plow. The illustration in Fig. 8 shows the chart about one-third completed. The broad wavy line on the chart represents the drawbar pull which is recorded by the pressure gage arm nearest the center of the dial. The narrow jagged line on the margin of the chart represents the time which is recorded by the clock arm on the right side of the dial. The capacity of draw

bar pull was 2500 lb., and the dial geared to revolve once for 1000 ft. of travel. The average drawbar pull of the chart shown is 1130 lb., the total distance traveled 1600 ft. and the elapsed time 12 minutes. The net drawbar horsepower delivered is, therefore, 4.6 h.p. (How Many Pounds Will the Tractor Pull? *Gas Power*, vol. 13, no. 10, p. 50, April 1916, 2 pp., 2 figs. *d.*)

Railway Engineering

The Empty and Load Freight Brake, Walter V. Turner

The author points out that in America vast expenditures have been made for grade and curve reduction, heavier motive power, heavier rails, better road-beds, etc., all with the idea

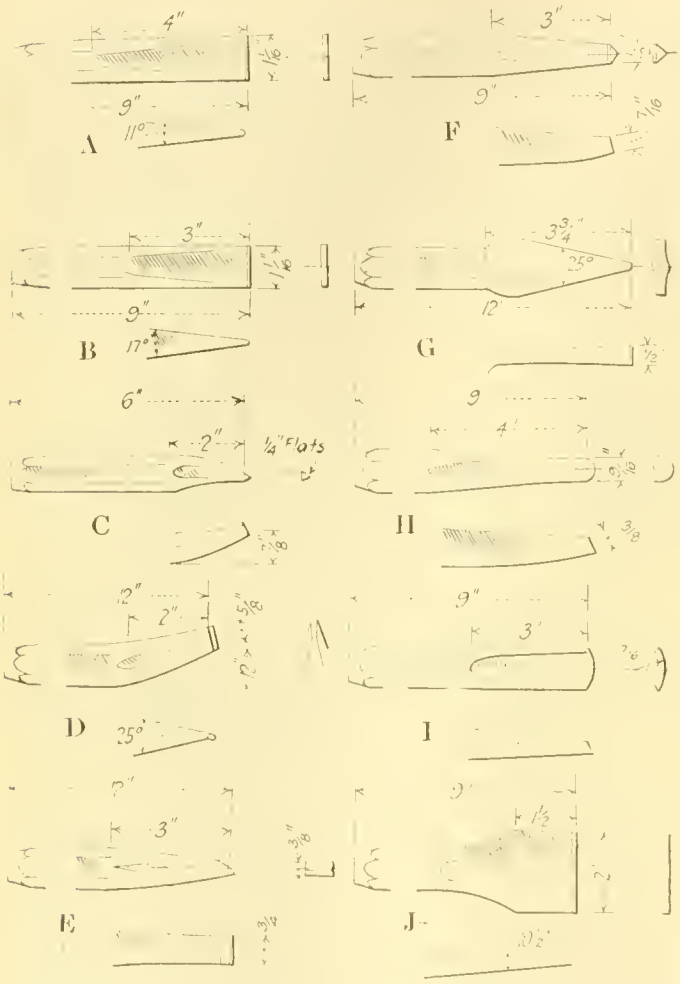


Fig. 7 Chisels: A, Heavy Brass Work; B, Heavy Iron and Steel Castings; C, Cylinder Repairs (Right Hand); D, Side Tool (Right Hand); E, Square Nose; F, Diamond Point for Jagging; G, Long Cross Cut; H, Round Nose; I, Gouge Tool; J, Metal Tool

of increasing the volume of traffic and of reducing operating expenses by running more trains composed of a greater number of heavier cars. But that end is not yet attained, because of the frequent damage to long trains even in level districts due to slack action, which is in turn due to the fact that the retardation is not uniform between the empty and the loaded cars of the train. The same conditions tend to restrict lengths of trains in hilly districts, as safety in descending grades is the limiting condition of traffic.

The secret of the elimination of slack action lies in uniform retardation on all cars, empty or loaded, in the train. Other things being equal, the retardation set up is proportional to the braking ratio, and the problem is by no means solved by increasing the braking ratio on the empty car, since doing so increases the braking ratio above 15 per cent when the car is loaded.

The paper presents an interesting discussion of the matter of elastic impact between two cars. The empty and load brake as designed for freight service, has two distinct braking forces due to the operation of one or of two brake cylinders during brake applications. The full service braking force obtained with the one cylinder is 60 per cent of the empty weight of the car and is used with the empty or partially loaded car, but when the car is loaded beyond a certain point the second brake cylinder is cut into action to assist the first. Starting with 60 per cent braking ratio for the empty car, the braking ratio for the fully loaded car drops to 15 per cent when the loaded weight is four times the empty weight of the car, as in the case of the new 180,000 lb. capacity hopper cars for the Pennsylvania R. R., weighing 60,000 lb. empty.

The lower braking ratio for freight service is especially

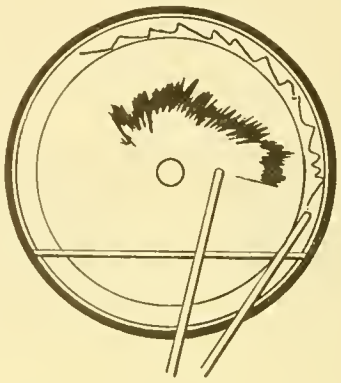


Fig. 8 Dynamometer Chart of Tractor Horsepower Test

desirable also from another point of view besides the one of having empty and loaded cars braked uniformly when the same cylinder pressure obtains on each. The greater safety, control capacity and economy possible by the use of the empty and load brake equipment is illustrated by the fact that when the same brake pipe reduction was made with a 90-car train having 30 empty and load brake equipments on the head end and also with a 90-car train of single capacity brake equipment, both on a tangent of 1½ per cent grade and at a speed of about 21 miles per hour, the train with the empty and load equipment on the first 30 cars was stalled, whereas the speed of the other train was only reduced to about eight miles per hour.

The results demonstrated the advantages of the empty and load equipment, compared to the single capacity brake equipment in permitting the handling of a similar tonnage with greater economy, safety and reserve capacity or for increasing the capacity of the road by increasing the amount of tonnage which can be handled down the grade with the same degree of safety and economy heretofore possible.

The average brake pipe reduction required to control the 90-car train with 30 empty and load brake cars on the head end was only half as great as with the 90-car train of all single capacity brakes. The single capacity brake train could not be recharged as promptly or as uniformly as the other, because 100 per cent heavier brake pipe reductions had to be made. In consequence of this the speed of the single

capacity brake train down the grade was more uneven and the brake pipe pressure restored at the rear end during the successive recharging periods while descending the grade steadily decreased.

The average speed on the grade was about 16½ miles per hour for the train without empty and load brakes and about 19 miles per hour for the train having 30 empty and load equipments. This, considered in connection with the lower average brake pipe reductions made, when handling the empty and load brake train, shows that a higher speed, and therefore greater capacity of load, can be secured and at the same time a greater factor of safety in operation afforded by the use of the empty and load brake equipment. Furthermore the speed of the train without empty and load brakes varied between a minimum of 8 miles per hour and a maximum of 21 miles per hour, indicating (also when considered in connection with the brake pipe reductions required and the impossibility of fully recharging between reductions) that the brakes on this train were being taxed to their ultimate capacity. The speed of the train having 30 empty and load equipments varied between a minimum of 15 miles per hour and a maximum of 24 miles per hour, an overall variation of only 9 miles per hour instead of 13 miles per hour with the other train.

Just preceding the final application at the foot of the grade with the train having all single capacity brakes, the brake pipe pressure was only 78 lb. instead of 91 lb., as it was to start with. With the similar train having 30 empty and load equipments on the head end, the brake pipe pressure preceding each successive application was maintained at 93 lb., no difference being noticed between the recharged pressure previous to the first application and that just before the stop at the foot of the grade.

With both the 90 and 100-car trains having empty and load equipments, there was an average reserve braking force available at all times during the descent of the grade, such that at any time the forces being employed might have been increased from 35 to 55 per cent, as occasion demanded. On the other hand, the train without empty and load equipment was being taxed to its capacity throughout the descent of the grade.

The following comparison of brake valve manipulation illustrates the additional capacity and economy of the empty and load brake equipment from the standpoint of brake manipulation alone:

No. Cars (all loaded) in Train	Kind of Eqpt.	Application and Lap Pos.	Full Release Position	Running Position
90.....	90 KD	63 Sec.	65 Sec.	32 Sec.
	No E. & L.	(39%)	(41%)	(20%)
90.....	60 KD	44 Sec.	37 Sec.	71 Sec.
	30 E. & L.	(29%)	(24%)	(47%)

( ) = Percentage of total time of descent.

The longer time spent in application and lap position with the train not having empty and load equipment, indicates the longer time the brakes had to be held applied in order to get the train under control.

The longer time in release position shows the increased difficulty of recharging the train not having empty and load brakes, due to the greater depletion of the system by the severe reductions made. This also necessarily involves more unavoidable overcharging at the head end of such a train.

The fact that more than twice as long a time was spent in running position with the empty and load train than was possible with the other train shows the increased braking reserve in the greater time available in which to fully and uniformly recharge the entire system.

From the foregoing it follows that the train with empty and load equipments was much more economical in the use of compressed air. (*Proceedings, St. Louis Railway Club,* vol. 20, no. 10, p. 221, February 11, 1916, 60 pp., 16 figs. *deA.*)

Steam Engineering

Steam Turbine Blade Fastenings, Jas. A. Capstaff

Data of tests of the comparative strength of Vickers-Ferranti, Brown-Boveri, and Lovekin methods of turbine blade fastening.

The various types of blades tested are shown in Fig. 9. In

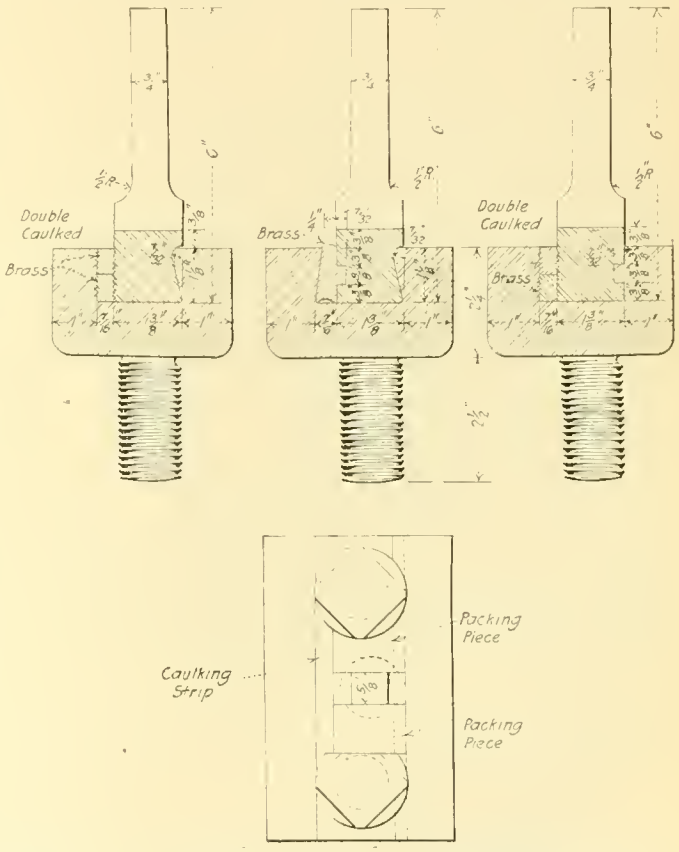


Fig. 9 Vickers-Ferranti, Lovekin, and Brown-Boveri Turbine Blade Fastenings

all cases the blades were of mild steel of the same dimensions and the caulking strips were of brass. The same distance pieces and holder stops were used. The holders were similar, the only difference being the method of securing the blades.

In the Vickers-Ferranti test, a load of 10,700 lb. was required to pull the blade out of the holder. In the Lovekin and Brown-Boveri tests, loads of 17,300 and 11,100 lb., respectively, were required to produce the same result, which shows that the Lovekin blade fastening is 61.5 per cent stronger than the Ferranti method, and 56 per cent stronger than the Brown-Boveri method.

The writer also made up a test piece of the Lovekin method applied to a 250-B standard Parsons blade which withstood a load of 1900 lb., thus proving that the Lovekin method is 52 per cent stronger than the Parsons.

Brass expands more than steel or iron; therefore, any

method of blading, where brass is used, that has the distance pieces caulked tightly into grooves or projections in the adjoining blades, must form a continuous ring of brass within the groove on the steel rotor or the iron casing. If, however, the groove is completely filled and heat applied, the brass ring must expand, and inasmuch as there is no room left between the blades and distance pieces for expansion, the compression of the metal must necessarily force the blading outward and thereby reduce the clearance between the blade tips and the rotor casing. This is likely to cause blade stripping, or, at least, rubbing.

The Lovekin method avoids this trouble, as the space left between the blades and distance pieces is ample for the increased expansion. It further permits of a uniform spacing and absolute radial alinement of blades around the entire circumference and avoids large gaps or openings between the final blades. (*Journal of the American Society of Naval Engineers,* vol. 28, no. 1, p. 55, February 1916, 6 pp., 12 figs. *edc.*)

U. S. S. Nevada Propelling Machinery and Auxiliary Equipment, Lieutenant Ormond L. Cox, U. S. N.

Description and trials of the U. S. S. *Nevada,* a sister ship of the *Oklahoma.* The article gives a general description of the hull, batteries, and propelling machinery with its auxiliary mechanical equipment. Only some features of its machinery are reported in this abstract.

All blades and distance pieces of the turbines are of rolled brass dove-tailed into grooves in the periphery of the wheels and drums. Intermediate blades are made of the same material and secured in the same manner to the holders. The shrouding is of rolled brass.

The forced lubrication installation in each forward engine room consists of two forced lubrication pumps, one oil-cooler circulating pump, one 250 gal. drain tank, one oil-settling tank fitted with steam coils, and one 1000 gal. oil-storage tank with necessary piping and fittings. Cooling water for the oil-cooler is supplied by the oil cooler circulating water pump or by a cross connection from the water service. The following data are given for one oil cooler:

Type	Reilly, vertical, multicoil
Number of passes of oil	3
Diameter, inside, in	40
Length overall, ft. and in	4-10
Coils, number	36
" diameter, outside, in	1
" thickness, inch	0.065
" cooling surface, sq. ft	221.4
Diameter, inlet and outlet, water, in	03
" " " " oil, in	03

(*Journal of the American Society of Naval Engineers,* vol. 28, no. 1, p. 20, February 1916, 35 pp., 8 figs. *d.*)

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1. Alignment chart for design of flat elliptical plates, uniformly loaded and either supported or fixed at the edge.

2. Alignment chart for design of flat elliptical plates supported at the edge and loaded with a concentrated load at the center.

3. Alignment chart for design of flat circular plate supported at edge with total load uniformly distributed on a concentric, circular area.

4. Alignment chart for design of flat rectangular plates uniformly loaded and either supported or fixed at the edges.

5. Alignment chart for design of flat rectangular plates uniformly loaded, fixed along shorter edges, supported along longer edges.

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Fig. 1. Weight of Double-Track, Through, Pin-connected, Petittruss Spans of Carbon Steel and Nickel Steel.

Fig. 2. Weights of Double-Track, Through, Pin-connected, Cantilever Bridges of Carbon Steel and Nickel Steel.

Figs. 3 and 4. Comparative Costs of Double-track, Through, Riveted, Pratt-truss Spans of Carbon Steel and Mixed Nickel and Carbon Steels.

Figs. 5 and 6. Comparative costs of Double-track, Through, Pin-connected, Cantilever Bridges of Carbon Steel and Mixed Nickel and Carbon Steels.

Fig. 7. Probable Weights of Very-long-span Cantilever Bridges of Carbon Steel and Nickel Steel.

Fig. 8. Weight of Metal Per Lineal Meter of Simple-span, Double-track Bridge.

Fig. 9. Weight of Metal Per Lineal Meter of Double-track Cantilever Bridge.

Fig. 10. Cost of Metal Per Lineal Meter for Simple-span, Double-track Bridge.

Fig. 11. Cost of Metal Per Lineal Meter for Cantilever Double-track Bridge.

Fig. 12. Total Weight of Metal Per Lineal Foot of Span for Double-track, Simple-span Bridges of Carbon Steel and Alloy Steels of Different Elastic Limits.

Fig. 13. Total Weight of Metal Per Lineal Foot of Span for Double-track, Cantilever Bridges of Carbon Steel and Alloy Steels of Different Elastic Limits.

Fig. 14. Comparative Costs of Double-track, Simple-span Railway Bridges of Carbon Steel and Mixed Alloy and Carbon Steels for E-80,000 lbs.

Fig. 15. Comparative Costs of Double-track, Cantilever Railway Bridges of Carbon Steel and Mixed Alloy and Carbon Steels for E-80,000 lbs.

Fig. 16. Comparative Costs of Double-track, Simple-span Railway Bridges of Carbon Steel and Mixed Alloy and Cerbon Steels, Contrasting Vanadium and Nickel Steels.

Fig. 17. Comparative Costs of Double-track, Cantilever Railway Bridges of Carbon Steel and Mixed Alloy and Cerbon Steels, Contrasting Vanadium and Nickel Steels.

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Lengths of pipe subtending angles, Section 3.

Diagram for calculating offset pipe bends.

Lengths of pipe subtending angles, Section 2.

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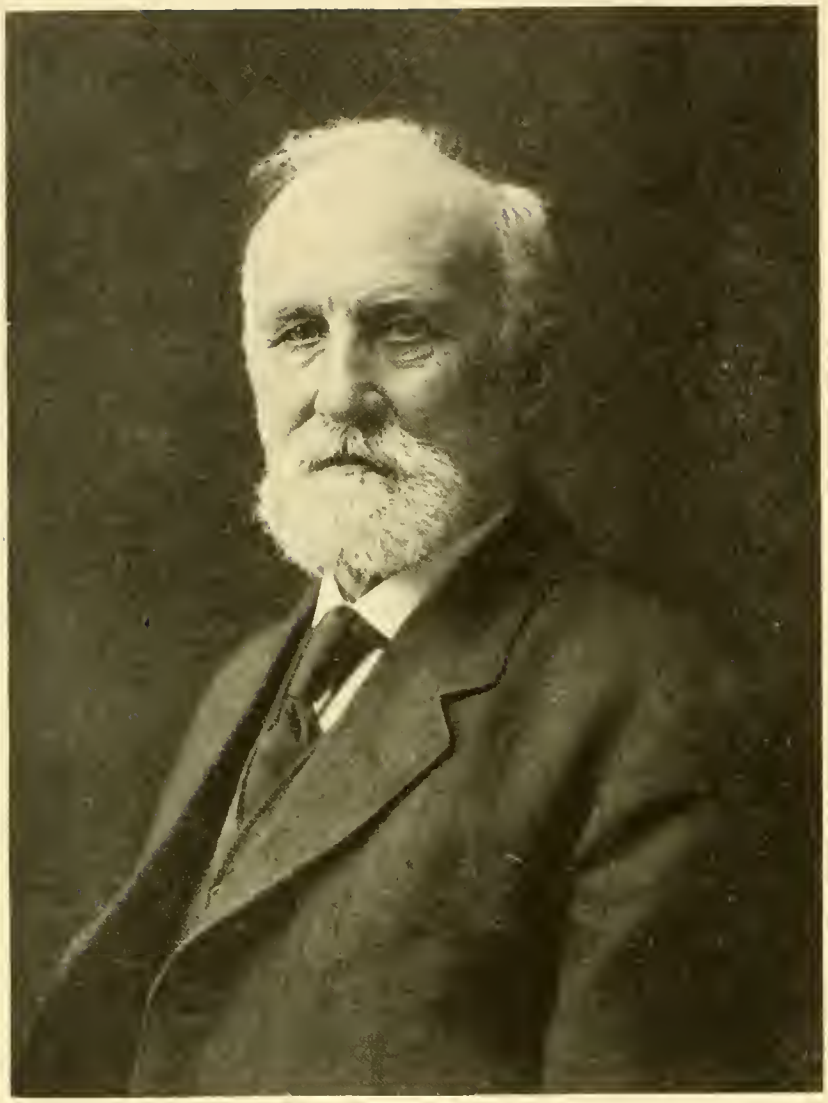

JOHN EDSON SWEET
HONORARY MEMBER IN PERPETUITY
FOUNDER OF THE SOCIETY
PRESIDENT, 1884

SEE PAGE 473

INDUSTRIAL PREPAREDNESS

Discussion on Organizing for Industrial Preparedness Given at the Spring Meeting in New Orleans by Engineers from all Sections of the Country

THE paper entitled Organizing for Industrial Preparedness, presented at the opening session of the Spring Meeting held in New Orleans, April 11 to 14, by Spencer Miller, Member of the Council and one of the Society's two representatives on the U. S. Naval Consulting Board, was placed in the hands of the hands of the membership in advance of the meeting; and for purposes of reference the introduction, which was printed in the inside cover of the paper as issued in pamphlet form and which is really a synopsis of the paper, is here reproduced. This introduction will serve to call to mind circumstances leading to the presentation of the paper, as well as repeat the interrogations put for the purpose of bringing out suggestions along lines of vital import in the matter of Industrial Preparedness. The discussion follows this introduction.

A REMARKABLE RESPONSE

The discussion here published represents the remarkable result of opening a meeting of the Society to a discussion of Industrial Preparedness.

The presentation of Mr. Spencer Miller's paper at the Spring Meeting brought forth an unprecedented volume of discussion, the nature of which is indicative of the spirit among the membership of the response to the request of President Wilson for our coöperation in the patriotic work of Organizing for Industrial Preparedness.

Participation in this movement is the finest opportunity the Society has ever been accorded of directly serving our country, and it is a matter of gratification that our membership has responded to this opportunity universally.

INTRODUCTION

The engineer is active nowadays in army and navy affairs, as witnessed by the appointment of the U. S. Naval Consulting Board, the nomination of representatives for the Industrial Census, the movement for an Engineer Reserve Corps and the notable lectures on Military Engineering which are being given to the engineers of New York and vicinity.

In recognition of this trend in the engineering profession, the author raises the question for discussion of how the engineer may best serve his country as a result of the call by the Government for coöperation in organizing for preparedness, a movement which is largely dependent on engineering.

The first step in this direction was the invitation from Secretary Daniels of the U. S. Navy to The American Society of Mechanical Engineers and ten other organizations, to form a Naval Consulting Board to be headed by Thomas A. Edison, Hon.Mem.Am.Soc.M.E. This board resolved itself into committees, one of which, the Committee on Production, has as its Chairman Howard E. Coffin, Mem.Am.Soc.M.E., who formulated a plan for organizing the industries for preparedness. This led the President of the United States to invite this Society and four others to nominate a representative in each state to assist the Naval Consulting Board in "collecting data for use in organizing the manufacturing resources of the country for the public service in the case of emergency." Its immediate work will be to make an inventory of the facts necessary to be known to the army and navy relating to the resources of the nation for the supply of munitions of war in the case of an emergency or a national calamity.

The author shows that with the facts of this census properly collated we shall learn where we are weak and where strong. Not only will it be known where munitions, which include supplies of all kinds, can be obtained, but how rapidly they can be produced; to what extent America is independent of foreign countries for raw materials and manufactured products; for what kinds of munitions we have ample manufacturing facilities, and wherein we must provide means for making up the deficiency.

These and other questions are suggested by the author, and it is hoped that by way of discussion the membership will present other aspects of the situation which will have a helpful bearing on the problem of how the engineer may best serve his country.

Among the topics which suggest themselves are the following:

How can mechanical engineers consolidate their efforts in a way to oversee effectively the manufacture of munitions?

Should there be modification of standards for arms and ammunition to facilitate their manufacture?

What part should tools, gages, jigs and machine tools play in Industrial Preparedness?

What part should the textile schools take in the training of men for responsible positions in munitions manufacture, and in the testing of materials?

What should be done in the way of storing materials—nitrate and tungsten, for example—against a time of need?

Inasmuch as this paper is to be presented at the New Orleans meeting, there are certain questions relating to southern industry which may profitably be discussed. The resources of the South might supply the country with many materials needed during a period of curtailment of commerce with other nations. For example, products, and especially by-products, to be derived in manufactures of wood; in the production of sugar, cotton oil and molasses; and in the petroleum and chemical industries, especially with reference to crude oil, gasoline and sulphur.

DISCUSSION

In the main, the discussion resolved itself into two parts: What constructive means we should employ in this country in the solution of the problem of Industrial Preparedness, and what corrective steps we should take to prevent any possible repetition here of the conditions encountered at the

outset by some of the nations now in conflict in Europe. As constructive measures, many valuable suggestions were offered, such as extending the idea of the census of industries now being made to embrace a "census of men," establishing government and civil organizations to control and direct the manufacture and output of munitions, inaugurating plans whereby all manufacturing concerns should become practised in munitions manufacture by executing small orders for such material annually, etc. Corrective suggestions were made by many having personal experience in munitions manufacture for foreign governments at the present time, and included several plans for minimizing the delay hitherto inherent to munitions production on account of lack of materials specified, inability to procure gages, inadaptability of existing tools for munitions work, etc.

Discussions advocating constructive measures were as a rule general in character; these are grouped as far as possible below, and precede those suggesting corrective measures which were usually confined to particular instances and examples.

ADVOCATES UNIVERSAL PREPAREDNESS. SAYS WE NEED CORRELATION OF EDUCATION AND VOCATION

Frank B. Gilbreth. This problem of preparedness is not one of merely preparing for war; it is also one of preparing for efficient living at any time. It is a problem of obtaining a greater general education, and a greater individual education in the same learning period. It is a problem of national elimination of unnecessary waste, of adequate general and individual effort toward utilization and conservation of our great resources. The problem comes to us as apparently original and unusually interesting to-day because of the war spirit pervading the world, and because of the glaring need for efficiency in war times. The problem existed long before the war commenced, and the results of the study of the problem will be equally useful and usable whether we engage in war or not. The experience of all Europe, the successes and failures everywhere, demonstrate that preparedness in its broadest sense means a general spirit of being ready, rather than a particular state of being ready *for war*. Just as in education it is psychologically sound to develop general abilities to a certain extent in order that special abilities may later reach their greatest height, so in preparedness it is most efficient to develop general preparedness in order that special preparedness for an emergency may be most quickly and satisfactorily developed.

This national preparedness divides itself, then, into two lines:

1 Preparedness of material things, that is, surroundings, living conditions, all of the material objects with which we deal.

2 Preparedness of people, as individuals, and as constituting society.

We must remember that in both these lines of preparation our problem here in the United States is an extremely complicated one in that our form of government, with all its advantages, lacks seriously, in many places, correlation of activities and a permanent centralized department for the planning and development of definite lines of national progress. This perhaps unavoidable lack, we must supply through a uniform and universal realization of what preparedness means and what it is for.

Much has been said already of a proper inventory of our individual equipment and resources, and a standardization of jigs, fixtures, templates and equipment of our factories and plants. I endorse the idea now put forward that this Society should be proposed as a nucleus of a permanent body to encourage and lead the way in such standardization. We must remember that such an inventory must include information as to our naval stations, founded upon measured data and recommendations of our naval officers, so that we shall judge the value of the location of our naval bases from the standpoint of their usefulness.

Let us at once apply measurement and standardization to all problems of material preparedness so that each one can do his own work with all the might that is in him, knowing that the finished products are bound to be what is required.

Efficient preparedness is not preparedness of the regular army and navy alone, or of the men available for military service alone. Nor is it the building of ships and forts only. It is preparedness of every man, woman and child in the country. Such preparedness demands, first, beginning the preparation at the earliest age available. Abroad children are trained to spend much time out of doors, and in out of door activity. Erect carriage in one country is secured at an early age by having the school child carry his books in a specially constructed bag, resembling a knapsack, on his back. Endurance is secured by out of door walks and contests. Powers of observation are sharpened through the availability, cheapness and general use of good field glasses and other stereoscopic optical devices. Thrift is installed through its practice in the homes, even to the general custom of serving of small portions at the table with the intention of passing food many times rather than to encourage the smallest portion to remain over. To take more than one wants is considered as a misdemeanor and an unpatriotic act. As a result they have, in the adult thus trained, a soldier, if such be necessary, who has strengthened his most valuable qualities by a general and not by a specific military training. In times of peace they have a citizen able to enjoy life amazingly, and to take his full share as a producer in the community, and one who realizes that the greatest individual wealth and comfort come only where there is the least waste.

Women should be prepared as well as men, prepared by a training in physical endurance, by manual training, education in household economics, in nursing and in habits of concentrating attention and following directions. It is this general training that has made it possible for women in all countries abroad to take up the work of men in all lines of activity where it is necessary.

It is not enough that the equipments and tools of the sudden need be made available. The methods of handling them must be taught in such a manner that the workers may gain not only a knowledge of the machine that makes the machines, but an idea of motion economy and of personal effectiveness.

I could run through my own experience and illustrate each point that I have brought out here by actual examples that I have seen with my own eyes in warring countries abroad, successes based on such training as this, failures caused by a lack of such training; but the feeling of partisanship so strong to-day would lead you, no matter where your sympathies lie, to evaluate the illustration as an evidence of efficiency or inefficiency *in some one country*, rather than as an argument for preparedness. The important thing is rather to re-emphasize that preparedness means not merely getting ready for war, but getting ready for real living. What should shock us is not what might happen to us in a war, but what is happening right now, while we have general peace. National waste, lack of general and specific education, lack of easy means for ob-

taining the fullest education in the vocation, for the worker in that vocation, lack of correlation! The "Spirit of 1776" is with us now, (and so are arms and ammunition of 1776). We have right here to-day the greatest opportunities that the world has ever offered. Let us not arm for a definite enemy, for tomorrow there may arise conditions that will cause us to revise our list of probable friends and probable enemies. Let us educate ourselves for individual and national efficiency. If we do this, we will be prepared, and adequately prepared, to live in peace and enjoy the durable satisfactions of life.

CONSIDERS WORK IS TREMENDOUS AND GOVERNMENT SHOULD DO IT. WANTS CENSUS OF MEN

E. H. Peabody (written). The author asks a question which is in all our hearts in these pregnant days, when all our old belief of the certainty of honorable peace and security from invasion has been swept away, and we stand face to face with possibilities which well may make us tremble. He asks: "What may we do to serve our country?" But he answers that question with a complacency which I believe to be more apparent than real. He expatiates upon the pride which engineers and scientists should feel on having been consulted by certain officials of the Government, the eagerness with which the call was answered; and he goes on to outline the work of the Naval Consulting Board, and leads us to believe, apparently, that all or nearly all that can and should be done is now serenely under way.

But the mistake this paper makes, whether intended by the author or not, is in presupposing that the enormous work of organizing for industrial preparedness can be effectively projected and completed with the despatch which the circumstances make imperative, by the engineering fraternity of this country as represented by the engineering societies, working in the odd moments snatched from the task of making a living, without compensation and paying its own expenses.

It is indeed a satisfaction for us all to know that this important movement of industrial preparedness has been initiated and is being carried forward to far better purpose than the facilities available might promise. But the mere preliminary step of making an industrial inventory is a tremendous piece of work in itself. Can it be done by a Society like ours, or by representatives of similar societies? May we expect that even the enthusiastic army of engineer census-takers referred to by the author—in the little time available and with comparatively speaking a limited backing—may we expect that these men can satisfactorily accomplish this important work? Have we time to do it in this way? I think not.

It is our Government which must do this work, and not the U. S. Naval Consulting Board, whatever may be the enthusiasm, self-sacrifice and ability of its members, and whatever may be the help which this Society's membership at large can give; and I believe that the steps that the Society should take are those which will put pressure upon our legislators with the effect of making an organized government measure of this industrial census and all the thousand other important features which must be included in complete "preparedness against war" (to quote Mr. Garrison). It is a mistake, in my opinion, to allow the impression to go abroad that the work which the Naval Consulting Board has begun and which is being promoted by the action of the allied engineering societies, is sufficient and satisfactory, and that it will fulfill the great needs of our country. We must go deeper to make this work effective; we must bend our energies along the line of stimulating public opinion, so that our representatives at Washington will be impressed and take the necessary steps to make the whole question of preparedness a Government policy.

Besides the industrial census there must be a census of men, and every man of us must be listed in it. The Government must find out in what way the experience and talents of every man of us may best be employed in time of conflict. Every man must be assigned to his job and be getting ready for the call—whether it be to active service with the colors or in those equally important fields of supplies, without which the army and navy become impotent. Has anything been done along this line? I haven't heard of it. The Plattsburg movement seems to be the only step which has attracted public notice. It is an important and valuable feature of the problem, but it is a drop in the bucket.

The appointment of the U. S. Naval Consulting Board was an inspiration and of incalculable benefit to the country, but anything short of putting this matter of preparedness straight up to the legislative and executive heads of our Government as a National duty, is merely playing with a problem which vitally affects our very existence as a nation.

RECALLS HISTORY OF PREPAREDNESS. SAYS ENGINEERS SHOULD TAKE CARE OF BIG THINGS

Charles Whiting Baker, who presented the paper in the absence of the author, said: It is interesting, I think, to recall at this time something of the history of the last half century in connection with the movement for preparedness, as it has come to be called. Those of more advanced years can recall that for twenty years after the end of the Civil War the United States did nothing in connection with national defense. While other nations were forging ahead in their military and naval forces, the United States forgot the necessity for national defense until the early eighties, when there was a sudden awakening to the wholly defenseless condition of the nation, and we began then the work of building a navy. Progress has been made—great progress, but within the last year engineers, especially, have awakened to a realization that, while we have been going ahead in a way, we have simply been following the example of some of the other nations of the world. Greater strides have been made on the other side, until we find ourselves again in a comparatively defenseless condition. It was the general awakening to that fact that led to the movement for preparedness—preparedness so that we may be able to defend ourselves.

A remarkable example of the interest the engineers are taking in this movement is given in New York City, where, in response to the call of the engineers to attend lectures on elementary principles of military engineering, given in the Engineering Societies Building, there was such a crowd assembled that many hundreds were turned away.

Regarding the industrial census, Mr. Peabody questions the wisdom of the engineers undertaking the detailed work of this census, and says that the Government itself ought to employ and pay men to do that work. I think that is a principle that could well be kept in mind, for there are so many other important things regarding which the advice of the engineer is needed, that there is no reason why the able engineers of the country should undertake the detail work of the census, which the Government itself, when shown, should undertake by its own paid agents.

The engineer can appreciate the sources of inefficiency. He has studied and made a science of many things, and the

best service that a Board of Engineers can do for the country will be to take care of the big things, and let the little things be done by somebody else.

SAYS PREPAREDNESS IS INSURANCE. ADVOCATES GOVERNMENT COMMISSION TO HANDLE MUNITIONS

Oberlin Smith. This subject of industrial preparedness along military lines is to my mind a very important one. A year or two ago I, in common with a great many more people, was a very strong peace advocate, and am yet. Then we were all struck dumb almost, so to speak, by this most terrible tragedy of all the world, and ideas of preparedness seem to have been forced upon us.

Writing to some of our Senators and Congressmen the other day, urging quicker action in this preparedness matter, I said, "Let us have peace at any price, even if it is a hundred battleships and a million men." It may seem foolish to spend millions, or billions, of dollars in making guns and shells and tools for their production; but is not this matter of preparedness simply one of *insurance?*

Military and naval preparedness, and the enormous expenditures involved, should go on with the utmost speed and to such an extent that there will be no danger of any nation attacking us. That is the only way to get peace—to buy it and pay for it.

And, together with military and naval preparedness goes this industrial preparedness in the making all sorts of munitions and tools for munitions, and in the furnishing of all kinds of army and navy supplies.

Mr. Miller emphasizes that machine tools for making munitions should be standardized. That work has already gone very far, but while it is going on, and munitions themselves are pretty well standardized in any one country, they are not standardized as they should be between the countries. It would be very convenient, of course, for one country to capture some of the shells of another and use them in their own guns—this may be a misfortune or a good fortune—but the fact remains that munitions are becoming more standardized.

Our tools for munitions and other military supplies should be standardized much more than they have been, so that if ever the time should come when our Government must set all its industries to work, and do it by government consent and under government protection and supervision, the matter would be easy for all concerned, and there could be almost immediate production.

Many little machine shops all over the country might have proper gages and standards, supplied by some central commission at Washington, as a bureau of the Government. Then parts could be made by the thousands and assembled in a few hours.

We can see the wonderful benefit of interchangeability of parts in some of our arsenals, automobile factories, sewing machine factories, typewriter factories, etc. By such system of interchangeability, a great many parts can now be made in a few hours which used to take weeks and sometimes months in their production.

To my mind the Naval Consulting Board is a decided step forward, and I do not see why the army should not have a similar board and the government personnel be brought together into one Commission, as I have mentioned, to handle all matters pertaining to munitions under the general direction of experienced generals and admirals.

Such a Commission could see that all the supplies for the army and navy were correlated, classified and otherwise systematized. Then we would have a true beginning of what ought to be done and what, if we now fail, we may some time find to our bitter disappointment to be one of the things that "we have left undone."

Referring again to the author's paper, one very important class of machine tools was not mentioned, namely, the presses with which brass cartridge-cases are made, up to a diameter of 6 or 8 in.,—usually not higher than about 6 in. A large number of such presses have been required in this war, made principally by four or five concerns that are equipped for such work. Hundreds of these have already been sold, and a great many more are wanted. The deliveries for such machines are now four or five months behind desired completion.

Regarding ammunition for small arms, with the bullets and powder in brass cases, less delay is occurring. Our Government at its arsenals, and also many private concerns, can turn out millions per day, and there are thousands of presses already in use for such work.

Referring again to the larger cases, the most important size is known as "three-inch" or as "75-millimeter" in France and Russia and as "18-pounder" in England. More of those are used, probably, than any other kind, and a great many American presses have been made for them. They are drawn in from six to nine operations, usually in presses giving 100 to 200 tons pressure. The blanks (disks) are cut from sheet brass, usually about 3/8 in. thick. They are then drawn into cup-shape by successive operations, with annealings between. The top edge is gradually squeezed thinner until it is about 1/32 in. thick.

The later operations are usually performed with 100 tons pressure until the cases get to full length. Then they require from 1000 to 1500 tons pressure to squeeze the thick head, which is left full thickness, into the same shape as is familiar in small cartridges. These cases are nearly all being made in presses already standardized. The presses themselves are almost exactly the same as have been made for years by the different press makers for all sorts of drawing work. Thus it is possible to furnish the European governments and private parties abroad with such machines as fast as they can be made. Some of the press makers, after rushing their own

In this paper you have before you in brief outline the main features of a patriotic national engineering endeavor, unique in the world's history.

We, as engineers and chemists, had harnessed the resources of this country for the people's service, and now at the direct request of the President of the United States we are asked to make a careful inventory of these resources for our defensive line.

A successful performance of this great task to which the governing bodies of our technical societies have pledged us cannot but bring the American engineer enhanced reputation and closer future relations with the national Government.—Howard E. Coffin.

Is not this matter of preparedness simply one of insurance?—Oberlin Smith.

shops, employed outside shops to help them out. I know of a big locomotive works which made numbers of these machines for press makers as outside work. An important ship-building concern is also helping out in the same way. There has been a great demand for such work, but this is now slackening.

These same machines would be necessary if a great many munitions were needed for our own Government. Many of them doubtless would be found in existence when needed and could be drawn upon.

Besides the presses for making cases, mostly mechanical presses, there are some very heavy machines used for perforating the steel shrapnel and other shells, although a great many of these are cut in turret lathes from solid bars. I do not know of any other substance except brass being used for the cases. We read in the papers that some European Powers are trying to make them out of steel, because they cannot get enough brass. The difficulty is, however, that when metal ⅜ in. thick has to be drawn to 1/32 in. or so, steel is very difficult to handle. Aluminum works well in the dies, but probably cannot be made strong enough.

Sad to say, millions of these brass cases are being spread over the battlefields of Europe. This makes one speculate whether brass mining will in future be a profitable industry for the future peasant-farmers in the war zones.

POINTS OUT ADVANTAGES OF PROPOSED PRODUCTION OF TOOLS IN GOVERNMENT FACTORIES

John H. Barr (written). The uniform standard which is vital in producing guns and ammunition for our military forces requires a corresponding uniformity in the quality of the gages and tools for producing these. It is well known, however, that the methods and degrees of refinement in tool making vary widely among various factories regularly engaged in similar products.

The proposed agreement in the paper requires each shop to maintain corrected drawings and to construct one set of tools for such product as it is expected it may be called upon to supply. It would appear that the desired result may be more certainly attained by construction of such gages and tools in specially equipped government tool factories controlled by a highly expert staff and manned by workmen of corresponding skill. These government tool factories can construct *all* gages required and most of the important special tools. Drill jigs made in these factories can be used in any shop having suitable drill presses. Some variations exist among the machines of the numerous civil shops in the requirements as to drop forging dies, punch press dies and milling fixtures, but this will not seriously hamper the wholesale manufacture of such tools by the government tool factories. The word *manufacture* is used advisedly in this connection, for the large production concentrated in the government tool factories would be on a scale to permit real *manufacturing methods* in constructing standard tools.

The industrial inventory will afford the data for determining what particular makes, styles and sizes in machine tool equipment are available in the civil shops, and will accurately indicate the numbers of each for which tools should be provided. An alternative to reliance upon this information solely would be to have each private shop fit to its machine tools specified die blocks, vice-jaws, etc.; shipping these to one of the government tool factories to be finished, hardened and tested. Such finished tools as are not required for the peace practice of the private shops can be either stored in government tool vaults till needed, or they can be deposited with the private shops.

There is one other advantage to this proposed production of all the important tools in government tool factories which also will tend to a uniform and high standard of product. The prosecution of this high-class tool manufacture will involve some considerable production in the government shops in thoroughly testing the equipment. This will develop a large corps of mechanics skilled not only in the making of these tools, but very familiar with their use and the requirements to be met by their output. This corps of specialists would be a source from which to draw inspectors and instructors for duty in the private shops.

SUGGESTS BUREAU OF PREPAREDNESS LIKE DEPARTMENT OF AGRICULTURE, ALSO CARD INDEX OF MEN

William Kent (written). The paper by Mr. Miller is excellent as far as it goes, and it might go a great deal further, but I understand that it is presented chiefly for the purpose of bringing out suggestions from the membership in regard to the general question of industrial preparedness. With this idea in view I beg to offer the following:

1 Why not have a General Industrial Staff or Bureau as a continuing body, out of politics, like the Geological Survey and the Bureau of Mines, to plan a national industrial campaign, doing the same service for the manufacturing and transportation industries of the country that the Agricultural Department is doing for the farmers?

2 A "form has been prepared for taking an industrial inventory." It relates chiefly to material resources, except that it includes lists of officers and directors of manufacturing corporations and lists of skilled workmen. Another form should be prepared, in order to get information for a card index of every engineer in the United States who is available for service in the Army or Navy or in any department of industry that can in case of need supply munitions, clothing, motor cars, aeroplanes or anything else that may be required by the Government. Should we be threatened with war, the first thing needed would be men of intelligence and experience who are

Let us at once apply measurement and standardization to all problems of material preparedness, so that each one of us can do his own work with all the might that is in him, knowing that the finished products are bound to be what is required.—Frank B. Gilbreth.

It is becoming perfectly clear that the principles underlying industrial and military efficiency are the same.—H. L. Gantt.

We must go deeper to make this work (which the Naval Consulting Board has begun) effective: we must bend our energies along the line of stimulating public opinion, so that our representatives at Washington will be impressed and take the necessary steps to make the whole question of preparedness a Government policy.—E. H. Peabody.

capable of supplying the Army and Navy with subsistence, transportation, inspection, and administration of shops, and men skilled in purchasing, contracting, industrial organization and the like. Should we be actually engaged in war, it might become necessary for the Government to "take over" any industrial establishment, any railroad, any ship, any automobile, any source of supply of natural products, such as coal mines or oil wells, and to "commandeer" the service of any man it might require for the operation of any of its establishments. For this purpose a competent board for the selection of the right man for each place is of the utmost importance, and this board should be supplied with a classified index of available men.

The form for the indexing of engineers should include name, age, nationality, health, record of education and experience, position now held, salary, positions capable of filling if the Government should command his services, position preferred, references as to character and ability, reasons, if any, why he should remain in his present position, and such other information as the Board might require.

3 In regard to gages, jigs and templates, I understand that much of the trouble that American manufacturers are having in furnishing munitions to foreign governments is due to the extreme, and in many cases unnecessary, refinement of the inspection, so that it is almost impossible to produce, with our present tools, goods that will satisfy the inspectors. Anticipating this difficulty in case our Government should need in a hurry vast quantities of munitions, we should have a Board of Inspection to review the specifications for every part of our munitions and make requirements which are reasonable and capable of being met by the available tools and manufacturing methods.

SUGGESTS LISTING MEN WHO, THOUGH INELIGIBLE FOR FIGHTING, COULD RENDER TECHNICAL SERVICE

Geo. R. Henderson (written). The point brought out by Mr. Miller, that for each man at the front, three are needed at home to prepare munitions of war, is a most interesting one, especially to those who, through age or physical disability, are prevented from entering the "trenches" or submarines; and it seems to me that in organizing for industrial preparedness, the engineer who may not be directly connected with a manufacturing plant should not be overlooked. There are many members acting in a consulting capacity, whose technical services would probably be of greater advantage to the Government than in digging trenches or shouldering a rifle, and I believe that these men should be listed, with their professional records, so that the very best use might be made of their services in the Navy Yards, Arsenals or other plants where mechanical skill is of the highest importance.

I would suggest to the Society's representatives on the Naval Consulting Board that they consider this feature as well as that of mobilizing factories, with their men and machines, so that all patriotic citizens would have opportunity to serve their country in time of need in a manner which would insure the greatest efficiency of the organization as a whole, and which would permit those who could not stand the rigors of active service, to perform their quota of usefulness.

ALSO ADVOCATES LISTING MEN AVAILABLE FOR WAR WORK

James A. Campbell (written). Members of the Society employing collectively several thousand mechanics could get signed statements from these men who would be willing in time of war to take positions in the large shell factories, or wherever machinists, etc., were required. These mechanics could be classed by their superintendents, so that firms requiring men could see from the lists the experience and class of men available. Committees could be formed for the drafting of these men so that there would be no loss of time in the production of munitions.

HAS PLAN FOR PLACING SMALL ANNUAL ORDERS FOR MUNITIONS WITH PRIVATE FIRMS AT ONCE

F. O. Hoagland (written). The shortage of arms and ammunition in this country, in case of immediate need, is very apparent; but it is however a fact that the great efforts in this line being made by private manufacturers would make it possible materially to change this condition at very reasonable cost, if proper steps were taken without delay.

The Springfield and Rock Island Arsenals are in good condition to turn out the .30 Springfield Army Rifles, and the Frankford Arsenal the ammunition for them in limited quantities. Arrangements are also under way to manufacture the .45 calibre automatic pistol and its ammunition at the same arsenals.

The Government has at times placed contracts for some ten million rounds of this small arms ammunition, divided between four or five private concerns in this country, but the quantities ordered have been too small to make it an object to go into the manufacture of ammunition very extensively, and no private manufacturer has made the .30 Springfield Army Rifles, nor has he any special tools, fixtures or gages necessary for making them. The conditions are about the same in regard to the .45 calibre automatic pistol as the concern which brought it out a few years ago for the Army service is the only private concern in this country equipped for its manufacture.

Judging from past experience and by the length of time it is now taking manufacturing establishments to get ready to fill orders for a product but slightly different from their regular lines, quick service is not to be expected unless several of these concerns are placed in condition to meet the demand. Orders for arms and ammunition of sufficient size to keep a small unit at work constantly should be placed with manufacturers without delay, in order to maintain the equipment in good repair and to have a number of trained workmen to form a nucleus for building up an organization in case of need.

Under the best of circumstances it takes from two to three months from the time the order is entered for the material to be prepared and the product to come through in fair quantities, even when having a suitable equipment and a trained organization.

For example, an order could be placed with each of four or five private manufacturers for, say, a minimum productin as follows, deliveries to be made mouthly:

2,500 — .30 Springfield Army Rifles per month
100,000 — .30 Calibre Cartridges " "
500,000 — Each .30 Calibre Shells " "
Bullets, Priming Cups and Anvils
5,000 — Artillery Brass Cases from 3 to 6 in. calibre per month and a similar quantity and calibre of projectiles, and up to 12 and 16 in. diameter.

Automatic pistols and heavy artillery guns could be handled in the same manner.

By loading a small portion of the cartridges only, just enough to check the production of shells and bullets, a fair supply of these latter could be accumulated and carried in

stock at a cost of one-half of the loaded cartridges. Danger of deterioration of the powder or primers would thereby be removed. The present European War has brought out very forcibly the seriousness of the condition when old ammunition failed to respond at the crucial moment.

Powder making has been developed to such an extent that with a fair supply on hand at all times the loading could be carried out at the government arsenals at a rapid rate and the troops supplied with fresh ammunition. Experience has proven that the supply of shells and bullets generally controls the output.

It takes about twelve months to prepare the special equipment of fixtures, tools and gages necessary for the production of, say 100 military rifles per working day, and about half that time to prepare for 100,000 cartridges per day, even when a factory has at the start a fair organization for similar work.

A good many months additional might be spent before manufacturing difficulties were overcome and a product turned out that would pass inspection.

The government arsenals could be of great assistance in preparing the special equipment of fixtures, tools and gages, but a few leaders and workmen in each plant who are thoroughly familiar with the requirements, are absolutely necessary in order to get quick and sure response.

It is very important that if anything is to be done in this line, it is done without delay before the ammunition and arms manufacturers break up their engineering organizations, as they have about completed this class of work in connection with the contracts now on hand and are about to get down to actual manufacturing. Having had some very costly experience in getting together and training an efficient corps of engineers, they may not be very anxious to go through this same experience again in the near future.

GIVES DETAILS OF MINIMUM ANNUAL ORDER CONTRACTS PLAN

H. V. Haight mentioned the following suggestions as to details in letting "minimum annual order contracts" in time of peace.

First. The Government should be the general contractor and let only sub-contracts. For example, if shrapnel shells are to be purchased, the Government should order steel from the steel mills, have it shipped to the forge shops to be forged and to the machine shops to be machined and assembled. Bullets should be ordered from the lead works, copper bands from the brass works, and so on. In this way, each man will undertake the work he best understands and the small shops will not be afraid of the work, because it will be simple both mechanically and financially.

Second. Shops should be encouraged to make their own equipment which might include even machine tools. In this way, the equipment could be rapidly increased in time of war. Of course, a set of inspection gages should be furnished by the Government but jigs, attachments, cutting tools and working gages will necessarily be special and adapted to the machine tools and methods of the individual shop. In time of war, it would be practically impossible to get these promptly from overworked tool shops or Government arsenals. Shops which are not equipped to make tools, jigs and working gages had better either get equipped or keep out of shell making, for the manufacture and upkeep of this equipment is such a vitally important part of shell manufacture that a good tool room is necessary. It will simplify the question of such equipment if each shop is given only one size of shell to make.

Third. The suggestion for a congress of ammunition manufacturers is a good one, but the dissemination of information as to methods of manufacture could be better served by arranging that manufacturers should visit each other's plants. A provision to this effect should be incorporated in government contracts. There is no doubt that a very considerable factor in the collective success of Canadian manufacturers of munitions has been the freedom with which they showed each other their shops and methods.

Fourth. As to the basis of payment, while "Cost plus a Fixed Sum" may be a fair basis for minimum annual orders, it is open to very grave objections as a basis of purchasing in quantity in time of war. The difficulty of determining the time cost is very great. The direct labor is not hard to determine but the calculation and distribution of the heavier item of burden and especially of depreciation is such that all methods may be considered mere rough approximation. The Government would need to detail an expert cost accountant for each plant. Furthermore, the cost would probably vary at least 100 per cent and it is a question if the country would be satisfied to pay one shop $1.00 and another shop $2.00 for the same work. The most serious objection, however, to "Cost plus a Fixed Sum" is that it would not give adequate incentive for low costs or large production. The Government can fix as low prices as contractors will take but, having fixed such prices, they should pay every one the same price and say "go to it." In placing war taxes, the Government might properly take a percentage of the net profits of all corporations as the Canadian Government is doing.

ADVOCATES GOVERNMENT OWNERSHIP OF DRAWINGS, GAGES, JIGS, TOOLS, ETC.

Frank O. Wells and Chas. E. Smart. It seems to the writers that we do not need big armies or big navies, as the present war has already demonstrated. What we do need in the way of preparedness to preserve peace is that our machine shops be equipped to manufacture munitions of war at a moment's notice. For over two years all the machine shops in the United States have been working for the Allies, for they had practically nothing else to do, yet even to-day, new designs for jigs and fixtures for this work are upon the drafting boards and new gages and tools are being made in hundreds of shops all over the country.

We believe that the following points should be well considered:

1 That the government should own all the drawings, books of instructions, gages, jigs and fixtures, in fact all the special equipment necessary to produce munitions of war.

2 Drawings and books of instructions worked out to the minutest detail should be in the vaults in all the arsenals and navy yards, ready to be distributed to the various plants at short notice.

3 Gages, jigs and special fixtures should also be in vaults in the arsenals to be given out with the drawings and books of instructions.

4 The operations and methods of handling the work necessary to make munitions of war should be standardized in order that the time of production, and hence the cost, will be the same in all sections of the country.

5 The present arsenals should be used more as experimental stations from which the private plants could get their instruc-

tions and information. There should be a number of private plants which should be given small yearly orders for parts which they are best adapted to produce, so as to keep their organizations familiarized with the product.

It has been shown that the weakest spot in the present war is the lack of ammunition. And in speaking of ammunition, we are not including small arms ammunition, but of the 1-in. to 16-in. calibre which is used by both the army and the navy.

Below are given some statistics of the time that it would take to get prepared and to make ammunition alone.

As a conservative estimate, it would require 50 engineers, designers and draftsmen at least 50 weeks to prepare the drawings for the 17 sizes of shells now used by the U. S. Army together with drawings for gages, jigs, fixtures and tools. To produce the latter would probably require 800 men, well trained and in well organized factories, at least 5 years, calculating 300 working days per year.

This would equip 100 factories, each employing 2,000 men, capable of producing a total output of 200,000 rounds per day. Twice this amount has been used in a single day in the present war by one of the combatants.

We have not mentioned the question of aeroplanes, rifles, battleships or a large number of other important parts of equipment which must also be provided for.

This all talks of war, but what nation would dare attack us, if it knew how well prepared we were? And we, as a peace loving nation, would surely never attack any other nation, and so perpetual peace would always be assured.

RECOMMENDS A THIRD ARM OF PREPAREDNESS—TRANSPORTATION

John Younger (written). The author deals largely, if not entirely, with the actual production of munitions of war. He sees a nation in arms as two vast bodies, one the fighting unit, the other the producing unit. My experience has shown me the tremendous importance of a third unit, the connection between the two,—the transportation unit.

We are exporting only a small percentage of the supplies used on the European battlefields and our transportation has not proved equal to the task. The situation is like the problem of a city's water supply. Many miles away is the big reservoir: Here is the city; how best shall we adequately connect them?

The mere building of railways in our immense territory would cost us a terrible price, which would render no adequate return in peaceful times. Even if they were built, their use would be of value only in very restricted areas. Germany, France, and Russia had all built strategic railways leading to, and paralleling their frontiers, but they did not stop at this. They also built good roads. They knew that every ton of freight carried on the railroad is sometime or other also carried on a road, and they took the precaution of having the road as efficient as the railroad.

Good roads are no luxury. They are not built for the motorist, who takes a week end spin for personal enjoyment. They should be built to link up the small villages, the communities and townships with the railway and the big city. A good road opens up new country to the farmer, who can carry his produce to market at a cheaper rate. A poor farm located on a good road is often a better investment than a good farm on a poor road. A good road is an economic investment in time of peace, and it is a sign of the times that the country is waking up to the fact.

In war times the roads are the first and last links in the transportation scheme. They carry munitions to the railway, and they distribute them from it. Each link in the chain must be of adequate strength. It is useless having a perfect railway, if it begins and ends in a bog. It is useless having stretches of perfect roads in New York State, if they be totally unrelated and unconnected with each other.

Great Britain, France, Belgium, Russia and Italy have bought from us vast numbers of motor trucks. They have taken making them themselves by the thousands, and still the supply is not adequate. Figures are not available, but I would estimate that France alone, on actual military service, is probably using 50,000 motor trucks. A vast army of men is kept exceedingly busy, making and repairing her roads. Actually munitions are being put on motor trucks in the industrial centers of England, carried along the roads to the desired port, thence the truck travels by steamer and completes its journey to the base depot along the roads.

The organization of our transport demands the attention of our engineering bodies, just as much as does the mobilization of our industrial resources. The standardization of our road systems, the standardization of the controls on our locomotives and motor trucks, so that men can change from one to another with all confidence, the education and discipling of numbers of men to the principles of transportation are all matters that can only be handled by engineering executives.

SUGGEST SOCIETY APPOINT SUBCOMMITTEE ON ORDNANCE MANUFACTURING TO ASSIST WAR OFFICE

Bernard M. Fine (written). The subject of Industrial Preparedness, while falling within the engineer's scope, should interest us, also, as citizens. As citizens we will have to meet the cost, and one good way to reduce it is to apply consolidated engineering experience and endeavor to put the design and construction of war material upon a basis similar to what is customary in the commercial field.

The time to do this is now, and it is really within the range of the Society's work to assist the War Office in modifying its standards for the purpose.

There is an argument for this sort of preparedness which should appeal to every engineer whether he is in favor of military preparedness or not. It can be made a powerful lever for improving industrial efficiency.—Fred E. Rogers.

In war, as now waged, the industrial force plays as important a part as the fighting force.—Bernard M. Fine.

A remarkable example of the interest the engineers are taking in this movement is given in New York City, where, in response to the call of the engineers to attend lectures on elementary principles of military engineering, given in the Engineering Societies Building, there was such a crowd assembled that many hundreds were turned away.—Charles Whiting Baker.

I would suggest that the Society appoint a Sub-committee on Ordnance Manufacturing to work under the jurisdiction of some of the other research committees. The field of this committee should be so broad that they undertake to secure and present papers not only on modified standards but on methods of supervision, jig, design, etc., and anything that will facilitate manufacture in time of need, and should even go so far as to organize a volunteer force of trained engineers to act as supervisors and inspectors.

To store in times of peace an amount of material equal to the needs of war would not be wise, but in times of peace let us educate ourselves to be adequate to meet this need. In war, as now waged, the industrial force plays as important a part as the fighting force. The industrial force must be officered by men trained in the peculiarities of munitions manufacture. This is the work of engineers and the Society should make the organizing of these men its business under an Ordnance Section and keep alive the work by requesting the presentation of papers on the subject to our meetings.

PROPOSES COUNCIL OF NATIONAL DEFENSE ON WHICH ENGINEERS SHOULD BE REPRESENTED

Alfred L. P. Dennis[1] sent a written memorandum of a plan for the Council of National Defense which he had proposed and which has formed the basis of an amendment of one of the Army and Navy bills now before Congress. This provides for the formation of a Council for National Defense and that it shall consist of nine members, viz.: three Cabinet officers, either two or four officers of the Army and Navy respectively, three experts in special fields, and an additional member as secretary. These last four could be appointed from the outside or be detailed from various government services. By coöperation, by steady investigation, and by careful study of historical and present conditions the materials for a continuous and constructive national policy for the future would be increased.

In relation to this, he stated that it would be a pity if a Council were provided which should not include representatives of the engineering and railroad professions and which might consist chiefly of the chairmen of various Congressional Committees and other regular Washington people. Of course, officers of the Army and Navy should be members of such a Council. But the questions which a properly organized Council of Defense would have to consider are so varied and so vast, that it would be a mistake not to have representatives of the engineers of such a board to do steady, constructive work when required.

ADVOCATES COÖPERATION BETWEEN GOVERNMENT ENGINEERS AND PRIVATE MANUFACTURERS

Arthur G. McKee. We have manufacturers in considerable number who are prepared, to a greater or less extent, to make shells, rifles and armaments of various kinds, but we have no organization and no nucleus of organization, as far as I know, which can coördinate, systematize and regulate the manufacture of the different items which enter into the schedule of preparation.

I think that the biggest problem that we have now confronting us and that we would have to solve in the case of the great calamity of a war, or a threatened war, would be the preparation of such an organization to bring together and schedule the different things that make up the requirements of the circumstances. It has been mentioned that shells were held up because they did not have the timing mechanism, which was in turn held up for the lack of a certain kind of screw. These are little things, but they are most important in working up a large quantity of material, and they multiply as we get into the different kinds and sorts of equipment.

For a considerable length of time after we seriously started to prepare for a war, I am afraid that the conditions would be chaotic. I therefore think everything possible should be done in the way of preparing machine tools and all other equipment for making the multitude of necessary articles and in addition a civilian organization should be perfected and every man thoroughly trained to do his part in the ordering, inspecting, assembling, testing and delivering in the field, of everything necessary from food to munitions.

It is a very general belief among manufacturers (whether justified by the actual facts or not) that specifications for army and navy supplies are often more drastic than the circumstances warrant and that the inspection of these supplies is unnecessarily severe. Coöperation between the government engineers and the manufacturers in the preparation of these specifications and in the actual inspection work should result in the elimination of any possible cause for complaint in this respect and bring the Government, the manufacturers and their engineers into complete harmony. It would at the same time train the civilian engineers to a much greater efficiency in case war should make their services necessary.

CONSIDERS EMPLOYERS SHOULD ORGANIZE INDUSTRIAL RESERVE, AND GIVES EXAMPLE IN OWN WORKS

Harry E. Harris. The program for Industrial Preparedness as it affects the engineering profession, and Industrial America as a whole, is well thought out and should be supported by every engineer and manufacturer. However, there is one point which is of vast importance and that is the outlined plan for organizing an Industrial Reserve. The labor conditions and troubles in foreign countries now at war have

To utilize the industrial resources of this country to the very best advantage, there must be a complete unification of all who participate. This can never be accomplished by the aid of a few individuals without the assistance of the Government of this country.—J. P. Brophy.

It is the duty of employers who are patriotically inclined and willing to give their support to their country to reach their men by individual talks.—Harry E. Harris.

The present war has demonstrated the tremendous advantage gained by the country that is able to start into the fight with effective equipment in sufficient quantity, and with the ability to provide at once the supplies necessary to keep the organization going.—Wm. B. Jackson.

[1]Prof. History, Univ. of Wis. Madison, Wis.

been a serious hindrance to the effectiveness of their offensive and defensive forces.

It is not only necessary to enlist the engineers and manufacturers, but it is necessary also to get the loyal support of every man who is a skilled workman and who is necessary to this country as such. Let these skilled employees know more about the plans of the Industrial Preparedness program, enlist their sympathies and obtain their pledge of willingness to be depended upon in case of emergency. Make them feel that in case America is called upon to defend herself their interests and their employers' interests are in a common cause, and that employers and men will stand shoulder to shoulder in such an emergency.

It is the duty of employers who are patriotically inclined and willing to give their support to their country to reach their men by individual talks, meeting them on a common ground, and obtaining their views and their willingness to enlist as members of the Industrial Reserve if called upon.

As an example of what may be done along these lines, a meeting of the workmen of the company with which the writer is connected has just been held, at which abstracts from Mr. Miller's paper were read and a general discussion invited; also the writer gave an impromptu talk. Men who, for various reasons, had neglected to take out their naturalization papers were earnestly advised to do all they could to get their intentions on record. An association was formed and the following resolutions passed:

"We, the undersigned, do solemnly and patriotically pledge ourselves to the defense of the United States of America in case of war against any enemy whatsoever."

"We have associated ourselves together as members of the Square Deal Industrial Volunteer Association, Employees of The H. E. Harris Engineering Co., and as native and naturalized citizens of the United States of America, and further voluntarily pledge ourselves to patriotically serve in the Industrial Reserve of the United States of America as skilled workers of The H. E. Harris Engineering Co., whenever called upon by the Government to do so, irrespective of our several religious, political beliefs, other associations, prior nationalities, antecedents or individual prejudices."

"This pledge and agreement is binding upon the Square Deal Industrial Volunteer Association as a whole, but any member leaving the employ of The H. E. Harris Engineering Co., and being released from his membership in the above association prior to the call of the United States Government, is also automatically released from this pledge."

The men evinced a hearty interest and exhibited a large share of patriotism, and demanded permission to sign at once, with the exception of one or two unskilled men who were desirous of joining either the Navy or the Army in case of war.

SAYS SOCIETY SHOULD COÖPERATE IN STUDYING CAUSES OF WAR

D. Robert Yarnall said he would feel very sorry to have the Society fail to include in this discussion one constructive thought which seemed to him necessary at this time. If the engineer does nothing else in his professional work, he analyzes the causes of trouble, and then, acting on this analysis, attempts to eliminate them. In this problem of industrial preparedness, commendable as it is from the standpoint of national defense, it seemed to him that quite as important at this time would be the study of and the elimination of the causes of war.

As a member of the Society, he would like to see a committee appointed to coöperate with other institutions which are engaged in the study of and the elimination of the causes of war. This question of industrial preparedness and the preparation of the industrial inventory may be desirable steps, but hand in hand with them he would like to see the Society enter into this even greater constructive work.

CONSIDERS DEVELOPMENT OF SHIPBUILDING FACILITIES AND MERCHANT MARINE IMPORTANT ELEMENTS

Henry A. Wise Wood[1] wrote in advocacy of the development of the shipbuilding facilities of the nation and of the merchant marine as important elements in Industrial Preparedness. Our shipping facilities should be great enough, not only to supply the great navy which we may need, but also the merchant marine which such a navy would require in times of war.

Our naval preparedness should include the upbuilding of such a merchant marine, not only that we may have it for use in war, but that in times of peace we may gather into our own hands our own overseas carriage of goods. The fleets of foreign nations built from the profits upon the carriage of our own goods will become in times of war our greatest menace because it is by means of those fleets that the trained troops of an enemy can be delivered upon our shores.

RECOMMENDS GOVERNMENT FACTORY TO CONSTRUCT JIGS, GAGES, TEMPLATES, FIXTURES, ETC.

Harold V. Coes. It seems to me that one of the vital elements necessary for the proper carrying out of the plan is for the Government to construct in its own factory under its own jurisdiction, and in accordance with its own standards, the necessary jigs, templates, gages and fixtures that are required and that are adaptable to special or standard machine tool equipment, and either to rent them or loan them or sell them to those manufacturers who are equipped and who signify their intention to manufacture shells, rifles and other war material of this character for the Government.

I think there is no doubt that the British Government in its present crisis would have been much further ahead with its plans if it had been able to send necessary jigs, templates, gages and fixtures to those manufacturers in this country who are making munitions of war for the British Government. The jigs, tools and fixtures which rifle manufacturers in this country use were of practically little use when it came to making the Lee-Enfield; consequently it would appear extremely desirable for us to profit by this lack of foresight on the part of one of the powers now engaged in the present world cataclysm.

THE EUROPEAN WAR. SOME LESSONS DRAWN BY THOSE WHO KNEW CONDITIONS AT THE OUTBREAK

H. L. Gantt. In considering the subject of preparedness, either for peace or for war, it is imperative that we learn as quickly as possible the lessons which are being made clear to us by the developments in Europe.

In order to do this, we must ask ourselves why it is that Germany has shown so much greater efficiency, both from a military and an industrial standpoint, than have the Allies.

It is becoming perfectly clear that the principles underlying industrial and military efficiency are the same and that, if a nation is to be efficient in a military sense, it must first be efficient industrially.

[1] 25 Madison Ave., New York City.

We have talked efficiency in this country for several years, and many books have been written on the subject, but many of us feel that the actual results so far have been lamentably small; and that we should be much more nearly in the class with England than with Germany if we were suddenly confronted with her problems. It would seem, therefore, that we should find the fundamental reasons why England presented such a strong contrast to Germany, and see if we cannot learn something therefrom.

It is only a short time since England led the world in the arts, but recently Germany has demonstrated her superiority to both England and France.

We must ask ourselves how this happened. It would seem to be something in this wise: The financiers of England, feeling that wealth could purchase whatever was needed for themselves and their national life, have devoted their energies for a number of years to securing the wealth which was produced by others rather than making strenuous efforts to produce it themselves. In this attempt they have sent abroad millions of dollars to develop industries in foreign lands, which brought them great returns.

The leaders of Germany, on the other hand, not being able to exploit foreign peoples to the extent which was possible in England, turned their attention to developing their own resources, and the ability of their own people.

When the supreme test came, Germany was found to be a nation of people who, in general, knew what to do and how to do it; while the industries of England were, in too many cases, controlled by people who understood only their commercial side.

We, following the footsteps of England, have regarded financial strength as the most important strength; forgetting the comment which the ancient philosopher made to the rich man who boasted of his possessions, when he said: "What availeth all thy wealth? He that hath better iron than thou will come and take away all thy gold." In those days *iron* meant weapons. Today iron may be taken as the symbol of both weapons, and tools of industry, and the statement is just as true today as it was two thousand years ago, that he that hath the better tools is more powerful than he that hath the wealth.

The move, therefore, to get the engineers of the country working together for preparation is a most hopeful sign, for in the strenuous times in which we are living wealth may be of little more value to us than it would have been to Great Britain, but for the twenty miles of water which separated her from the Continent of Europe.

On the other hand, the power to do things cannot be taken away from us. The greater that power, the more important will its possessor become, as we realize the real meaning of the titanic contest which is now going on in the world.

The man who knows what to do and *how to do it is pre-eminently the engineer.* The new world, therefore, which is being ushered in by the great struggle now taking place is one in which the engineer is destined to be the supreme power, for it is becoming increasingly clear that, in future, the man who *owns things* will not be as important a factor in the world as the man *who can do things.*

CITES PRESENT WAR TO SHOW GOVERNMENT MUST COÖPERATE WITH MANUFACTURERS

Wm. B. Jackson. There is a tendency for many who have not given the matter considerable consideration to feel that the Government of the United States should place itself in a position to own its own manufacturing establishments capable of fulfilling all of the requirements of preparedness.

The sooner such an idea is rooted out the better, since at best the Government itself can own and operate only what might be considered sample establishments for the production of the materials and supplies which would be necessary in case of a serious attack upon this country. Were the United States to be attacked by a formidable foe, it would require the most intense activity of any reasonable development that the Government might have in the line of the manufacture of munitions and supplies together with the most intensive activity of every private manufacturing establishment that could be pressed into the service. The present war has demonstrated the tremendous advantage gained by the country that is able to start into the fight with effective equipment in sufficient quantity and with the ability to provide at once the supplies necessary to keep the organization going.

Manufacturing establishments do not feel safe in making broadly conceived and comprehensive plans for assisting the Government in case of trouble, owing to the possibility that the Government itself may enter their fields of activity and take away from them the business which might with propriety come to their hands during the periods of peace. It would appear that this move on the part of the Government to work up a thorough census of the industrial possibilities of our country should lead to the development of a plan whereby our manufacturing establishments may be brought into hearty coöperation with the Government with profit to both the manufacturing establishments of the country and the Government.

ATTRIBUTES SLOWNESS IN PREPARATION IN PRESENT WAR TO LACK OF DRAWINGS, GAGES, TOOLS, ETC.

Fred E. Rogers (written). A very large munitions plant would be required to run steadily for a year to turn out the shells fired by the Allies' guns in one day on the western battle-front. To provide the millions of shells they have used has required the united efforts of thousands of manufacturing plants. But these plants had to be provided with drawings, tools, gages, jigs and fixtures and plans of operation before they could begin to produce. It has been due to their lack that Great Britain has been so slow in getting ready.

Take, for example, the manufacture of military rifles. This is a complex process requiring special skill and experience, and with the exception of our government arsenals there was, at the outbreak of the present war, perhaps not one plant in the United States properly equipped and manned for manufacturing military arms that would pass the rigid test prescribed by government inspectors. There are about 800 principal machine operations involved in making the parts of the simplest military arm, including the wood stock and hand guard. Many of these operations require special machinery and practically all the parts must be held in jigs or fixtures while machining. When we consider the fact that to provide equipment for an army of one million men, from two million to three million rifles are required, the size of the task of equipping an army of a million with shoulder guns alone becomes apparent. What the condition of this country would be in a sudden emergency, we can only guess. Judging from the experience of some of our ill-advised manufacturers who undertook to make shells, it would be one of great confusion and enormous waste.

An idea of what it means to prepare for the manufacture

of rifles may be had from the fact that there are 55 operations on the receiver[1] of a Spanish Mauser rifle and several hundred jigs are required for each unit of a plant producing 200 rifles daily, and the same applies to the gages. Data concerning their production must be prepared by experts but considerable experience is always required before satisfactory results can be obtained. That such elaborate plans pay is known from the fact that a rifle complete with strap, bayonet and scabbard can be produced with less than twenty man-hours labor.

Comprehensive plans should be prepared for the manufacture of shrapnel, high-explosive shells, cartridge cases, rifles, field guns and all the varied equipment of war. Every step of the operations should be laid down, specifying in each instance the tool and the machine on which the work should be done and the limits of accuracy required, including an estimate of the possible production. It will be a great undertaking, but how much better it will be to spend a few million dollars working out plans to provide means for industrial mobilization and rapid production than to run the risk of a complete smash-up in time of stress.

It is true that all plans, tools, jigs, fixtures and methods of operation will become obsolete when improvements in the means of production and arms are developed, as they certainly will be, but is it not better to face this certainty and be ready to reconstruct the means of production and keep them up-to-date rather than to spend several hundred million dollars in the manufacture of those munitions which themselves become obsolete and practically worthless in a few years.

There is an argument for this sort of preparedness which should appeal to every engineer whether he is in favor of military preparedness or not. It can be made a powerful lever for improving industrial efficiency. It is unfortunately true that many of our manufacturing plants are working far below their possible efficiency. They employ penny-wise and pound-foolish methods of production; their men are not trained to understand the basic principles of interchangeable manufacturing. Gaging systems are inadequate and incomplete; data on the life of gages are wanting as well as the number required for any given unit of production. There is, too, a lack of the coöperative spirit so absolutely necessary to success in any great trade or military emergency. Those emergencies will surely come to the United States, though, we trust, in the trade sense only. It will be only when we have coöperation in the true industrial sense that we can face with confidence great national emergencies.

[1] See *Machinery*, April 1916, page 655, in which every machining operation is specified and the types of machines and tools; the production per hour is given and the number of machines that each man operates, etc.

Engineers might render their best possible service at this time by suggesting such improvements in organization as would result in getting more for the money and effort expended than is at present received.—Fred J. Miller.

The best service that a Board of Engineers can do for this country will be to take care of the big things, and let the little things be done by somebody else.—Charles Whiting Baker.

Why not have a General Industrial Staff . . . doing the same service for the manufacturing and transportation industries of the country that the Agricultural Department is doing for the farmers?—William Kent.

DISCUSSES MILITARY RIFLE MANUFACTURE IN LIGHT OF REQUIREMENTS IN PRESENT WAR

K. A. Juthe (written). There are many different sides to the question of preparedness, and one of them is that of military rifle manufacture.

The present industrial activity in small arms or military rifles and ammunition has brought out several factors that seem to warrant a general discussion. When hurry-up orders for rifles began to come to this country over a year ago, the manufacturing interests were totally unprepared to take care of them, and they, and particularly their engineers in charge, were confronted with the unique and at the same time serious situation of being unable to secure both the number of skilled men for the preliminary work and the necessary material of the high standard required by the different governments. From the statement that orders for from 1,000 to 5,000 complete rifles per day were placed with different manufacturers, the magnitude of the problems which arose can hardly be comprehended, but the following considerations will show in which particulars we were worse off at the outset than any superintendent or engineer in charge of such work had ever thought possible.

The gage problem was one of the greatest magnitude, as it was found that it would take at least 300 first-class gage makers six months to furnish the first working set, inspector's set and the master set necessary for guns in quantities; and when 1,000 complete rifles per day is figured on, it means that the working sets must be increased from one to ten and the inspectors' sets from one to five, keeping the master set simply for reference. It was shown conclusively that among the total of practically 2,500 to 3,000 first-class gage makers in the country there was no adequate means of tackling several different propositions at the same time.

In regard to tool making, it was found that the jigs, fixtures and small tools required would take a small army of toolmakers. It would take at least 1,000 toolmakers one year to furnish tools of this kind for the output of 1,000 rifles per day. Therefore, should our government require, say, 5,000,000 rifles, or 1,000,000 rifles per year, our tool plants would be taxed to the utmost.

The suggestion put forth in Mr. Miller's paper for a central plant wherein tools and gages could be manufactured and sent out to different plants is one to which engineers should give careful consideration. No manufacturing can be started until gages have first been made. The manufacture of the gages should, however, be carried out in one plant laid out for that particular purpose and under the supervision of one head, as it would be necessary that all gages bear the same relative characteristics.

The proposition of toolmaking under central supervision, however, both as regards small tools, jigs and fixtures, is an entirely different one. Jigs and fixtures are largely made by individual concerns to suit their own particular machine tools

for rapid interchangeable production. As practically no two tool manufacturing plants have the same facilities, it is practically impossible to standardize tools for making the jigs and fixtures, and the latter would be of no value unless they were interchangeable under the majority of conditions existing.

Approximately five distinct and separate rifles are now being manufactured in this country. It would seem as though the engineers of the United States Government could design a gun, in the manufacture of which a great deal of the machinery and tools now in use could be used with equal facility; at the present writing the rifle adopted by the United States Government is so different in sizes of parts as to make this impossible.

There seems to be a necessity for a standardization of parts, or, at least, for some method whereby tools could be made up and jigs and fixtures made suitable to fit the conditions existing at each of the large manufacturing plants now engaged in similar work. These could be kept in stock, and as soon as occasion required they could be handed over and manufacturing could proceed with practically no stop, excepting the necessary adjustments and preliminary inspections.

This is only a rough outline of what the writer has in view insofar as the situation for actual manufacturing is concerned. There is ,however, another point pertaining to getting the raw material into shape for an actual manufacturing proposition. The materials specified by each government vary largely in analysis and physical requirements. In some cases such requirements are more than a ballistic test has shown necessary as a factor of safety. It is easy by heat treatment to get steel of a certain analysis to meet the required physical specification, but manufacturers have a specification of their own which reads that all steel furnished must possess machining qualities within certain limits. At the present writing, the steel mills are doing splendid work in furnishing steel to requirements, but when an overcrowded condition, careless handling or unknown quantities creep in amongst the billets we are confronted with what we term a "dirty steel," and although all requirements as to physical qualities can be met, drilling and rifling a barrel becomes a serious and heartbreaking problem, as it is impossible to perform these operations satisfactorily if any dirt or a slag deposit is encountered in the center of the steel.

The following factors have already been thoroughly demonstrated as entering into the making of a standard high explosive rifle:

1 Analysis of steel necessary.

2 Manufacture of such steel with minimum waste

3 Forging or rolling of rifles without harmful effects to the steel.

4 Heat treatment of rifle barrels to give the high physical properties required with a high degree of machining qualities. The small parts of the rifle can be readily taken care of as far as hardening and heat treatment are concerned.

Also the following matters need very careful consideration, especially as they are not at present in a very satisfactory condition:

1 Design and standardization of parts

2 Design and manufacture of gages

3 Design and manufacture of interchangeable tools, jigs and fixtures

4 Supply of a proper quality of kiln dried lumber for stocks.

POINTS TO WASTE OF LESS COMMON METALS IN WAR AND CITES REMEDY IN BILL OF MATERIAL

Percy E. Barbour[1] contributed an interesting account of the prodigious waste of the less common and semi-rare metals in the war. Cartridge brass for use in making cartridge cases must necessarily be composed of the best brands of copper and zinc because the drawing of cartridge cases is the severest test to which such metal can be put. But specifying high-grade copper, zinc or brass for everything required in military work is wholly uncalled for.

For example, in the manufacture of shells the British have been using a brass plug for closing the opening in the nose of the fuse temporarily between the time when the shell is completed ready for shipment, and the time of its fusing prior to the action in which it is required.

The 4½-in. high-explosive shell manufactured in Canada has a brass plug which weighs 10½ oz., is very carefully machined and threaded and screws into the nose of the projectile easily by hand, but has a square recess in the top for the insertion of a square-end wrench in case it cannot be unscrewed by hand. When the shells are fused in the battle area, these plugs are taken out and thrown away and are a total loss. If 1,000,000 shells are fired in one engagement in one day, some idea can be formed of the prodigious waste of war, so far as this item of copper and zinc is concerned. The same shell also has a copper rotating band near its base and has a time detonating fuse of brass in its nose, both of which are converted into hundreds of pieces on the explosion of the shell.

There is no valid reason for making these temporary plugs of the most expensive material available, and evidently this has dawned upon those at the head of the munitions manufacturing department in England, because wood plugs are now being used in place of the more expensive metals. Recently a manufacturer of war material was approached for a bid on a large number of these nose plugs. His figure, scaled down to the minimum, was more than a million dollars. This price being unsatisfactory to the representative of the foreign purchaser, the bidder made an alternative figure, which was less than 1/400 of the first, if he were allowed to make the plugs

[1]Eng. & Min. Journal, New York City.

The biggest problem that we have now confronting us and that we would have to solve in the case of the great calamity of a war, or a threatened war, would be the preparation of an organization to bring together and schedule the different things that make up the requirements of the circumstances.—Arthur G. McKee.

It is becoming increasingly clear that, in future, the man who owns things will not be as important a factor as the man who can do things.—H. L. Gantt.

Your action is a patriotic one, and a needed step in the right direction, for it will show us some of our weaknesses and give us a better idea how to remedy our defects.—Major W. Goff Caples.

out of wood. The turning of these plugs from wood and the cutting of a satisfactory thread on them is said to be one of the most difficult manufacturing details, but they are now being turned out and used and so far as is known with perfectly satisfactory results.

We have it from an authoritative source, that one reason why the Russian supply of ammunition was so slow in coming forward early in the war was because, prior to the exigencies of the recent campaigns, the Russian specifications required that all of their projectiles be nickel-plated and neither the time nor the nickel was available for fulfilling these requirements on the vast number of shells that were being expended on the battle front. Nickel-plating the projectile of course reduces the wind resistance, but it is probable that grinding and polishing, which can be done so cheaply by American methods, would accomplish the same result.

As an effective means of reducing these wastes of valuable materials, which, while they are often minor items, yet in the aggregate are very large, the writer suggests, quoting from an editorial in the *Engineering and Mining Journal.*

The army general staff should determine the number of men to be put into the field in the worst possible contingency. It should draw up a complete bill of material for the supply of such an army, which, with the specifications, should then be referred to the U. S. Naval Consulting Board, representing the engineering societies, and by it should be cut up and distributed among the engineering societies—the metallurgical parts to the metallurgical engineers, the mechanical parts to the mechanical engineers, the chemical parts to the chemists, and so on. Those bodies would then subdivide things among their specialists. They would scrutinize the specifications, finding out whether certain things likely to be troublesome or costly were prescribed by reason of necessity or by reason of tradition; they would suggest substitutes and improvements. Having determined what was really needed, they would formulate plans for the supply of it, making a survey of the industries, listing industrial plants, etc., and recommending steps for the filling of gaps.

ILLUSTRATES NECESSITY FOR STANDARD MACHINE TOOLS AS SHOWN BY WAR. ENUNCIATES PRINCIPLES

L. P. Alford (written). Mr. Miller, in his excellent outline of the need of organizing for industrial preparedness, points out that consideration should be given to machine tools from several aspects of their design and supply. The importance of these machines in time of war is strikingly proved by comparing the machine-tool exports from the United States for the calendar year 1915 with the record of the best previous year in our history. In round figures, $42,000,000 worth of machine tools were shipped during 1915, while the highest preceding yearly record was about $16,000,000 worth.

But little is known in this country of the methods that Germany has employed to build and maintain the machine tools necessary to produce her munitions of war. On the other hand, there is considerable information available in regard to the methods employed by Great Britain and France. Thus it is from the experiences of these latter named countries that we can formulate the principles of action to govern the design, purchase, production, and distribution of machine tools which must be carried out in preparing for a national emergency of war.

The machine tools shipped abroad during the past 20 months analyze into three general classes. *First*, simple, plain machines that were either standard with certain manufacturers before the outbreak of war, or have been designed and built under the stress of the tremendous foreign demand. *Second*, regular machine tools of a more highly organized grade, particularly automatic machines that were the standard product of some manufacturers prior to the outbreak of war. ***Third,*** special machine tools developed for some operation or series of operations in the manufacture of some particular detail of munitions, and grouping into: (*a*) lathes for the outside turning of shells; (*b*) lathes for boring shells; (*c*) lathes for waving, grooving and undercutting shells. The first class comprises by far the greater volume of the exports, and simple lathes are the predominating machines. In like manner, lathes predominate in the third class.

The methods adopted by Great Britain, France and Russia in buying these machine tools need brief consideration. The early orders were placed by European machine-tool agents who had handled American machine tools for years and whose knowledge of the business gave them the first entrance into the field. These dealers' contracts were followed by others given by special agents or government commissions who came over to this country during the first year of the war. These orders brought about a condition of scarcity of machine tools in the United States, and at the same time filled all the regular machine-tool building plants with such a volume of business that deliveries in many cases have been seriously delayed. The third class of buying has been by government commissions in shops making high grade machinery other than machine tools, as printing presses and woodworking machinery, and in general have been for machines of the third class previously mentioned. Their buying has been most ably managed, and the results of their work has been more uniformly successful and satisfactory than that of any of the private buyers.

The private buying, that is, the buying done by machine-tool dealers, can be roughly divided into three periods. During the first period simple lathes and turret machines were bought almost exclusively. The demand during the second period was for grinders, drilling machines, and millers. The demand during the third period was for planers, shapers and toolroom machinery.

After learning from the hard school of experience, it is now realized that toolroom machinery should have been bought during the first period. The reason is obvious, for such machines are needed to produce the jigs, fixtures and gages which are the necessary accompaniment of machine tools for duplicate production.

In case of war with a first-class power, the United States would unquestionably need to add an enormous number of machine tools to the present equipment of her machine shops. Based on the record of the years immediately preceding the outbreak of the European war, the normal surplus of machine-tool production of the United States, as represented by the amount shipped abroad, has a value of about $15,000,000. This supply would naturally be kept at home, but in addition thereto we would have to draw from the industrial nations of Europe, provided we were not involved in a European war. This buying would have to be done by some organization not now in existence, for the reason that there are only a few agencies in this country that market European machine tools here.

Thus, the European buying for the United States would have to be placed in the hands of experienced men, perhaps civilians representing both builders and users. The present British Ministry of Munitions with its sub-committees might well form a model for the American organization charged with the duty of buying machinery abroad. There are facts that tend to prove that the work done by the British Commission

has been most efficiently handled, and has brought excellent results. This is an experience well worth careful weighing.

As already stated, but little is known of the conditions that have surrounded the machine-tool industry in Germany during the war. However, at the outbreak of war edicts of the Ministry of War placed a prohibition upon the exportation of machine tools as one of the items in a list of articles that might be of value to the enemy. As the war progressed, the Ministry formed two committees, one the War Raw Materials Committee, and the other the Industrial Committee. These Committees have controlled the machine-tool building industry as well as other German industries. They have directed what machines should be built and where they should be built, have handled the supplies of raw materials for machinery building, and have arranged for the distribution of the new machines as well as other machines that could be released from their regular employment.

It is reported that France mobilized the machine tools of the Republic as one of the early war measures. The purpose was to bring together the machine-tool equipment into units of such a size that manufacturing could be carried forward expeditiously and efficiently.

Thus from the experience of Great Britain, Germany and France, the necessity of controlling the supply and distribution of machine tools is evident in case of war between first-class powers.

No exact estimate can be given of the number of machine tools that might be immediately available in Germany in case there should be an emergency demand from the United States. A careful estimate for Great Britain, however, is that under normal conditions there are some 1,200 to 1,500 lathes in the stocks of dealers and builders at any normal time. In any event, it is fair to assume that the stock of machine tools in the possession of dealers and builders in Europe would not be very great, and, in fact, would be a very small factor in the number that we would be liable to need. Accepting this situation as a starting point, a decision can be made as to whether the nited States should buy standard machines regularly manufactured abroad, or order special machines particularly adapted to our own needs.

Mr. Miller has pointed out the necessity of standardizing machine tools. If they are to be standardized for our own makers and needs, it follows that the machines brought from Europe should be uniform with those produced here. Without question, machine tools should be standardized, and the motive of industrial preparedness should be sufficient to inaugurate the study and work of standardization at once.

From the experience of the allied nations in purchasing machine tools during the past 20 months, it seems justifiable to lay principles for the standardization and procurement of machine tools in organizing for American industrial preparedness. The first of these are:

1 Organize at once, in skeleton form, an industrial committee to control the standardization, design and preparation of machine tools for the production of American munitions.

2 Through joint action of this committee, The American Society of Mechanical Engineers, and the National Machine-Tool Builders' Association, standardize the details of regular machine tools and design whatever additional special machine tools may be necessary for the rapid and economical production of American munitions.

3 Immediately on the outbreak of war, prohibit the exportation of any machine tools from the United States.

4 Immediately on the outbreak of war prohibit the importation of any machine tools into the United States except under license and control of the committee mentioned under 1.

5 Order all machines abroad through this committee or its representatives in the capitals of Europe, and entrust these men with the responsibility of securing the desired deliveries and quality.

6 Order no machine tools abroad except to standardized American designs, either for the complete machine or the essential details as the committee may determine.

The subject of standardization of machine tools was thoroughly talked over at a convention of the National Machine-Tool Builders' Association a few years ago. However, as that body is a business rather than a technical organization, no efforts have been made to bring about uniformity. The suggestion has been offered that this work of standardization should be done jointly by The American Society of Mechanical Engineers, the Industrial Committee outlined in this paper, and the National Machine-Tool Builders' Association. I believe, however, our Society should initiate and prosecute the work.

Subsequent to the presentation, Mr. Alford presented a motion, which was duly seconded and carried unanimously, that the Council be requested to consider the advisability of appointing a Standardizing Committee for Machine Tools, in view of the necessity for standardizing our industrial resources for war.

FROM PERSONAL EXPERIENCE IN CANADA SHOWS NECESSITY FOR MODEL MUNITIONS PLANTS

Chester B. Hamilton, Jr. (written). The writer is too busy right now producing munitions to go into this matter as it deserves, besides being rather too close to the subject to get a proper perspective. There are, however, several matters which might be added for consideration from the experience of one who has been through this strenuous war time organizing.

1 During the period immediately following a declaration of war there would likely be a considerable interruption to business with consequent disorganization. Following this the shops that got started to work on war materials first would promptly gather to them the best men from their neighbors. This would leave some plants in a very bad condition. The writer has noted this especially in the case of leading hands and sub-foremen, some shops being practically stripped. Means should be provided to compensate for or offset this.

2 Somewhat similar to the above is the necessity for providing understudies for the more important men in the plant. This is generally appreciated, but its need is felt a hundredfold in war time.

3 A skeleton of an inspection organization would be provided in advance by a wise government, thus eliminating innumerable troubles that arise when a lot of slightly informed and hastily got together inspectors are given power.

4 One or more small model plants should be maintained for each of the principal classes of munitions and should be worked actively under an approximation to war conditions. The size should be the minimum economical unit for the machinery involved. One of the greatest hindrances to Canadian munition manufacturers in getting started was the lack of an efficient and up-to-date sample plant. We had no idea at just what speed the different operations could or should be performed until we found out by months of work.

5 In placing "Minimum Annual Orders" or other form of government subsidy for preparedness, attention should be paid to the necessity for room for plant extension. A certain proportion of the subsidized firms will fail to make good when put to the supreme test. Others will do exceptionally well. It is absolutely necessary that those succeeding promptly, due to superior organization or brains, should enlarge and extend, again and again, until they have taken up and carried the load of their weaker fellows.

6 Following on the above two other points must be considered:

a Financial assistance for plant extension should be promptly furnished to those shops which have made good in production and efficiency.

b There should be some central control over employment to prevent one shop unnecessarily stealing operatives from another, as its necessities increase, instead of training its own.

7 Payment for munitions should be made partly in the form of government bonds. If some of these were in small denominations, employees would likely invest in them. Perhaps I am astray in this last suggestion. I can only speak of those I know. Our best are Scotch.

8 As to a profit limitation, and payment on a "cost plus" system, why not consider something akin to the ordinary premium or bonus systems of wage payment, by which a contracting firm would get a greater percentage return, or greater profit per unit of product, in proportion as the cost per unit was reduced by efficient production.

GIVES EXAMPLE OF RAPID ORGANIZING FOR MUNITIONS BUSINESS IN PLANT IN SOUTH

Harrington Emerson. I would like to tell you of an experience that one of my friends had with a munitions plant he organized just a year ago. This plant was in the South, not in the North. There were no buildings; no machines; no employers. My friend told his assistant that they would subdivide the work; that he himself would look after the equipment, getting the buildings up and securing all the necessary machinery, much of which had to be designed, and that it would be the assistant's duty to have the men ready to go to work when the time came.

The assistant sulked at first, as he had no desire to be sidetracked in that way, put on the job of employing men when he had expected to do executive work; but the head of the concern said to him: "You seem to miss the whole point. You don't know that you have the biggest job that was ever offered to any man in connection with this work; you don't seem to know that you have got to examine and list for this plant over 20,000 men in order that we may pick from them 2,000 of the kind that we need. What I expect of you is that when I call for the men you will have them ready."

That woke the young man up to the importance of the undertaking assigned to him. He went out into the country, north into Pennsylvania, to Harrisburg, Reading, Lebanon, Hagerstown, and south into North Carolina and as far as Georgia; and he collected the names of a great number of farm boys, boys who knew how to handle tools, to mend harness, repair farm machinery, sharpen a ploughshare, do carpenter work about the house, boys that were versatile if as yet crude mechanics. These boys were investigated as to their ancestry for two generations back, and owing to the war difficulties they applied the principle of selection to a greater degree than I have ever seen it applied before anywhere, except, perhaps, for admission to West Point and to Annapolis.

These boys were there when they were wanted and were brought into the plant when needed—some 1,600 in all. The foremen had been told in advance what they were to do and they were prepared for the recruits. They gave to each one, two or three days of special instruction, each foreman having been obliged first, to demonstrate his own ability to run each machine in his department and to turn out satisfactory work, the plant having been run by the foremen on a small scale for a few weeks before the recruits came in.

The boys were put on the jobs, and in less than a week they were "making the foremen hustle," as one of the foremen told me, and the manager told me that in all his experience of many years as the executive head of one of the largest plants in the United States, he had never brought together so good, so able, so efficient a set of workmen as he had in that plant within three months. This shows there is abundant opportunity to find in America the raw material if we go about it in the right way.

Should we be actually engaged in war, it might become necessary for the Government . . . to "commandeer" the service of any man it might require for the operation of any of its establishments.—William Kent.

There is abundant opportunity to find in America the raw material (to produce efficient workmen) if we go about it in the right way.—Harrington Emerson.

In case our Government should need in a hurry vast quantities of munitions, we should have a Board of Inspection to review the specifications for every part of our munitions and make requirements which are reasonable and capable of being met by the available tools and manufacturing methods.—William Kent.

ALSO DRAWS LESSONS FROM CANADA REGARDING MUNITIONS MANUFACTURE

Ralph E. Flanders. During the early part of the European war my firm was quite familiar with conditions in Canada. There were a number of points in connection with our experience which would be useful on our side of the boundary.

One of the great difficulties was in getting gages. Mr. Wells treats of this subject in a written discussion, so I will say nothing about it, except to indicate that the difficulty was extremely serious, accounting in some cases for delays of many months. The rapidity of wear of gages in constant use was also much more severe than had been expected.

The second difficulty was the lack of coördination in the furnishing of materials and supplies. Conditions were the same

as if in a manufacturing establishment one department should get ahead of another. The makers of shell bodies, for instance, were sometimes months ahead of the makers of fuses; also fuses were held up for a small screw. It will be necessary to pay particular attention, possibly by means of a special committee, to this matter of coördinating the production of the separate parts.

An exceedingly favorable thing in the Canadian manufacture of munitions was the hearty coördination of all the firms engaged. There were no secrets in their shops. It was a requirement of the Shell Commission that every one who desired to engage in the manufacture of munitions should be privileged to see what every one else was doing. While the whole country was ignorant and unprepared at the start, in a remarkably short time the necessary information was spread to every corner of the Dominion.

Conditions are quite different in our country where munition manufacture is kept more or less secret in private plants. This is even the case at the present time at the Frankford Arsenal, unless conditions have changed recently. This is a bad condition. It is not necessary that the arsenals should be thrown open to every one, but it is advisable that every one who may be called upon to manufacture munitions should have free access to the government arsenals.

Canadian experience would indicate the impracticability of standardizing methods, at least, so far as the making of shells is concerned. The demand is so tremendous that the problem cannot be approached from the ideal standpoint. Every imaginable kind of tool has to be used. For instance, the finishing of the inside of a shell may be done on the engine lathe, the hand turret lathe, the automatic lathe, the drill press or on special machines made for the purpose. It would be folly to confine the doing of this work to any one machine and leave the resources of the other machines untouched. I am inclined to think we should go slowly in the matter of standardizing too closely the processes of shell making, or we will greatly cut down our rate of production.

Another interesting point is the possibility of improvement in design. There are two sides to this subject. The machine shop man who undertakes munition work meets a large number of apparently foolish restrictions. After he understands the problem better he finds that many of these restrictions are not foolish, but are necessitated by the unusual requirements of the case. There are some directions, however, in which it is possible for the ordnance designer to come more into line with the manufacturer. As an example there may be mentioned the question as to when the shell should be heat-treated. The classical method followed on the English shell and by our own Government is to treat it in the blank immediately after forging. Under pressure from the manufacturers it has been found possible, so far as the English shell is concerned, to leave the heat-treating until the final finishing operation on the outside, thus greatly increasing the output of shells with a given equipment. This would be worth while looking into for our own work.

Mr. Miller speaks of the possibility of paying for munitions on the basis of cost plus a fixed percentage of profits. This is exceedingly important. There must be no excessive war profits to American manufacturers on our own government work. There are rumors of excessive profits even in well-governed Canada, and conditions would be certainly as bad in this country unless the Government firmly controls the situation from the start. Something in the line of a standard method of accounting should be worked out defining the method of figuring depreciation and other items of the overhead, but leaving the details of the calculations to follow the regular accounting systems of the manufacturer. These requirements could be made quite simple and could be easily taken care of.

If I may be permitted, I would like to speak a word on the general problem from a viewpoint which strikes me as very important. We are proud of our democratic form of government, and believe in it thoroughly, but we nevertheless see its disadvantages when compared with a highly centralized government, particularly when carrying on a war. It is sometimes discouraging to read reports of congressional investigations, recriminations and changes of policy with relation to army and navy matters. The question arises whether we have not here a splendid opportunity arising from the fact that the various engineering societies are continuous organizations, not subject to periodical overturns. If we can get into a position of close sympathy and coöperation with the continuous organizations of the army and navy, it may be possible to formulate and develop lines of policy that will be permanent, consistent, systematic and thorough, even though administrations and parties come and go. Then this industrial preparedness will become a normal, continuous thing, little affected by the unfortunate cataclysms that go with our democratic form of government, using "democratic" in the larger rather than in the party sense.

DISCUSSES PRODUCTION OF FUELS, ACIDS, ETC. ENUMERATES RESOURCES OF SOUTH

C. S. Williamson, Jr. Mr. Miller says that "an interesting and profitable inquiry might be directed towards securing fuel other than gasoline . . . ," and that the resources of the South "might supply the country with many materials needed during a period of curtailment of commerce with other nations."

The production of grain alcohol from saw-dust and waste-wood is beyond the experimental state. Grain alcohol has been and is being produced on the commercial scale economically, possibly as cheaply, if not more cheaply, than from molasses or grain. Two things are necessary for more extensive utilization of alcohol, hence more extensive manu-

When we consider the fact that to provide equipment for an army of one million men, from two million to three million rifles are required, the size of the task of equipping an army of a million with shoulder guns alone is apparent.—Fred E. Rogers.

One of the greatest hindrances to Canadian munition manufacturers in getting started was the lack of an efficient and up-to-date sample plant.. We (in Canada) had no idea at just what speed the different operations could or should be performed until we found out by months of work.—Chester B. Hamilton, Jr.

It is from the experience of Great Britain and France that we can formulate the principles of action to govern the design, purchase, production and distribution of machine tools in preparation for a national emergency of war.—L. P. Alford.

facture (1) its successful use in motors, (it has a heat value two thirds that of gasoline); (2) tax-free legislation which will permit its sale for specific uses in manufacture in the undenatured condition.

Alcohol plays an important part in the manufacture of explosives and also medicines. Because of the lack of a tax-free alcohol, however, a great many of our medicines cannot be manufactured on an economic scale, to say nothing of many other manufacturing processes involving the use of a pure alcohol.

We are producing explosives to-day for the fighting countries, but in doing so, we are employing nitrate of soda (as a source of nitric acid), wholly imported from another country. If we were thrown upon our own resources, we would have a reserve of 25 per cent of the required amount of nitrate of soda available for the manufacture of explosives in the States. We import 1/5 of the production from the Chilean mines. We use 75 per cent of this amount in the manufacture of nitric acid and explosives, the other 25 per cent being left for the fertilizer and other industries. We do not, at present, make nitric acid in this country (with the exception of a few small units in industries devoted to other processes and a small experimental plant at Nitrole, S. C.) except from Chilean nitrates, and not an explosive can be made here without the use of nitric acid.

Nitrogen in an available form is necessary food for both animals and plants, which adds to the importance of having a source of manufacture non-dependent on Chilean nitrates.

Synthetic nitric acid, on a commercial scale, had its birth on American soil, but because of withdrawal of financial support, the life of Bradley and Lovejoy's plant at Niagara was short. Had they had governmental support, we would be producing nitric acid from the atmosphere today, instead of being lookers-on at Norway and Sweden, Germany, and others who are doing so, and dependent upon our importations of Chilean nitrates. At the outbreak of the European war, Germany had within her borders 660,000 tons of nitrate of soda; during 1914, up to August 1, she imported 800,000 tons from Chili, and she captured at Antwerp possibly 200,000 tons more. Yet in spite of these quantities which were used up during the first few months of the war, she has expended since then in development of her nitrogen industry practically $100,000,000. Nitric acid is the means to every explosive, to every dyestuff (coal tar dyestuffs), and to a great many other materials, and available nitrogen is the means to the life of every animal being.

As to the resources of the South: regarding the fuels, we have oil, gas, lignite, coal, sources of alcohol, untouched beds of peat; regarding explosive materials, we have cotton, wood pulp, can and do produce coal-tar products, and materials for glycerine; as regards munitions, we have iron and steel, manganese, aluminum, copper, zinc, and lead; we also have cement materials, timbers, building stones, etc., for housing plants; regarding dyestuffs, we have the coal out of which to make the raws and intermediates, we have the petroleun out of which to produce intermediates; as regards textiles, we are already spinning 3/5 of the cotton spun in the United States; as regards forest products, we have in Louisiana alone the largest standing body of long leaf yellow pine in the States, and are unsurpassed only by the Pacific states and Idaho in quantity of timber. I mention yellow pine, especially, because of the naval stores industry and of the demonstration beyond a question of the practicability of manufacturing paper and paper pulp from it; two plants have for some time been successfuly operating on yellow pine, one at Moss Point, Miss., and one at Orange, Texas. Another forest products development is the tanning industry, which concerns the supplying of shoes for an army. In the eastern part of Tennessee, this industry has found considerable development within the past year and a half. We have large quantities of hard woods and tanning woods in the South.

As regards water power, in the State of Alabama alone, there is listed 1,000,000 horsepower capable of development, 20,000 of which have been developed. Other water powers of the South are yet unmentioned.

For every dyestuff and explosive, heavy chemicals are required. For the manufacture of heavy chemicals, we must have sulphuric acid; for sulphuric acid we must have nitric acid (except by the contact process). For the manufacture of nitric acid, unless we resort to Chilean nitrates, cheap electric power is necessary.

The development of the resources of the South, and sections additional to the one in which such marvelous development has taken place, viz., that along the coast from New England to Virginia, is one of the points high in importance and one we should take note of in our discussions and campaigns for preparedness.

SUGGESTS CENSUS OF THINGS WHICH STAND IN THE WAY OF INDUSTRIAL PREPAREDNESS

Adolph L. De Leeuw. I thoroughly believe in the recommendation of taking a census of all our resources, which may lead to ultimate industrial preparedness. I would like to call attention to the desirability of also making a census of those facts and conditions that may stand in the way of industrial preparedness. One of these facts was mentioned by Professor Williamson.

There is a condition in regard to the manufacture of alcohol which makes it inadvisable for a great many people to take up its manufacture, who otherwise might do so. In case of war, we would not be in a position to manufacture alcohol in the quantities in which we might, if that one obstacle had been removed.

I have been personally able to observe some of the conditions imposed by the Government in making munitions for guns, which probably are entirely satisfactory, if there is no particular hurry and if all that is wanted is just a beautifully made piece of mechanism, but these conditions should not exist if guns are wanted that will shoot tolerably rapid and close and which can be manufactured in a minimum of time. I refer here especially to the matter of limitations. In this case I do not believe the government specifications or limitations are any worse than can be found in almost any industrial establishment, but it has also been our experience that in any shop there are limitations which are entirely too fine; they have simply crept in, and stay until somebody wakes up and discovers them.

As an illustration: A number of years ago, I was in a shop where they made for the Government some twelve-inch mortars of which both the barrel for the outside diameter and the jacket for the bore had allowances of three thousandths. Of course, if the jackets were three thousandths too large and the barrel three thousandths too small, the shrink would have been materially affected. Therefore, there was nothing foolish in this particular case. However, it happened at one time, that one of the barrels was a shade over three thousandths too small and was rejected. This annoyance might have been avoided if dimension with limitation had been given on one of the two pieces and the other piece had contained a notation

giving the difference between bore and outside diameter. In this case it was merely an annoyance to the manufacturer and perhaps a little loss of money, but in case we badly needed a gun, it would have been a different kind of annoyance. This is only a single illustration indicating what might be done in the matter of allowances and limitations. This not only would hold good for guns, but also for ammunition and all other materials to be used.

The census of all those conditions which might be avoided should not merely treat of things that the Government has done which we would like to have changed, but also of things which ordinary private citizens have done. If the Government should ever send out jigs and fixtures to be used in various shops, they would be up against the impossibility of taking a jig or a fixture from one machine and putting it into another, as well as taking it from one shop and placing it into another. Of course, I realize full well that it would not be possible in the course of a few years, to have all planers or shapers and all spindles the same size, but something ought to be done to prevent the annoyance of too much variation, the variation being simply the expression of the desire of some manufacturer to push his product at the expense of his neighbor. If there is any particular reason why his particular size is superior to his neighbor's, well and good, and there is no reason why this size should not be accepted by his neighbor also, but if there is not, the census I have mentioned should take into account the delay and annoyance that might be caused by having too great a variation of designs and sizes in machines. Again, this does not only apply to machines, but to everything. I would, therefore, recommend that in addition to the census of factories, materials, machines, men, executives, etc., there should also be taken a census or list tabulating the conditions which prevent the speedy and easy manufacture of those materials and products which we want.

SAYS INDUSTRIAL CENSUS WILL SHOW WEAKNESS AND BRING ABOUT DESIRABLE CHANGES

Major W. Goff Caples.[1] We should know accurately what we can rely upon in war and should make good, in advance, any deficiencies which the proposed industrial census may show. The nation will need the coöperation of every one, from the manufacturer, the engineer and the chemist, clear through to the laborers in the mills, because wars now are fought not by armies but by nations.

I am glad to see the interest taken in preparedness. My last detail was two years and a half in the organization and equipment of engineer troops. Unless our orders were large, manufacturers were not enthusiastic about our business, because we required special articles. We must have special articles, because a soldier has to carry on his back what he needs for several days, and is limited to 50 pounds, and because we must keep down our wagon transportation to narrow limits, lest the Army be immobilized by too much transportation. An extra ounce or so in the weight of a given article makes little difference in commercial practice, but is of great importance in military practice. Foreign manufacturers were anxious for our business and offered us, frequently, more suitable articles than we could obtain from American manufacturers. We refused all such offers, on the principle that a nation should produce everything it uses in war, and accepted the best that our manufacturers would give us, even though this "best" might not be exactly what we required. The awakened interest of the manufacturers will help greatly, for when the manufacturer and the officer get together in this spirit and understand one another's needs and limitations, both can better serve the nation.

Your census will show what we have and, I hope, bring about such changes that we shall be prepared to supply as large an army as our country can support in war. Your action is a patriotic one and a needed step in the right direction, for it will show us some of our weaknesses and give us a better idea how to remedy our defects.

[1] Queen and Crescent Bldg., New Orleans, La.

THINKS SERVICE OF ENGINEERS SHOULD BE TOWARDS GETTING VALUE FOR MONEY

Fred J. Miller (written). Engineers have always paid far more attention to efficient organization than have any others, and it seems to me that they might render their best possible service at this time by suggesting such improvements in organization as would result in getting more for the money and effort expended than is at present secured.

From an English statistical authority I take the figures below showing the army budgets of various countries for the year 1913-1914.

Japan	$48,500,000.00
Italy	82,000,000.00
Great Britain	137,000,000.00
U. S. A.	146,000,000.00
France	178,000,000.00
Germany	292,000,000.00
Russia	327,000,000.00

We thus see that only three nations spent more money in the period named than we spent. The figures include the Federal Budget only, with nothing included for the State troops.

Yet we are told by people who should know that our army is a negligible factor and that even for such a job as pursuing a few bandits over the Mexican border its showing is "pitiful."

If that is so and if substantially the same is true of our navy, as we are told that it is, then is it not time for us to try to discover what the $146,000,000 does buy and whether or not some results worth while can be secured by an expenditure of money exceeding that of Great Britain, and exceeded by only the three great military nations, France, Germany and Russia?

Preparation for war is largely an engineering work and the nation which does most in making this work of preparation efficient, that is, in getting the largest possible results for each dollar expended, will have gone a long way in the work of Preparedness and will get the best support from its people upon whom the burden of taxation falls.

SAYS GOVERNMENT NEEDS MANUFACTURING DEPARTMENT WITH CABINET OFFICER AS SECRETARY

Elmer H. Neff. This paper by Mr. Spencer Miller is extremely interesting and timely. It is, however, as he well indicates, simply an outline of the general subject of "Preparedness." He mentions under the head of "Munitions of War," a wide range of topics, the complete discussion of which would cover the whole range of "preparedness" and fill several volumes. New York City has perhaps been the great storm centre for placing orders for war equipment of every description. When the foreign governments involved in this war began to flood this country with orders, it was simply a question of getting them placed with the utmost expedition. The result has been some confusion with regard to deliveries as herein indicated. The work of taking inventory of shop

facilities for possible use by our own Government can certainly do no harm. It is apparent, however, that the experience gained in filling these foreign orders has placed the shops of the United States in a very good position to take up similar work for our own Government. Our greatest weaknesses are not in the direction of machine shop preparation, but in our facilities for producing the necessary chemical supplies for the manufacture of explosives.

I wish my contribution for this subject to be the suggestion that the United States Government needs a manufacturing department headed by a secretary who should be a Cabinet Officer. I do not in this suggestion have in mind the Government taking up the manufacture of everything it needs. It is already manufacturing on a large scale, and the department which I recommend would take charge of the manufacturing plants which the Government now owns. As you well know, the British Government found after the war had progressed a few months, and things had become hopelessly tangled, that it needed a munitions department. They placed in charge of this department a civilian. Probably you have noticed in the public press that the Navy is very short of officers. If you visit one of our Navy Yards you will find every department in charge of a Naval Officer overseeing in many cases, if not in most cases, construction operations with which he has no training or familiarity. The proper place for the Naval Officers in my opinion is on board ships where we are continually being told there is a shortage of officers. Likewise in every arsenal you will find army officers in charge, men who are not familiar with the work of manufacturing, and have no experience in that direction except what they have picked up while on these temporary details. Colonels, majors, captains, are here a few months, and then on to the next position to which they may be sent. There is no possibility, so far as I can see, that there would be efficient administration under that sort of management. It is no reflection on the army and navy officers that this should be a fact. They are simply the victims of a system of procedure over which they have no control. With a Secretary for Manufacture and civilian experts of the quality that private firms would employ for similar work, placed in charge of the great manufacturing department which the Government owns, a long step towards efficiency, economy, and preparedness would have been taken.

In harmony with the preceding suggestion, I think Mr. Fred J. Miller's discussion of this paper has touched upon a vital point of the whole question. That question relates to the efficiency of the organization of the army and navy, as at present administered,—the question of the returns for the dollars that are being spent. It would seem from the figures quoted by Mr. Miller, that these returns are exceedingly small. If this Society or its committees could investigate and point out methods of improvement, they would have given the country help of the greatest importance.

With regard to the suggestion of a committee to standardize machine tools for munitions manufacture, I do not see the necessity for such a committee. It is a fact that the operations for producing the parts of a military rifle are nearly all performed on standard machine tools. The only thing special about them are the fixtures and tools to go on the machines. For instance, the parts made from bar stock can be made in standard screw machines. The drilling is done in standard grinding machines. The rifle barrels are drilled and rifled in machines which have been standard in this country for years. The punch presses used are standard machines. Similar comments would apply in the main to the production of shells and time fuses. It is therefore, only a question of the best tool equipment for the machines. In this field competition will take care of that, because the buyer, whether for a private plant or for the Government will consider the methods suggested by different manufacturers of machinery, will look into the system of tooling operations proposed, and in that way make the best selection.

Finally I cannot too strongly urge the desirability of the United States Government putting in operation at the earliest possible moment its plants at Springfield and Rock Island, for the production of military rifles. It is an easy matter to obtain men to defend the country, but it is a difficult matter to provide rifles and the ammunition that go with them in the quantities that would be needed in case of war, without great delay.

The experience of all Europe, the successes and failures everywhere, demonstrate that preparedness in its broadest sense means a general spirit of being ready, rather than a particuler state of being ready for war.—Frank B. Gilbreth.

When the supreme test came, Germany was found to be a nation of people who, in general, knew what to do and how to do it; while the industries of England were in too many cases controlled by people who understood only their commercial side.—H. L. Gantt.

What should shock us is not what might happen to us in a war but what is happening right now while there is general peace. National waste, lack of general specific education, lack of easy means for obtaining the fullest education in the vocation for the worker in that vocation, lack of correlation!—Frank B. Gilbreth.

SAYS MEANING OF INDUSTRIAL PREPAREDNESS IS NOT OFTEN GRASPED. MUST BE UNIVERSAL

J. H. Brophy[1] contributed a written discussion stating: I am under the impression that it will take years of pounding away at the facts to enlighten people on this great undertaking of Industrial Preparedness.

When using the word "Industrial" it is possible in many instances we fail to grasp its real meaning.

Industrial Preparedness is an extremely vital question, and the meaning of the word Industrial is so deep and reaches so far that it requires a vast amount of labor to impress those in a country of such magnitude as ours what it actually means. To be Industrial in the extreme means a genuine commingling of all lines of business and labor of all descriptions. It might easily be said that this country has at times been awake to the meaning of this word Industrial because we have up to the present time in all sections of the world been considered real leaders in a vast number of enterprises. To improve upon what has happened in the past, when considering the future, means a genuine amalgamation of all with whom we deal. This means that the leading business men should have one thought and that, never to allow the business of this

[1] Cleveland Automatic Machine Co., Cleveland, O.

country to go backwards, always having in mind going ahead, even on a stronger basis than it has ever been before.

The word Preparedness has been used quite extensively of late in this country, and it also has great depth of meaning. I have in mind that the big thing in the way of preparedness in any undertaking means the best use of your thinking powers to plan in advance and follow the path of being ever ready to meet your adversary from a business or your country's standpoint.

Competition from all sections of the world, after this war ceases will be somewhat severe, although a vast number of bright business men are under the impression that we control the world from a manufacturing standpoint. Perhaps we do in a certain sense of the word, but that which is occuring abroad means, from an Industrial standpoint, the men in business should, if possible, have those in their employ thoroughly satisfied, getting men as close as consistent to work along as an organized body. It means a homogeneous mass of brain power, all thinking in one direction, as nearly as possible, constantly having in mind self-protection.

The word Industrial, from the writer's standpoint, cannot be considered of benefit to this great nation if it is not genuinely universal. An educational campaign seems absolutely necessary, and the newspapers are the best channels through which to reach the people of this nation, teaching them to cling and work together, and this must be done with a great pride for our country.

It is a difficult problem and will need a vast amount of time to get those interested in business, as well as the working men, thinking in the same direction, and if they do not, the matter of Industrial Preparedness is liable to be forgotten because it will not reach an actual working condition. To utilize the industrial resources of this country to the very best advantage, there must be a complete unification of all who participate. This can never be accomplished by the aid of a few individuals without the assistance of the Government of this country.

POINTS OUT WEAKNESSES IN SOUTH. SUGGESTS TRADE SCHOOLS FOR WOMEN LIKE AGRICULTURAL SCHOOLS

Commander H. T. Wright[1] said that the discussion of the paper had been mainly upon the question of getting materials and he doubted very much if the visitors from the North realized that in the South it is rather a question of securing men educated in the trades who are able to step into the shops and perform the work necessary to the preparation of war materials.

The South has been very lax in its training of men for trades. In one city in the South, there is a fund of one million dollars for the establishment of a trades school, but although that fund is available, the school has not yet been started. In that city intelligent boys and young men, 18 to 22 years of age, had come to him to work as laborers. They told him that they had attempted to learn a trade, but there was no such thing in that city as an apprenticeship system. There is nothing in the South that parallels such splendid apprenticeship systems of the North as those of the Westinghouse Companies, the Western Electric Company and the Fore River Shipbuilding and Engine Company. The South cannot mobilize an army of workmen unless it first educates them.

It will take a long time to build up that force of working men who must be the backbone of any industrial preparedness no matter how many raw materials are available or how many machine shops are lying idle. Industrial preparedness cannot be obtained without the men to manufacture the raw materials and to operate the shops.

In time of war many of the best *men* have to go to the front, with the result that women must be employed in the industrial trades. Very few in the South know about the women of the North who are willing to be employees in the manufacture of war material, textiles, etc. The South has been and always will be slow to approve and start the mobilization of the women of America in the industrial trades. But why not at least have, as an addition to the agricultural schools, trades schools for girls, to give them a fundamental knowledge of the trades in order that they will be ready?

Another thing in which the South is very weak is functionalization, but it is hoped that this will be accomplished in the trades schools that are going to be established in the country.

Bearing on the question of the education of the mechanic and touching closely the question of the mobilization of the American women in industrial preparedness is the question of coöperation. The following quotation from Frederick W. Taylor, Past President of The American Society of Mechanical Engineers and the highest exponent of coöperation, gives perhaps the briefest and the most concise statement of coöperation: "The time has come when all great things will be accomplished by the coöperation of many individuals, each performing the function for which he is best suited, each supreme in his particular function, yet retaining his individuality, while collaborating with his fellows toward the production of the complete and perfect whole."

Commander Wright spoke briefly in regard to materials and said that while it is true that the Government specifications must not be too severe and that they must be reasonable, it is also necessary to get as much as possible out of the material. The question of tolerances had been brought up and a speaker said that all that was needed was the proper correlation of parts. Commander Wright said that he did not know whether the speaker realized that the Navy retubes every one of its big guns and that each is retubed when it is taken off a ship after it has been fired 200 or 300 times. When the materials are to be used over and over again, merely replacing defective parts, mechanical tolerances have to be watched closely.

It would require 50 engineers, designers and draftsmen at least 50 weeks to prepare the drawings for the 17 sizes of shells now used by the U. S. Army, together with drawings for gages, jigs, fixtures and tools. To produce the latter would probably require 800 men, well trained and in well organized factories, at least 5 years. This would equip 100 factories, each employing 2,000 men, capable of producing a total of 200,000 rounds per day.—Frank O. Wells and Chas. E. Smart.

It would take 1,000 toolmakers one year to furnish tools . . . for an output of 1,000 rifles per day. Therefore should our Government require, say, 5,000,000 rifles, or 1,000,000 rifles per year, our tool plants would be taxed to the utmost.—K. A. Juthe.

[1] U. S. Naval Station, New Orleans, La.

CURRENT TOPICS

The Engineer, April 28, 1916, describes a new type of Humphrey pump working on a two-stroke cycle, the novelty of the construction being that a solid mass is placed, as it were, between the exploding gaseous mixture and the water surface. All the useful work is done on the up-stroke during the expansion of the gases. On the down stroke, the work is spent against friction and in compressing the fresh charge. A feature of the design lies in the fact that no side-thrust is generated at any point by the piston against the cylinder walls as in an ordinary crank pump. The movement is purely reciprocating and there is an entire absence of rotating parts except for the exhaust valve bell-crank lever.

One of the most notable achievements in gas engineering is the successful construction of a subaqueous tunnel connecting Astoria, L. I., with the borough of The Bronx, New York City. The tunnel lies beneath the waters of the East River at an average depth of 225 ft. below mean sea level. It is 19 ft. wide, 18 ft. high and 4662 ft. long. It accommodates two 72-in. gas mains, with abundant space for other utilities. The route of the tunnel lays through a long stretch of disintegrated rock where the water pressures ran up to 95 lb. per sq. in., thus making it impossible to use compressed air to exclude water.

Three principal (anhydrous) oxides of iron have long been familiar in chemical literature: ferric oxide, Fe_2O_3, occurring in nature as the mineral *hematite;* ferroso-ferric oxide, Fe_3O_4, occurring as *magnetite;* and ferrous oxide, FeO, which is not known to occur in nature. A less common mineral form is *martite,* which has a somewhat variable composition immediately between Fe_2O_3 and Fe_3O_4. It is commonly described as "hematite pseudomorph after magnetite," as it usually lies nearer hematite than magnetite in composition, but has the external octahedral form of magnetite. In addition to these natural oxides, many other oxides have been prepared and described by various investigators.—*The Oxides of Iron, Jour. Am. Chem. Soc., April, 1916.*

Sheet steel or iron containing copper shows greatly increased corrosion resistance when exposed to atmospheric conditions. The most effective amount of copper to be used for this purpose is approximately 0.25 per cent. Smaller amounts of copper down to as little as 0.04 per cent have a considerable influence in lessening corrosion.

Phosphorus added to open-hearth steel slightly lowers the corrosion rate. Silicon, while probably without effect in the amounts normally present in open-hearth and bessemer steel, accelerates corrosion when added in amounts from 0.10 to 0.30 per cent. The addition of small amounts of aluminum probably has little influence on corrosion. The addition of sulphur to steel greatly increases the corrosion rate. The addition of cold steel to molten steel does not lower the corrosion rate, but if it has any influence at all, it is to increase the corrosion.—*Jour. Ind. & Eng. Chem., Vol. 8, No. 3.*

The Hudson Motor Car Company has recently carried out some interesting experiments on the determination of the rigidity of crankshafts, for which an ingenious rig was used. The shaft was supported vertically so as to eliminate the possibility of bend due to overhang. In order to eliminate any chance of torsional strain due to an auxiliary driving mechanism, the fly-wheel with its face provided with teeth was converted into a turbine, several air nozzles being arranged to revolve it without actual mechanical connection.—*The Automobile,* May 18, 1916.

An interesting paper on theory and practice in the filtration of water was presented before the Institution of Mechanical Engineers on April 14, 1916. The author establishes the following conclusions: (1) the practice of mechanical filtration is based on the theory that the filtering film is essential; (2) the speed of the filters is always high so that the length of time during which the water is under treatment is not considered of importance; (3) when cleaning, the filter materials are violently agitated throughout their mass; and (4) the bacteriological purification of water is dependent on a single operation carried out with extreme rapidity, and the sole means for preventing the passage of pathogenic organisms through the filter consists of an artificial gelatinous film.

The chemistry of water softening is fairly complete, but there are still a number of undetermined points about which more information is desirable. Such, for instance, are the questions of foaming and of after-deposits.

The foaming in a steam boiler is more active if the water contains comparatively large amounts of soluble salts or organic matter. It will increase as the concentration of the water increases.—S. A. Greeley, in *Jour. Am. Water Works Assn., Vol. 3, No. 1.*

The subject of power plant losses at high altitudes is discussed by A. Vincent Clarke in the *Compressed Air Magazine* for May, 1916. Oil engines working at high altitudes cannot develop the same power as at sea level owing to the smaller weight of oxygen contained in the cylinder. At an elevation of 10,000 cu. ft., the pressure of the atmosphere is about 10.3 lb. per sq. in.; hence at the commencement of compression the engine cylinder will be full of air at a pressure of 10.3 lb., whereas at sea level the same volume of air would be present at a pressure of 14.7 lb. As the amount of oxygen would be in the same proportion in both cases, the power obtainable would be in the ratio of 14.7 to 10.3, giving a loss of about 29 per cent because of the high altitude.

With internal combustion engines when the initial pressure is reduced the compression pressure will be lower.

Diesel engines at high altitudes require a larger compressor for the air used for the injection of fuel than is necessary at sea level, as it is essential for their satisfactory operation to have the same volume and pressure of air as at sea level.

REPORT UPON EFFICIENCY TESTS OF A 30,000 KW. CROSS-COMPOUND STEAM TURBINE

BY H. G. STOTT, NEW YORK and W. S. FINLAY, JR., NEW YORK

Member of the Society Non-Member

THE determining factors in the selection of power generating equipment, either for an original installation or replacement purposes, present about as many variables as there are installations. Engineering experience has practically standardized the electrical end. The steam engine on the other hand, does not seem to have been capable of such standardization, as engineers are not agreed as to the most desirable superheat, pressure, etc., which must be considered both from the standpoint of reliability and boiler and engine economy. This thought is more than ever pertinent at this time, as it appears that we are on the eve of the employment of higher pressures and perhaps even new systems of power generation.

Further, the capacity of the machine to be selected and the relation of point of best steam consumption to maximum continuous load and provision for heavy overloads for limited periods are all dependent on load factors, diversity factors, etc., which present a new problem for every installation.

Without detailing at length the considerations which led to the selection of three 30,000 kw. units for the 74th Street Station of the Interborough Rapid Transit Company, a brief summation of the main questions involved will possibly be of interest and serve to classify the installation properly.

The prospective daily plant load, as was subsequently demonstrated, could be best provided for by units of 30,000 kw. maximum continuous capacity each. At that time there was assurance that machines of this capacity could be constructed and furthermore, by the employment of the two-speed compound principle, as described more fully hereinafter, no hazards were involved, nor in fact would there be any departure from well tried principles of construction. Ample steam supply was available by reason of development in the matter of relative boiler capacity coincident with the increase in efficiency of prime movers since the original construction of the plant in 1902. Economic considerations warranted the withdrawal of the horizontal-vertical double cross-compound engine-generator sets installed at that time, and their replacement by more efficient and larger units.

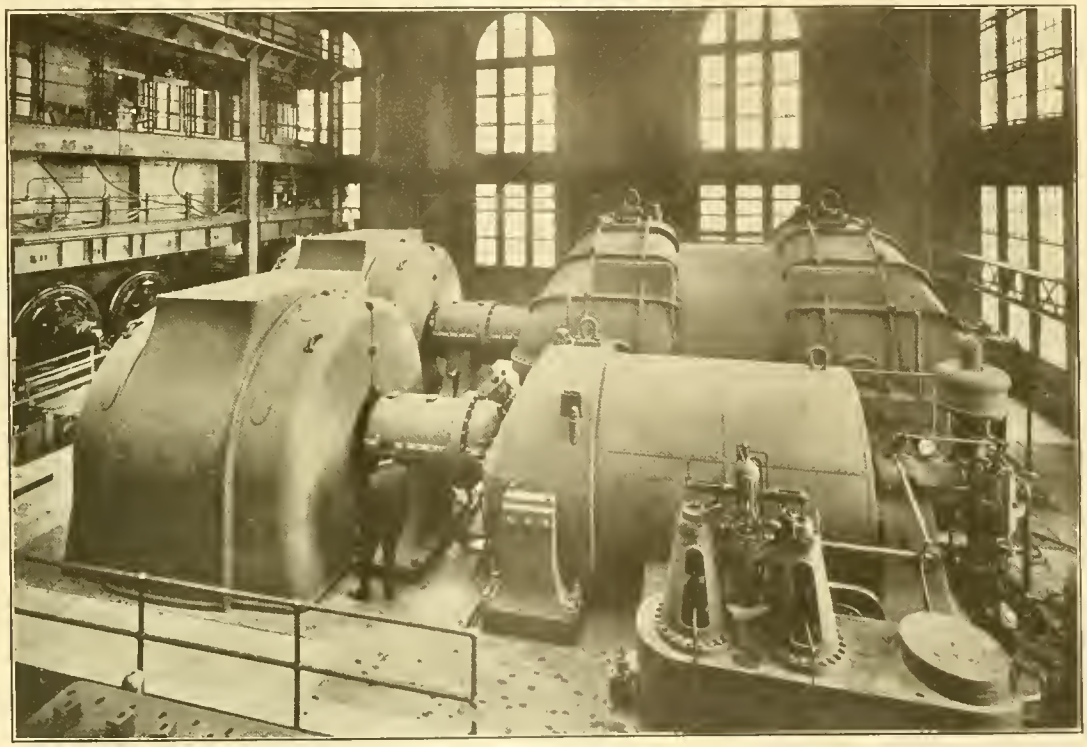

FIG. 1 30,000 KW. CROSS-COMPOUND STEAM TURBINE

The generally accepted essential requirements of a railroad plant were the next considerations, viz.: reliability, efficiency and cost.

In the development of turbine design, at the time the installation was being considered, possibly the simplest type of machine in many ways was the single-shaft, single-rotating element turbine as a natural outgrowth of the generally accepted type developed in smaller capacities. Certain structural features, however, inherent with the larger capacity tended to favor the division of the unit into two elements.

In a steam turbine, maximum centrifugal stresses are encountered at the exhaust end, where the greatest steam

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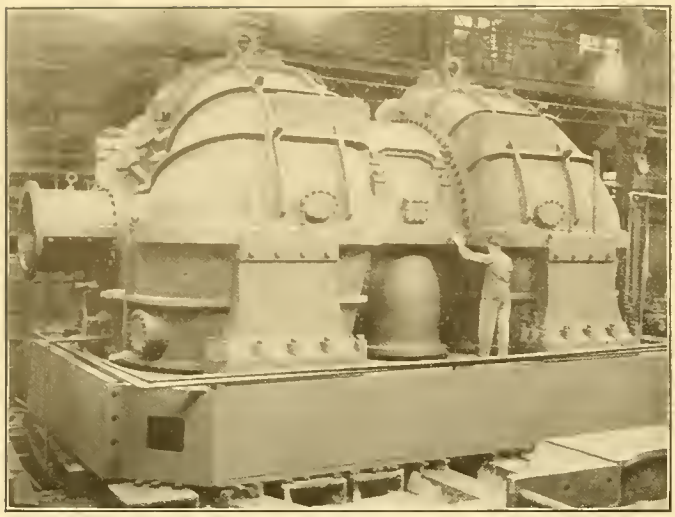

Fig. 2 Casing, Low-Pressure Turbine

volume requires the greatest blade area. In the high-pressure blading which uses steam of small specific volume, the best velocity ratio conducive to high economy cannot be met by the rotative speed as determined by the exhaust end. To avoid a compromise, the conditions are more readily satisfied by carrying out the expansion in two separate elements, and avoiding congestion due to the high specific volume of the steam at one inch absolute exhaust pressure by the use of the lower speed, longer blades and the double-flow principle.

Reliability also seemed better served in the double element machine by the shorter shaft, and reduction of danger from temperature strains. Furthermore, there was the possibility, in an emergency, of operating either element of the unit alone, and that at a fairly high efficiency, the low-pressure element being available for service simply by the use of a by-pass. The use of the high-pressure end alone in the case of a bad breakdown on the low-pressure end was to be obtained by removing the low-pressure rotor and closing the shaft openings with special covers.

An extremely important consideration, favoring the divided unit in this particular case, was the matter of the weight of the parts to be handled by the crane which, in the case of the single unit, involved provision for additional crane capacity beyond that then available at the plant. To take care of such additional requirements would have necessitated the installation not only of a new crane, but reinforcements of the steel work of a most elaborate nature and far in excess of that required for use in connection with the double unit.

In the matter of efficiency the double unit offered still more desirable possibilities, prominent among which was the relative flatness of its water rate characteristic. Without entering into the matter of cost in this particular case, it may be said that the advantage was again with the double unit.

As a result of such considerations as the foregoing, the double-unit turbines were selected, together with condensing equipment designed to perform at a relatively high rate of efficiency, and including the necessary auxiliary apparatus, all of which is described in the following:

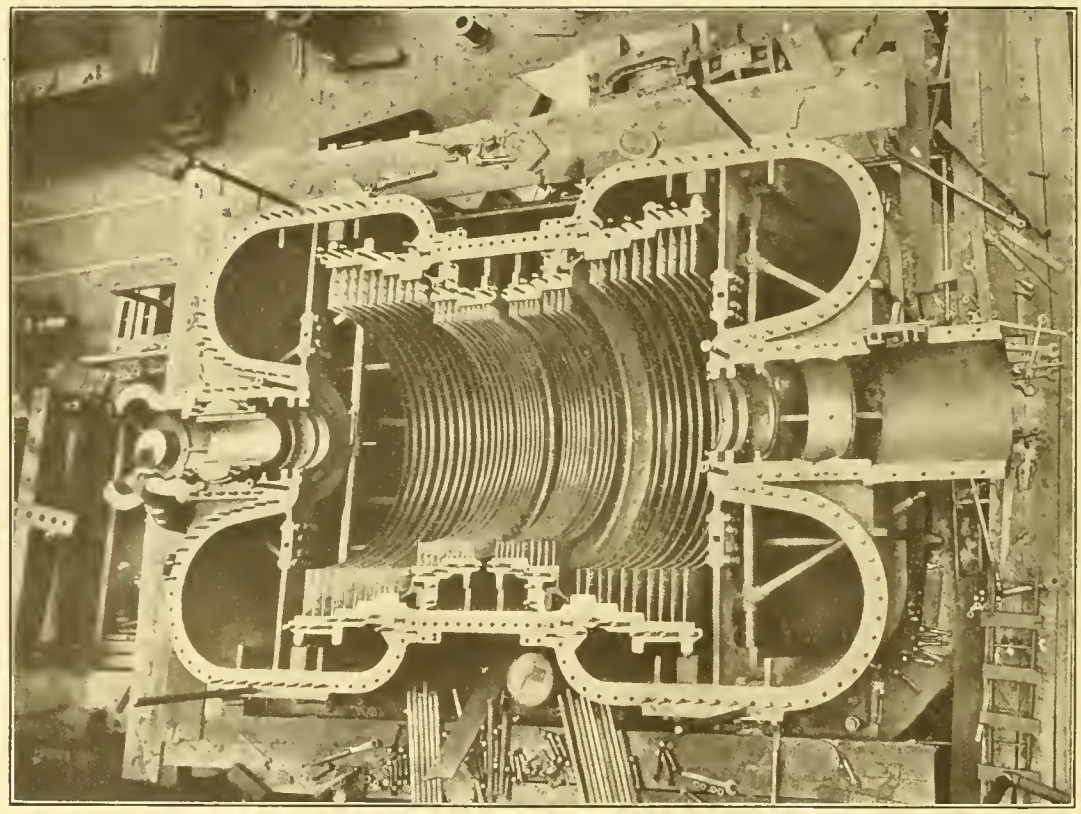

Fig. 3 Interior, Lower Half of Low-Pressure Turbine

One of the complete units is shown in Fig. 1, the high-pressure element with its governing apparatus being in the foreground. This element is practically a typical single-cylinder reaction turbine, containing 38 rows of blades. The low-pressure element in the background of Fig. 1 is a turbine of the double-flow type. The casing is possibly unusual in its size and details of reinforcement. The complete casing of a low-pressure element is shown in Fig. 2, and the interior of

the lower half in Fig. 3. Fig. 4 shows a detail of the lower casing with the rings removed which gives a very clear idea of the reinforcing. No blading is mounted directly in the casing but through the intermediary of rings secured to it, as shown in Figs. 3 and 10. The central portion of the low-pressure rotor (Fig. 5) consists of a drum to which are bolted two cast steel shaft ends. These shaft ends have discs mounted upon them, carrying the last rows of blades.

Each turbine was erected upon a foundation of steel framework set in concrete, the steel structure alone being amply sufficient for support, the concrete being added to eliminate vibration.

Inasmuch as the high-pressure rotor was inherently of small diameter, it was possible to design it to operate at the maximum speed possible for 25 cycle service, i. e., 1500 r.p.m. The low-pressure turbine was designed for the next lower synchronous speed, namely, 750 r.p.m., utilizing a four-pole generator.

The surface condensers which occupy most of the open space beneath the foundation framework consist each of two shells containing 25,000 sq. ft. of condensing surface apiece. The condenser shells are connected directly to the turbine outlets without an intermediate expansion joint. The weight of the condensers is carried by means of lugs, cast as a part of the shell, resting upon a number of spring jacks, which are adjusted to carry the load without appreciable strain upon the turbine exhaust nozzles. Practically no restraint has been put upon longitudinal expansion of the low-pressure turbine by the circulating water piping, which is fitted with rubber expansion joints. There is one expansion joint of copper in the steam equalizing pipe between the shells.

The condenser auxiliaries were selected and installed with the prime factor of reliability continually in mind. The turbine-driven tri-rotor circulating pumps of 37,500 gal. per min. capacity each were installed in duplicate, the reliability consideration being augmented by one of efficiency in the matter of the relative requirements for winter and summer use; during the winter months with cold water one pump is sufficient, but during the summer months high water temperatures necessitating two units in service.

The hot well pumps were also installed in duplicate. A single rotary dry vacuum pump was provided for each unit, with sufficient capacity to handle the dry air from two units, cross connections being provided for the purpose.

The turbines are equipped with water-sealed glands. The gland water system has a small centrifugal turbine-driven

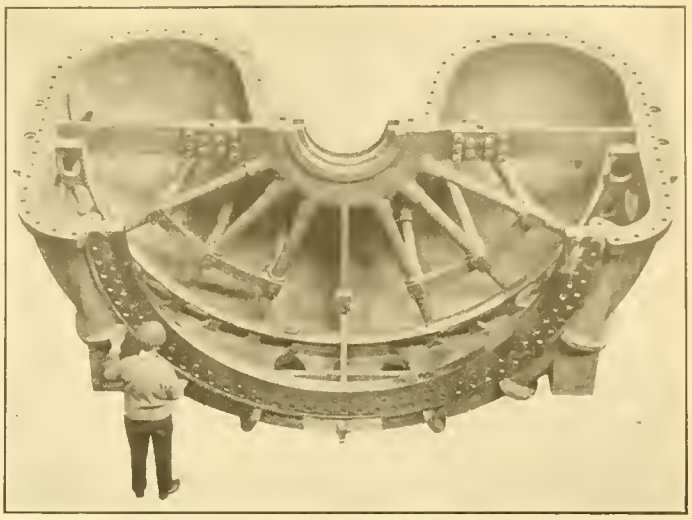

Fig. 4 Detail Showing Bracing, Low-Pressure Casing

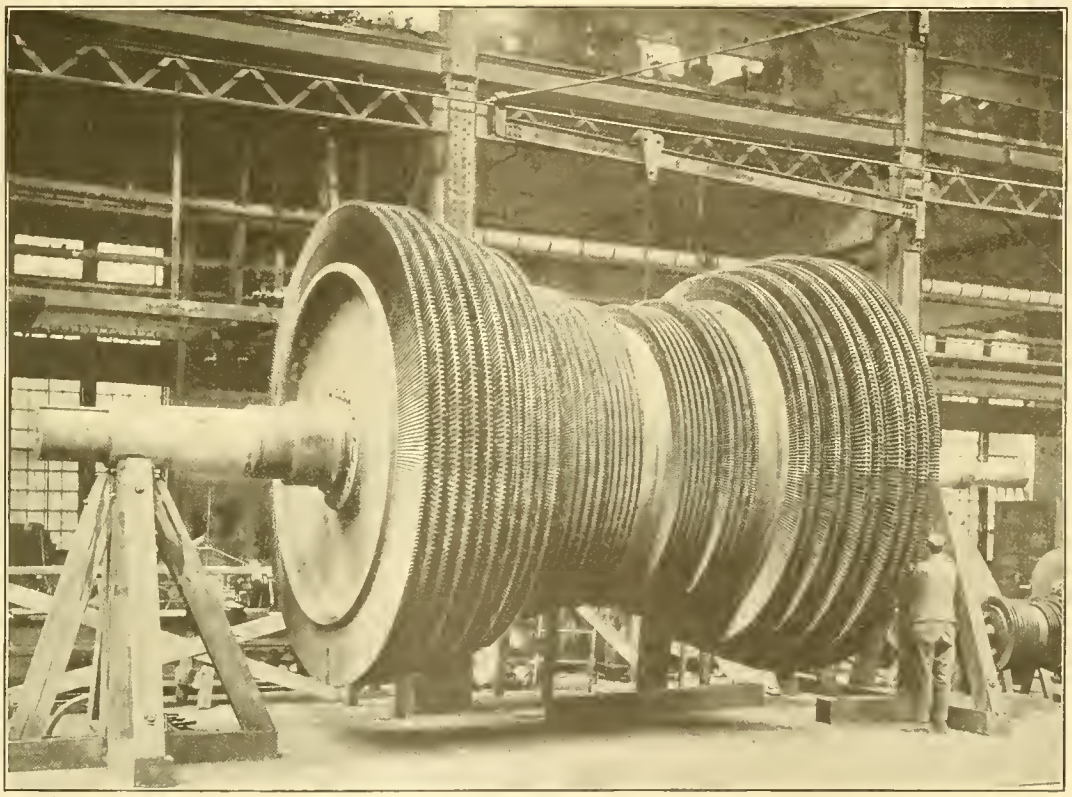

Fig. 5 Rotor, Low-Pressure Turbine

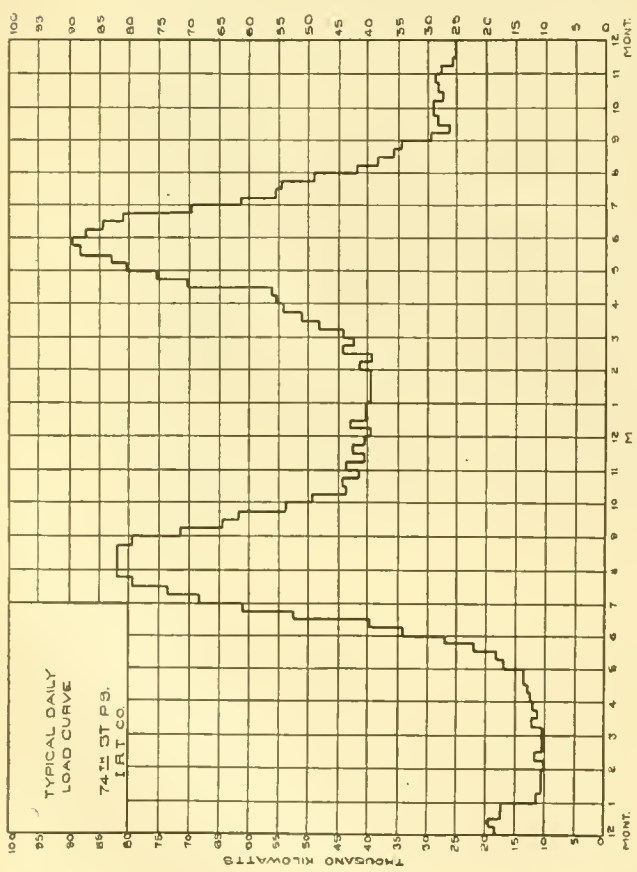

FIG. 6

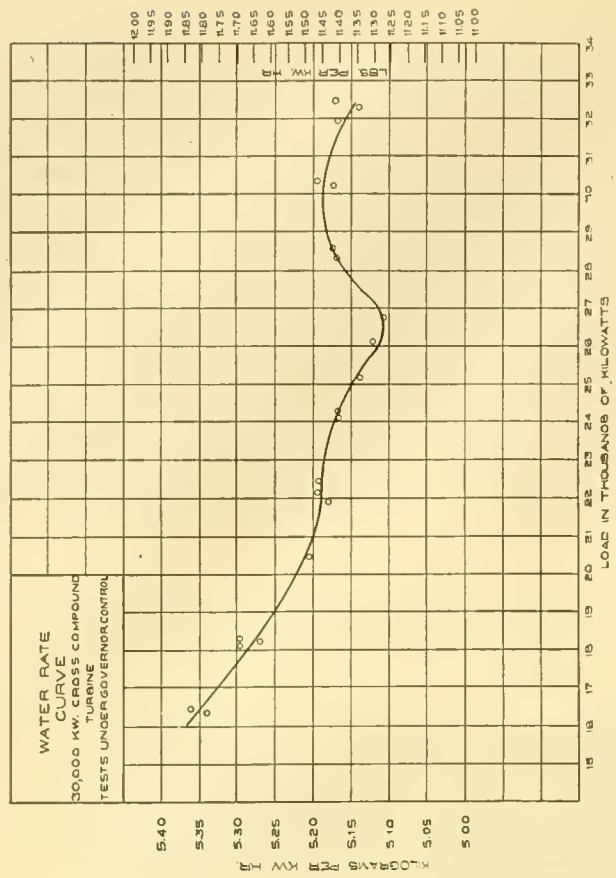

FIG. 7

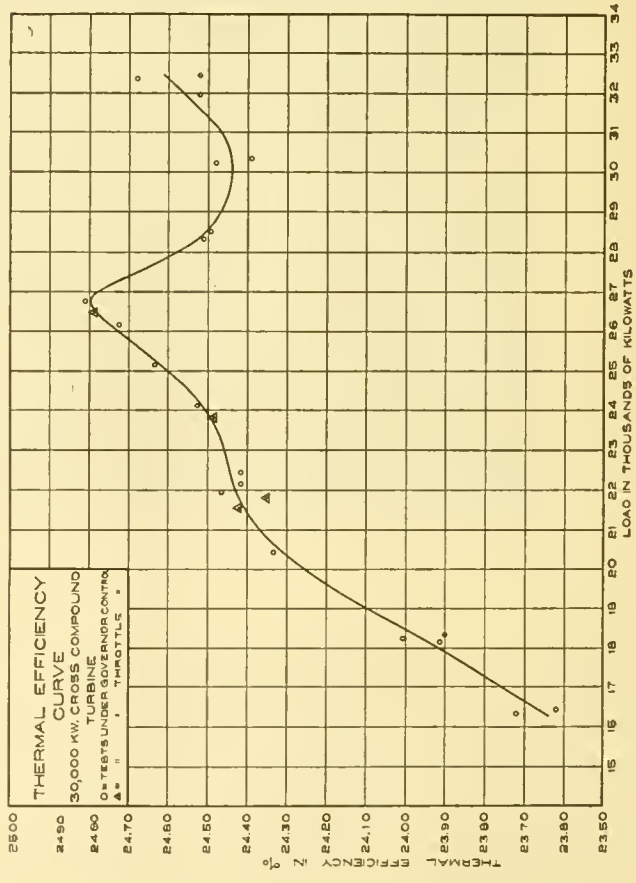

FIG. 8

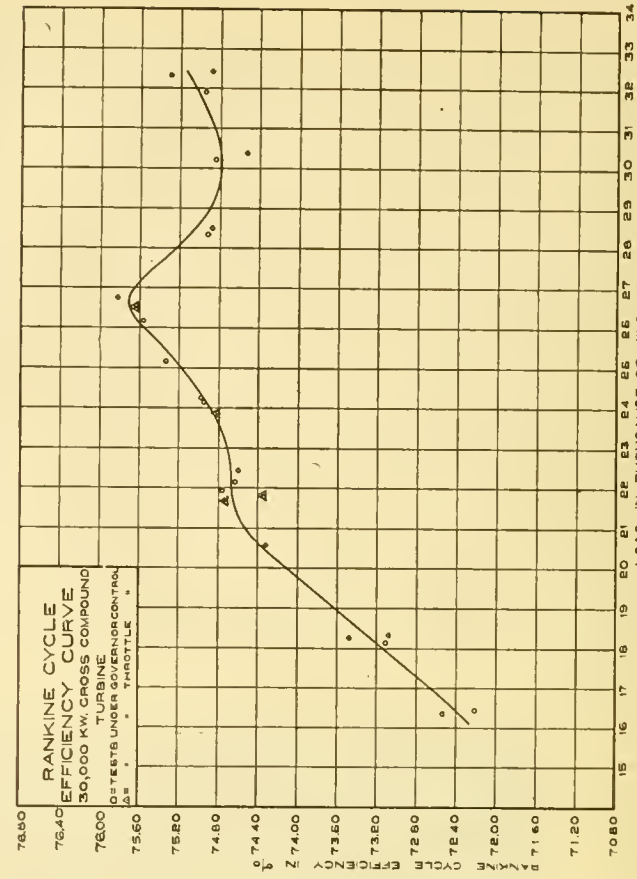

FIG. 9

PERFORMANCE CURVES, 30,000 KW. STEAM TURBINE

TABLE 1 SWINGING LOADS DURING TESTS AS RECORDED BY GRAPHIC CHART

Test No.	Duration of Test, Hr.	Average: Kw. Load by Watthour Meter *A*	From Graphic Load Chart: Minimum Load During Test *B*	Maximum Load During Test *C*	Difference in Kw. of Max. and Min. Loads *C—B=D*	Per Cent of Avg. Load *D/A*	Avg. of Diff. Bet. Min. and Max. Load During Each 2½ Min. Period During Test *E*	Per Cent of Avg. Load *E/A*	Max. Single Load Swing During Test *F*	Per Cent of Avg. Load *F/A*	Length of Swing *F* in Sec.	Time of Test
1	3	16342	10100	20800	10700	65.5	6080	37.2	8700	53.3	21	12.00– 3.00
2	3	16447	9800	20300	10500	63.8	6200	37.7	8200	49.8	40	12.00– 3.00
3	3	18158	12800	23000	10200	56.2	5680	31.3	7800	43.0	34	1.00– 4.00
4	3	18273	10400	23100	12700	69.5	5860	58.6	10600	58.0	41	12.00– 3.00
5	3	18317	11600	22000	10400	56.8	6360	34.7	9400	51.3	24	12.00– 3.00
6	3	20472	15600	22600	7000	34.2	3810	18.6	6500	31.8	42	2.00– 5.00
7	3	21925	14900	26100	11200	51.1	3740	17.1	6650	30.3	26	8.00–11.00
8	3	22150	16500	27400	10900	49.2	4200	19.0	6500	29.4	24	8.00–11.00
9	3	22432	16900	25400	8500	37.9	4580	20.4	7400	33.0	33	8.00–11.00
10	3	24137	18700	27800	9100	37.7	3700	15.3	6900	28.6	36	8.00–11.00
11	3	24200	20500	27600	7100	29.3	3160	13.1	4300	17.8	15	8.00–11.00
12	3	25170	19700	27400	7700	30.6	3260	13.0	5500	21.9	12	10.30– 1.30
13	3	26153	20200	28900	8700	33.3	3080	11.8	5400	20.6	12	8.00–11.00
15	3	28378	21000	32700	11700	41.2	3700	13.0	5400	19.0	1	3.30– 6.30
16	3	28517	23200	29700	6500	22.8	2200	7.7	4000	14.0	11	3.30– 6.30
17	3	30232	24400	32000	7600	25.1	3040	10.1	4500	14.9	12	3.30– 6.30
18	3	30397	24600	32800	8200	27.0	2780	9.1	5600	18.4	2	3.30– 6.30
19	3	31986	29400	35200	5800	18.1	2450	7.7	3700	11.6	9	4.00– 7.00
20	3	32348	32900	28300	4600	14.2	2490	7.7	3100	9.6	5	4.00– 7.00

Test 19–22 incl.—no chart taken.

TABLE 2 SUMMARY OF RESULTS, TURBINE TESTS

Test No.	Abs. Steam Pressure at Throttle		Steam Temperature at Throttle		Superheat		Abs. Steam Pressure Primary Inlet		Abs. Steam Pressure Exhaust H.P.		Abs. Steam Pressure Inlet L.P.		Exhaust Vacuum		Exh. Pres. Referred to 30-In. Bar, 762 M M. 58.1 Deg. Fahr., 14.5 Deg. Cent.		Load Average	Water per Hr.		Water[1] Rate		Rankine[1] Cycle Efficiency	Thermal[1] Efficiency
	Lb. per Sq. In.	Kg. per Sq. Cm.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Lb. per Sq. In.	Kg. per Sq. Cm.	Lb. per Sq. In.	Kg. per Sq. Cm.	Lb. per Sq. In.	Kg. per Sq. Cm.	In. Hg.	MM. Hg.	In. Hg.	MM. Hg.	Kw.	Lb.	Kg	Lb. per Kw.-Hr	Kg. per Kw.-Hr.	Per Cent.	Per Cent.
1	224.3	15.78	493.2	256.2	101.6	56.5	148	10.41	10.6	.745	10.2	.717	28.411	721.63	1.589	40.37	16,342	192,350	87,250	11.770	5.339	72.540	23.72
2	223.3	15.7	486.8	252.7	95.8	53.2	144	10.12	11.8	.83	10.0	.703	28.52	724.41	1.48	37.59	16,447	194,431	88,194	11.822	5.362	72.222	23.62
3	224.1	15.77	485.7	252.1	94.2	52.3	166	11.68	...	...	11.0	.773	28.539	724.9	1.461	37.1	18,158	212,029	96,176	11.677	5.297	73.118	23.91
4	223.3	15.7	489.6	254.2	98.4	54.7	159	11.18	11.8	.83	11.5	.809	28.471	723.15	1.529	38.85	18,273	212,330	96,313	11.620	5.271	73.476	24.02
5	222.6	15.65	496.5	258.05	105.7	58.7	163	11.46	11.8	.83	10.8	.759	28.588	726.15	1.412	35.85	18,317	213,976	97,059	11.682	5.299	73.086	23.90
6	220.4	15.5	510.9	266.1	121.0	67.3	175	12.31	12.7	.893	12.0	.844	28.586	726.08	1.414	35.92	20,472	234,930	106,564	11.476	5.206	74.400	24.33
7	219.8	15.46	519.3	270.7	129.5	72.0	182	12.8	12.8	.9	12.5	.879	28.683	728.55	1.317	33.45	21,925	250,407	113,585	11.421	5.181	74.757	24.46
8	221.8	15.6	518.8	270.5	128.0	71.1	185	13.01	13.5	.949	12.8	.9	28.791	731.3	1.209	30.7	22,150	253,388	114,937	11.439	5.189	74.630	24.41
9	221.1	15.54	501.5	260.8	111.2	61.8	187	13.15	...	...	13.0	.914	28.744	730.1	1.256	31.9	22,432	256,716	116,446	11.444	5.191	74.606	24.41
10	221.3	15.56	513.9	267.7	123.5	68.6	194	13 64	14.2	.998	14.1	.992	28.902	734.1	1.098	27.9	24,137	274,971	124,727	11.392	5.167	74.947	24.52
11	220.3	15.49	512.9	267.2	123.0	68.4	196	13.78	13.7	.963	13.6	.956	28.882	733.6	1.118	28.4	24,200	275,593	125,009	11.388	5.166	74.973	24.52
12	220.3	15.49	496.8	258.2	106.8	59.4	197	13.85	14.6	1.027	14.1	.992	28.896	734.0	1.104	28.0	25,170	285,184	129,359	11.330	5.139	75.357	24.63
13	217.9	15.32	524.3	273.5	135.2	75.2	211	14.84	14.5	1.019	14.7	1.033	28.761	730.53	1.239	31.47	26,153	295,373	133,981	11.294	5.123	75.597	24.72
14	224.0	15.76	500.0	260.	108.5	60.3	215	15.12	...	...	15.0	1.055	28.862	733.1	1.138	28.9	26,740	301,035	136,549	11.258	5.107	75.840	24.81
15	221.6	15.58	510.0	265.5	119.5	66.4	210	14.77	16.5	1.16	15.9	1.118	28.862	733.1	1.138	28.9	28,378	323,353	146,673	11.395	5.169	74.928	24.51
16	220.0	15.47	515.5	268.6	125.6	69.8	211	14.84	16.6	1.167	16.2	1.138	28.812	731.82	1.188	31.18	28,517	325,072	147,453	11.399	5.171	74.901	24.49
17	220.3	15.49	513.0	267.2	123.0	68.4	210	14.77	16.5	1.16	16.8	1.181	28.78	731.01	1.22	30.99	30,232	344,787	156,395	11.405	5.173	74.862	24.48
18	217.2	15 28	518.0	270.0	129.1	71.8	206	14.48	17.3	1.216	17.2	1.208	28.801	731.55	1.199	30.40	30,397	348,018	157,861	11.449	5.193	74.574	24.39
19	217.1	15.27	515.4	268.6	126.6	70.3	212	14.9	18.5	1.301	18.5	1.301	28.623	727.03	1.377	34.97	31,986	364,280	165,237	11.389	5.166	74.968	24.52
20	218.2	15.33	519.5	270.8	130.4	72.5	209	14.7	17.6	1.237	18.2	1.28	28.75	730.25	1.25	31.75	32,348	366,572	166,277	11.332	5.140	75.343	24.64
21	216.3	15.21	513.3	267.4	124.9	69.4	209	14.7	18.1	1.272	18.9	1.328	28.765	730.63	1.235	31.37	32,490	370,335	167,984	11.398	5.1701	74.908	24.52
22	222.8	15.66	518.0	270.2	127.0	70.5	182	12.78	13.9	.976	13.0	.913	28.55	724.70	1.45	36.83	21,610	246,661	111,850	11.414	5.179	74.733	24.42
23	224.0	15.76	508.0	264.5	116.5	64.5	186	13.05	14.2	.998	13.3	.931	28.53	724.67	1.47	37.23	21,800	250,134	113,600	11.474	5.207	74.412	24 35
24	222.9	15.67	512.0	266.7	121.0	67.3	194	13.66	14.8	1.042	13.9	.976	28.92	734.57	1.08	27.43	23,890	272,335	123,600	11.400	5.170	74.824	24.48
25	223.1	15.67	515.4	268 9	124.3	69.0	213	14.98	16.2	1.139	15.1	1.062	28.85	732.8	1.15	33.15	26,505	298,810	135,600	11.274	5.114	75.660	24.79

[1]as corrected to 215 lb. per sq. in. or 15.1 Kg. per sq. cm. Abs. Press.; 120 deg. fahr. (66.6 deg cent.), super heat; 29 in. Hg. (736.6 mm.)

pump for each unit, the piping for all of which is cross connected through a common header. The water used for the turbine oil coolers returns the heat which is thus regained by way of the feed water heaters.

The exhaust from the auxiliaries has been carried into the

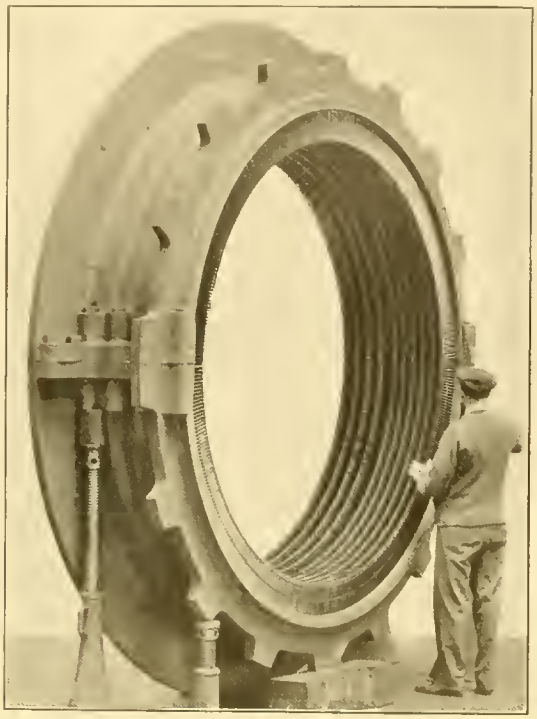

Fig. 10 Ring Section of Low-Pressure Blades

feed water heaters which operate at low pressure. The shortage or excess of heat in this heater system, as the case may be, is compensated for or utilized by means of heat balance valves operating between the auxiliary exhaust lines and the receivers between the turbine elements.

For test purposes one unit was selected as representative of the installation. Tests were made upon this unit by the use of standard methods, special provisions being taken to secure accuracy, some of which are detailed below:

High steam pressures were observed by the use of gages, in duplicate where of importance, such gages being calibrated before and after each test. Temperatures were observed by carefully calibrated thermometers, immersed in iron pipe wells, filled with mercury or oil, depending upon conditions. Wells were of ample depth and correction was made for immersion. Low pressures were observed by the use of mercury manometers. Vacuum readings were made by the use of mercury columns provided with a vernier reading to 1/100 of an inch. The mercury in these columns was regularly cleaned and its specific gravity determined before and after test series and corrections made accordingly. Temperature corrections on mercury columns were provided for by the use of thermometers set in each column casing and additional corrections were made for specific gravity, meniscus and barometer reading. The barometer used on the test was calibrated by reference to the U. S. Weather Bureau.

The condensate was weighed in tanks mounted upon two

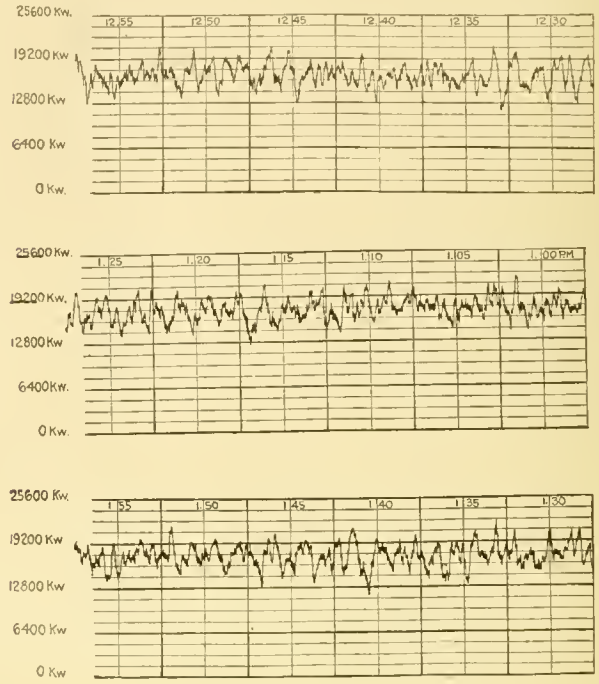

Fig. 11 Watthour Meter Charts

carefully calibrated platform scales. Platform scales were also used to measure drips and leakage. The unit was isolated so far as water and steam outlets were concerned. The large atmospheric relief valve necessarily remaining connected to the exhaust system was water sealed, the seal being

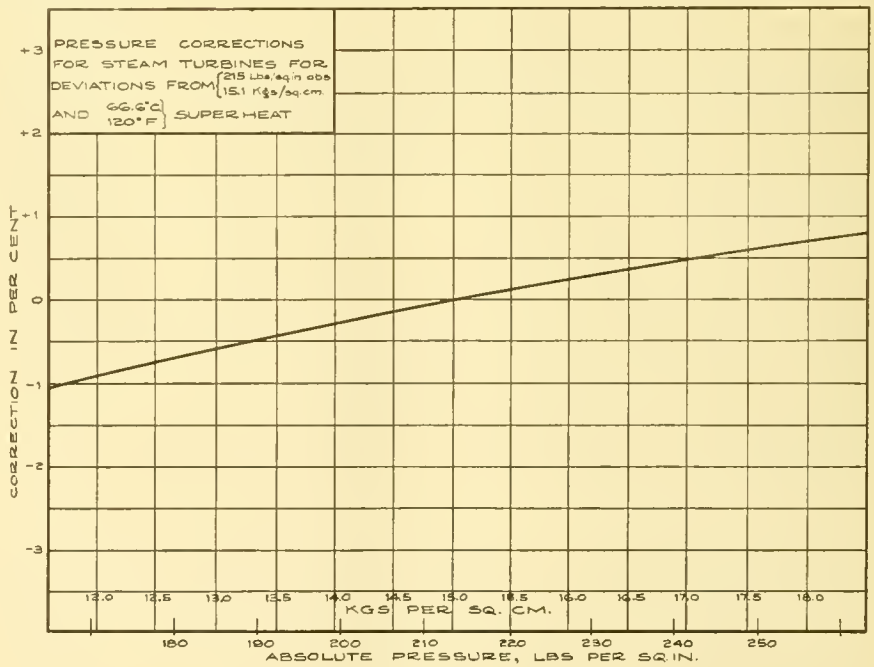

Fig. 12 Pressure Correction Chart

kept under continual observation by means of a window in the valve cover and interior illumination by electric light.

The unit output was obtained by means of three single

phase rotating standard watthour meters, one connected to each phase. These watthour meters were calibrated before and after the test series, which calibration included the current and potential transformers and showed no variation in excess of 0.2 per cent.

Each test was of three hours' duration with about a half hour preliminary operation under test conditions. The load was controlled from the switchboard, the turbine operating upon the governor with hand throttle wide open. This subjected the turbine to the full swings of the railroad load, as observed by means of a graphic wattmeter, which furnished an interesting index of such load variations. Table 1 gives a summary of the results of these charts and Fig. 11 shows a typical section of a chart. At light loads these variations were more pronounced, approximating frequently 5000 kw. either side of the average. A variation of 10,000 kw. total in half a minute was not uncommon, especially on loads of 16,000, 18,000 and 20,000 kilowatts.

The test results have been shown graphically in Figs. 7, 8 and 9, upon bases of load and water-rate, load and thermal efficiency, and load and Rankine cycle efficiency ratio. In conducting these tests, naturally every effort was made to maintain certain standard conditions under which guarantees had been given, and the test results as tabulated have been corrected to such standards. These standards represent what is probably the average of operating service. Corrections for variation from standard conditions were based upon curves as shown in Figs. 12, 13 and 14, which corrections were agreed upon prior to the commencement of tests.

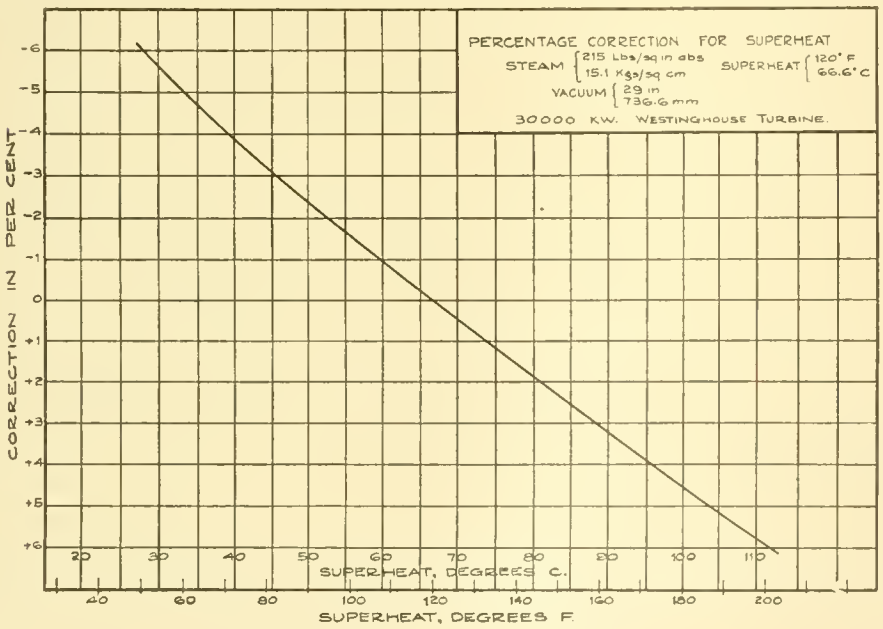

FIG. 13 SUPERHEAT CORRECTION CHART

In discussing and analyzing the test results, attention might be called to the following particular features:

1. With due allowance for scale of ordinates the performance curves may be considered unusually flat, naturally conducive to high plant efficiency.

2. The dip in the curve between 22,000 kw. and 26,000 kw. is a peculiarity which was received at first rather skeptically, but which was later remarkably checked by repetition of tests throughout the range, including a special series under steady load made three months subsequent to the original series and given herein as Nos. 22-26 in the tables showing test summaries. Various theories have been advanced in connection with this dip and a series of special tests was made to investigate the relative action of the receiver between the two cylinders as a separator, and the velocities of the steam passing through it, with the idea that this might have some direct bearing upon this dip. Unfortunately, winter load demands terminated further research work in this direction without any definite results having been obtained.

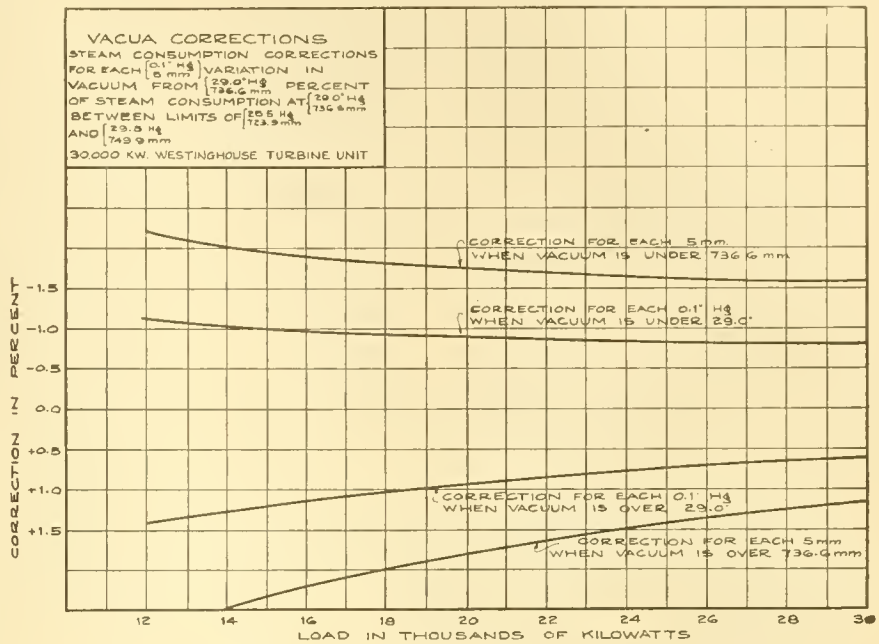

FIG. 14 VACUA CORRECTION CHART

3. The turning up of the curve between 30,000 and 32,000 kw. is another peculiarity, accounted for by the turbine designer as follows:

"Concerning the supposed inconsistency in these tests, i.e., the turning up of the efficiency curve between 30,000 and 32,000 kw., consideration and figuring indicate that this is actually not an inconsistency, but a new experience. This turbine was designed for higher hydraulic efficiency than probably any machine heretofore built, thus approaching the crest of the efficiency curve. The overload capacity of the machine is small, or in other words, the amount the turbine is by-passed when the secondary valve opens is small, and the velocity ratio, therefore, is very little lower when full steam pressure is applied to the secondary inlet than when such pressure is applied to the primary inlet. Further, the hydraulic efficiency is nearly the same, so that the Rankine cycle at 32,000 kw. should not be more than 1 per cent lower than at the point of best efficiency, viz., 26,000 kw. The efficiency at the intermediate overload, say, 30,000 kw., is somewhat worse than this,

TABLE 3 CONDENSER TEST, SUMMARY OF RESULTS

Pressure at Throttle, Abs..	220 Lb. per Sq. In.	15.466 Kg. per Sq. Cm.
Temperature at Throttle..	487 Deg. Fahr.	252.8 Deg. Cent.
Superheat.....	97 Deg. Fahr.	54 Deg. Cent.
Load, Av. Kw.....	31233	
Exhaust Vacuum.....	28.61 In. Hg.	726.69 Mm. Hg.
Exhaust Pressure, Abs.....	1.39 In. Hg.	35.31 Mm. Hg.
Corresponding Temp.....	89.4 Deg. Fahr.	31.9 Deg. Cent.
Mean Temp. Difference (Log.).....	12.9 Deg. Fahr.	7.17 Deg. Cent.
Heat Transferred per Hour	316,000,000 B.t.u.	79632000 Large Calories
Heat Transferred per Unit Surface per Hour.....	6,330 B.t.u. per Sq. Ft.	17150 Large Calories per Sq. Meter
Heat Transferred per Unit Surface per Hr. per Deg. M.T.D.....	490 B.t.u. per Sq. Ft.	2390 Large Calories per Sq. Meter
Air Leakage per Min.....	16.88 Cu. Ft.	478 Cu. Dm.
Condensate per Hr.....	357,060 Lb.	161962 Kg.
Temp. of Hot-well Water..	86 Deg. Fahr.	30 Deg. Cent.
Temp. of Intake Water....	70.8 Deg. Fahr.	21.5 Deg. Cent.
Temp. of Discharge Water..	80.9 Deg. Fahr.	27.2 Deg. Cent.
Rise.....	10.1 Deg. Fahr.	5.7 Deg. Cent.
Cir. Water per Min.....	64700 Gal.	243890 Litres

for while the blading and hydraulic efficiencies remain as high there is a loss due to a certain portion of the steam expanding through the secondary valve to a lower pressure without doing work."

A number of tests were made upon the condensers and auxiliaries, separate and individual guarantees having been made upon the condenser proper, circulating pumps, dry vacuum pumps and hot well pumps. Publication of the test data upon the pumps would simply show good efficient performance without unusual features. The results of the tests upon the condenser have been given, however, simply as a matter of information and interest in connection with the installation as a whole. The guarantees were based upon operation under maximum load, viz., about 32,000 kw., and the test was made with the turbine carrying as near that load as was possible. The duration of this test was three hours, the preliminary operation under test conditions, half an hour. The results have been shown in Table 3. No corrections were made in this test, as operating conditions approximated the guaranteed conditions very closely, with the exception that air leakage was high. The tests were made very shortly after the installation of the machine and little opportunity had been given under operating requirements properly to eliminate this leakage, which has since been done. A permanent gasometer has recently been installed in connection with each unit, in order to observe air leakage at regular intervals and aid in its elimination.

Summarizing the results of these tests, it may be said that the performance in the case of both turbine and condenser showed higher efficiencies than was guaranteed under contract, and the installation has proven to be thoroughly satisfactory in every particular, having fully realized the considerations which governed its selection.

DISCUSSION

Henry G. Stott. I think it may be of interest for me to make a few historical remarks. The station in which this apparatus is located was designed about the year 1900, so that from that time until the present represents a period of about sixteen years. This installation illustrates very well the tremendous evolution of the art in that brief period.

Sixteen years ago the turbine was hardly heard of in this country; only a few practical experimental sets had been installed, and the large engines which were then designed for the Allis-Chalmers Company by the late Mr. Reynolds, became known as the Manhattan type engine. That engine, as some of you may recall, consisted of a horizontal high pressure cylinder connecting on to a vertical low pressure cylinder, at right angles on the same crank pin. Then on the other side of the generator was a duplicate set. Only two cranks were required for four cylinders.

These engines established an enviable reputation for reliability. Their economy was as good as could be expected in reciprocating engines at that time, with comparatively moderate pressures of about 175 lb. and no superheat. The valves were the regular Corliss type.

It is an interesting fact to recall about what these units cost. They were 5,000 kw. rating, with a maximum overload capacity of 50 per cent, bringing up the maximum load to 7,500 kw., which they would readily carry, but with correspondingly poor water rates. The water rate of the engine on test ran over 17 lb. per kw-hr., and that was considered a very good record. The cost of these units, for the engine, generator and condenser, was a little over $40 per kw. capacity, based on the rated capacity. To contrast that with what has been installed in place of them is rather interesting.

To go back just for a moment to the original plant. It was designed on what was practically a unit basis, as far as the engines and boilers are concerned, that is to say, there was a group of eight 520 h.p. boilers per unit, and each unit could be operated independently of the rest of the plant, but normally was operated with all the boilers connected together through two headers. The boiler capacity, therefore, was 4,160 boiler h.p. for a 5,000 kw. unit.

In place of the engine, the new unit was installed, the test of which is described in the paper,—a 30,000 kw. unit, cross-compounded, the high-pressure turbine, running at 500 r.p.m., exhausting into a low-pressure turbine running at 750 r.p.m., and that unit of 30,000 kw. capacity was placed between the same centers as the 5,000 kw. unit we took out. The cost per kilowatt of the modern unit, including condensers, I think was a little over $9, as compared with $40, in the first place.

You see that we put in the same space a 30,000 kw. unit in place of a unit having a maximum of 7,500 kw., or 5,000 kw. economic rating, for the efficiency curve of the engine took on approximately the shape of a V, so that it did not pay to run the units very much over the rated capacity of 5,000 kw.

The plant which has been put in place of it is operated by the same eight boilers, that is to say, the boiler capacity has not been increased, except to put in underfeed stokers under the boilers, so that we have simply changed a 5,000 kw. unit to a 30,000 kw. unit. That is about six to one increase in capacity, on the same number of boilers. Of course, this is being accomplished by correspondingly low water rates, as shown in the test described in the paper.

The improved water rate is obtained through the more economical turbine and through the use of the superheat, so that the actual water rate, discounting the superheat, is, with the present unit on the average of about 12 lb., as compared to about 17.5 on the average with the previous unit. We therefore have here a very good illustration of the enormous

progress which has been made in fifteen years in the art of developing steam motors.

The advantages which have been procured are, first, in the same floor space we get six times the capacity at a cost per kilowatt of approximately one-fifth of the original unit; and, what is still better, the water rate, when reduced to saturated steam, has been reduced approximately fifty per cent. That is an enormous gain, and I think we ought to feel very much gratified at the wonderful development which has taken place in the steam engine as a prime mover.

The progress of the steam turbine has been so great that to-day it has practically displaced the gas engine. If you will look at the thermal efficiency given in the test described in the paper, you will find it runs up to about 25 per cent. That is practically in the same class as the best gas engine practice to-day. So, as the cost of the gas engine unit is probably seven or eight times as great as the turbine unit, the gas engine has been practically put out of the running for large power plant work.

Another very interesting sidelight in this matter is the value of the installation as a general prime mover in competition with anything else that could be cited. Fifteen years ago hydroelectric power developments were looked on as a choice investment, worth lots of money at almost any cost of development. Waterpowers were developed that cost $200, $250 and $300 a kilowatt. To-day you could not get money for an investment of that kind. Why? Simply because the steam turbine has become so efficient and at the same time decreased in first cost, that it has driven out all possibility of developing a great many of these waterpowers, because when you consider the fixed charges, the steam turbine can make power more cheaply than the high-priced hydroelectric development.

Even take the case of Niagara Falls itself, where there is no dam required, and where there is practically an unlimited supply of power, the steam turbine plant can compete as long as the load factor is less than 60 per cent. The only chance for waterpower development is on high load factor.

These things are all due to the wonderful development in the steam turbine in the last fifteen years. We all probably recollect the first few large units which were developed, and a great many of us were rather doubting Thomasses at that time. The water rates obtained were from 20 to 24 lb. per kw., and it seemed that it was hardly worth while to bother with the turbine. The only thing that seemed in its favor was that it took less floor space and cost less, but to-day that argument no longer applies. The steam turbine has apparently come to stay, for some time at all events, and as far as we can foresee in the future, as our principal prime mover, and its only rival is hydroelectric power when the load factor is large.

Francis Hodgkinson. In the report of these tests one should not be misled by the large scale ordinates employed. The casual inspection of Figs. 7 and 9 would lead one to believe there are many inconsistencies. Both of these figures exhibit two rather curious reverse bends, one occurring between 22,000 and 26,000, the other between 27,000 and 32,000. The latter lends itself to the explanation quoted in the text of the paper.

The reverse bend occurring between 22,000 and 26,000 kw. is not as easily explained. Its existence during the tests was doubted and various errors were suspected. Repetition of the test, however, made it very certain that this vagary actually exists.

It is unfortunate that Fig. 7 did not have total steam against kilowatts plotted thereon because up to the point of best efficiency this should be a right line and hence any irregularities in the test results may be best studied by means of such a line.

Plotting this line through the averages of the test points it is found that the greatest deviation from the right line law amounts to only 0.053 lb. in test No. 4. It was supposed that the behavior of the receiver separator installed between the high-pressure and low-pressure turbine elements was the reason.

It seemed in advance that there was an advantage in the cross-compounding scheme in that there was an opportunity to separate effectively the precipitated water between stages

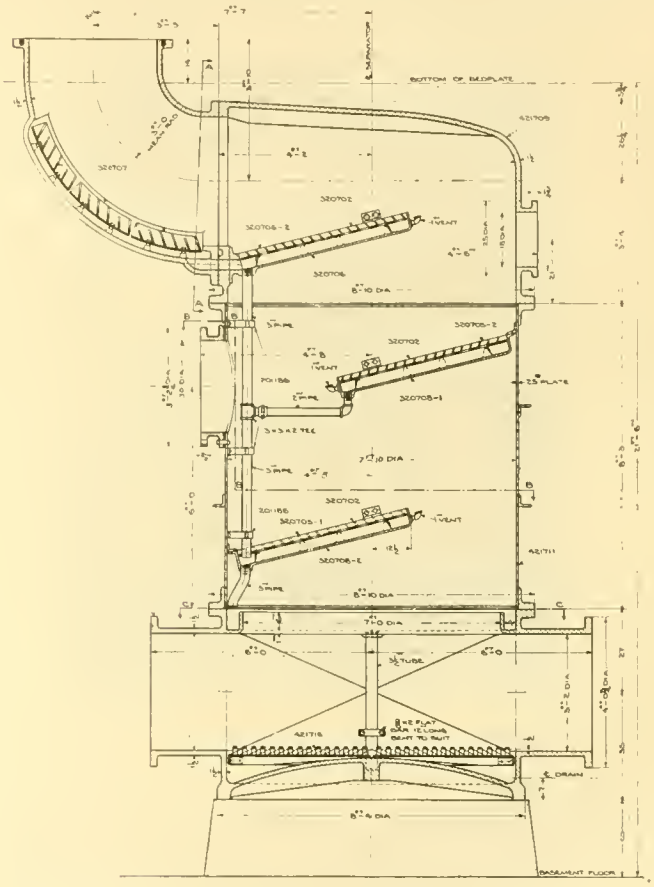

Fig. 15 Steam Separator Used in the Plant

and relieve the low-pressure elments of the friction of this inert fluid, and so an attempt was made to provide a satisfactory steam separator between the two turbine elements. Everyone agreed that the most effective separator would be a vessel in which the steam velocities would be lowered to some 20 or 30 ft. per sec. Such a separator was, however, out of the question with the enormous volumes involved. The design of separator finally adopted is shown in Fig. 15, in which the moisture is abstracted by the use of baffles, and to some extent at least by centrifugal force as the steam flows around the curved surfaces at high velocity.

The baffles are hollow boxes with perforations and riffles on their upper side, the interior being piped to the base of the separator to preclude the water once separated being picked up again by the flowing steam; the inlet elbow is similarly treated. The general arrangement of the separator is shown in Fig. 16.

The steam leaves the base of the separator by means of two pipes on either side which join together, subsequently again dividing and entering the low-pressure turbine by means of the two pipes shown on the left, the peculiar arrangement of piping being necessary to give space for the condensers which are located either side of the inlets to the low-pressure turbine.

During the tests calorimeter readings were made of the quality of the steam entering the low-pressure turbine and these seemed to indicate that the separator was effective at minimum and maximum flows with a point of ineffectiveness at moderate flow. It was found, however, that these calorimeter readings were not to be relied upon and in fact any calorimeter readings are difficult to obtain under variable load conditions, because of the heat inertia of the calorimeter parts. Contemplation, however, of the separator makes it

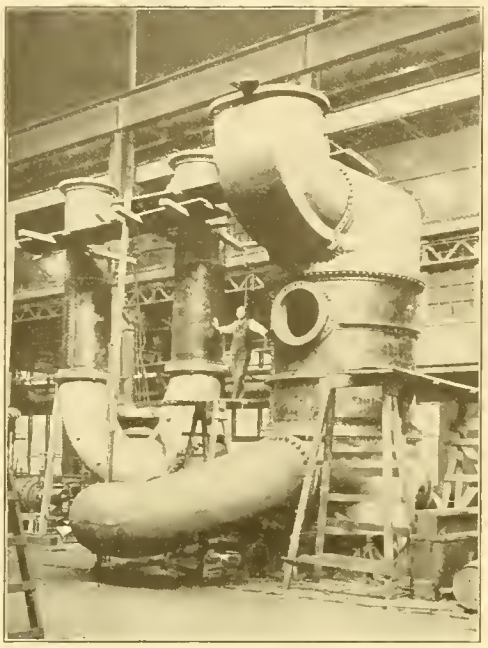

Fig. 16 General Arrangement of Separator

readily conceivable that with small flow effective separation may be accomplished by virtue of the low velocity; that at large flow, the separator was also effective by reason of centrifugal forces, and that there may be some intermediate and critical point where the water would sweep through without separating.

At the conclusion of the tests the builder's engineers set about an investigation of this separator with a view to eliminating the peculiarity in the test results and generally bettering the performance.

It is unfortunate that on account of the exigencies of power house operation these could not have been brought to a conclusion. These investigations were of course of real interference because the moisture observations were useless except with quite steady loads. It is further unfortunate that only observations of the pressure drop through the separator and the steam quality entering the low-pressure turbine were made and no means were installed for measuring the quantity of water actually separated and discharged to the condenser hot well through the trap.

The observations showed a considerable drop in pressure through the separator and it seemed that an improvement in performance might be obtained by removing all baffles even though this might result in some increased moisture delivered to the low-pressure turbine; the riffle plates at the base of the inlet elbow being replaced with a smooth perforated plate.

Fig. 17 has been plotted showing the pressure drop and moisture in per cent plotted against steam flow both with and without the baffles and it is seen that the removal of baffles not only caused material reduction in the pressure drop through the separator but also a material improvement in separation.

Considering further the matter of the separator, I have had plotted curves, Fig. 18, showing the weight of water going to the low-pressure element; also the calculated quantity of water leaving the high pressure. This is calculated on the assumption of all turbine elements of the complete unit being equally efficient which is not quite technically correct and from the actual steam consumption of the complete unit. The ratio of these two lines is plotted in Fig. 18 and shows the effectiveness or efficiency of the separator.

It is plain, therefore, that were the tests to be now repeated, one to one and a half per cent better results might be expected.

A clause in the contract for these turbines provided that the tests should be carried out with the load variations incidental to the elevated railroad and indeed the load was anything but steady as shown in Table 1, there being load varia-

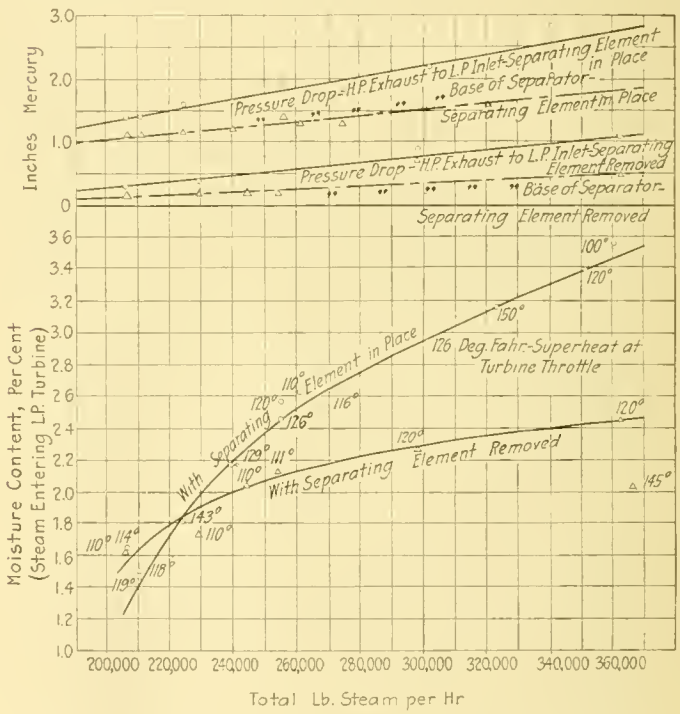

Fig. 17 Pressure Drop and Moisture Plotted Against Steam Flow

tions recorded as high as 69 per cent and single swings as high as 58 per cent—all of which one would suppose would affect the test results quite deleteriously. For while the heat absorbed by the turbine walls during an upward swing is all given back to the steam in a downward swing the heat is taken from the steam when it is at a higher pressure than when it is returned to it, which is of course a direct loss. However, subsequent tests with the governor hobbled did not show any particular difference.

A point of interest in these tests is that between the loads of 21,000 kw. and 32,000 kw., i.e., a range of 11,000 kw., the

variation in steam consumption was from 11.274 to 11.449, a difference of but 17/100 pound.

R. J. S. Pigott. It seems almost superfluous to compliment Mr. Stott on the success of this undertaking, as the habit of bringing such engineering feats to a successful conclusion is almost chronic with him.

Referring to the use of two speeds for high- and low-pressure elements, as noted in the paper, the inherent difficulty with the reaction type turbine is that the high-pressure blading is always noticeably less efficient than the low-pressure blading. The hydraulic efficiency of each is probably about the same, but the leakage area over the tips of the high-pressure blades is much greater than the leakage over the low-pressure blades because of the relative shortness of the former. The high speed possible with the high-pressure element makes it possible to reduce the diameter of the drum and at the same time maintain satisfactory blade speeds, and in this manner lengthen the blades for a given annular area; thus, of course, reducing the percentage of leakage area. The gain due to this feature alone is approximately 3 per cent of the total water rate of the unit.

Referring to the use of the individual elements separately in emergency, it is to be noted that in case the low-pressure element is used on by-pass, it must be protected against overspeed in the same manner as the whole unit; therefore, the by-pass was fitted with a 12-inch automatic valve operated from the overspeed governor of the turbine, in the same manner as the main throttle.

Referring to foundations, it is to be noted that in the case of turbine foundations of steel the question of strength is of little importance if the structure has been designed for the allowable deflection, since the foundation is then many times as strong as a normal load-supporting structure. The maximum stresses, disregarding the reinforced concrete envelope, amounted to about 7,000 lb. per sq. in., disregarding the stiffening effect of the reinforced concrete. The increase of strength due to the concrete envelope is about 40 to 45 per cent additional.

The main reason for employing concrete coating was to destroy the excessive harmonic vibration occurring in plain steel structures. It has been found in those plants where uncovered steel foundations are in use (notably the 201st Street Station), that with a turbine equally well balanced, harmonic vibrations are very much more pronounced. The concrete envelope has also an additional function: of protecting the steel permanently against corrosion. The maximum deflection used in designing the steel structure was 0.020 in.

Referring to the condensers and their supports, the unusual feature of this installation is the large amount of movement between the two exhaust openings. In most installations at the present time, a single condenser has been employed, but as the change of length between the centers of the exhaust openings amounts in this case to 0.150 in. between the operating condition and the non-condensing condition, it would be practically impossible to use a single condenser without expansion joints between the turbine outlets and the condenser. In the original design bronze single bellows were used on the piping, there being two 60-in., two 42-in., two 12-in. and a 36-in. It was found, however, that the comparative stiffness of these joints caused the turbine casing to be distorted enough to endanger operation. When it is remembered that one of the 60-in. joints is at a distance of approximately 27 ft. from the center line of the turbine, it is clear that a tremendous leverage is exerted. Some of the joints were tested, and it was found that one of the 42-in. joints took a 32,000 lb. load to compress one-eighth of an inch. It was evident that no metallic joint with a reasonable thickness of shell would be satisfactory. Rubber joints were, therefore, substituted, using the rubber in much the same manner as the bronze had formerly been employed, the cast iron parts being so designed as to give the rubber the maximum degree of support against either pressure or vacuum. As these rubber joints are only used in contact with water, there is no especial danger of oxidation and consequent short life. If any trouble from exterior oxidation should appear, it could no doubt be very readily prevented by shellacing or paraffining the exterior of the joint.

Referring to the return of all waste heat possible, it is to be noted that the return of heat from the oil coolers amounts to nearly 1 per cent of the total heat in the turbine, and the

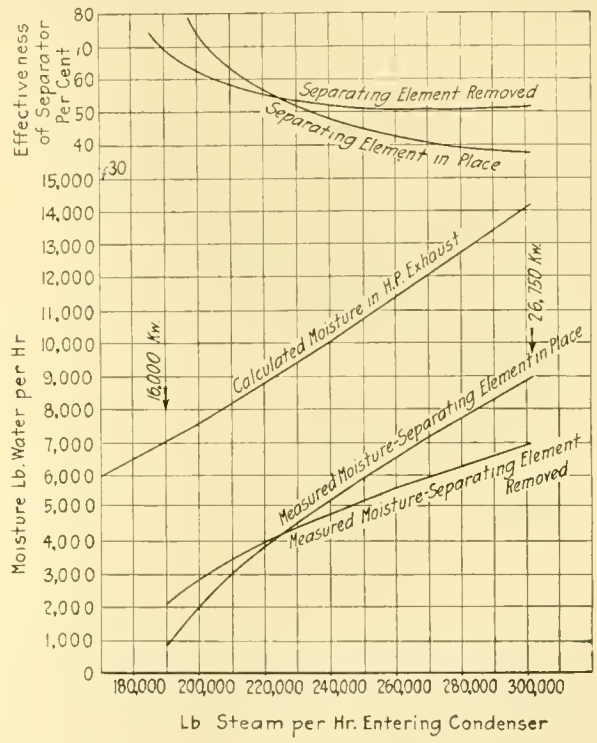

Fig. 18 Water Going to Low Pressure Element

heat in the air from the turbine generators which amounts to about 1 per cent, is also returned by carrying a discharge duct to the boiler room cellar, where the warm air is used by the forced draft fans. The question of steam or electric-driven auxiliaries was settled by a graphic method of heat analysis covering all loads; in this plant all auxiliaries are steam-driven. The total quantity of auxiliary steam increases very slightly with the load on the main unit; it is, therefore, evident that at light load there will be excess exhaust steam over that required for the feed water heater, and with heavy load there will be too little, the balance occurring at approximately 25,000 kw. on the main unit. The heat balance valve compensates for this feature; at periods of light load it will be noticed that the receiver pressure is less than atmospheric; at such times the excess exhaust steam is free to be admitted into the low-pressure element and there produces a certain amount of power. At high loads, the pressure in the receiver is higher than atmospheric, and the conditions are, therefore, right to deliver steam to the auxiliary exhaust systems as noted. Considering the almost ideally automatic nature of

the above operations, the heat balance valve designed by Mr. Hodgkinson is admirably simple. In the original layout no free atmospheric exhaust was to be provided; ordinary free exhaust being expansive, large sized piping, used a few times during the life of the turbine. It was thought practicable to dispense with it by providing an additional automatic throttle valve controlled by a mercury tripper operated by the vacuum. This tripper was directly connected to the condenser and was in the form of an exaggerated mercury gage; if the vacuum fell below a predetermined amount, say 19 to 20 in., a float in the mercury was lifted, tripping a pilot valve which closed the main throttle. It was also so arranged that in starting up the same method of safeguarding could be employed, operating at 1 to 2 lb. above atmospheric pressure, the device automatically resetting itself for the vacuum conditions, as the vacuum rises in the condenser.

However, the auxiliary exhaust system is of such dimensions that it can be used as an atmospheric relief, merely by en-

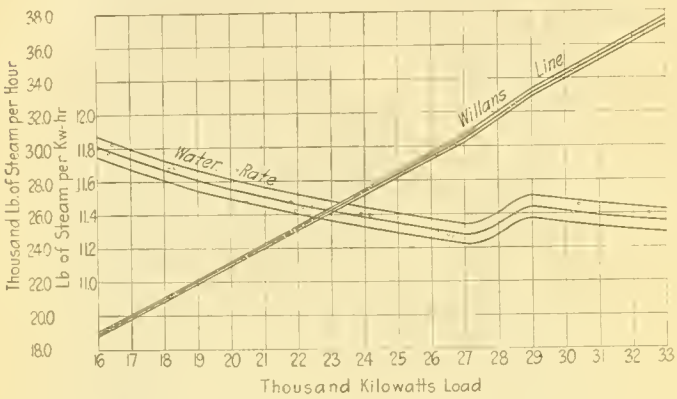

FIG. 19 WILLANS LINE AND WATER RATE FOR 30,000 KW. TURBINE

215 lb. absolute; 120 deg. fahr.; 29 in. vacuum; 30 in. barometer.

larging a short section of the line from the turbine to the main exhaust. The old 30-in. engine relief valves were remodeled and the connection was made between the high- and low-pressure cylinder. The loading of these valves which, of course, have to stand pressure at the receiver of as much as 25 lb. absolute, is accomplished partly with a hydraulic cylinder connected to the gland sealing water. In addition, the dashpot on the other side of the valve was ring-packed and connected direct to the condenser, so that were the vacuum lost, part of the load would be automatically removed from the valve, assisting it to relieve the system promptly. As the discharge side of the valve was on the auxiliary exhaust system at 15.5 lb. to 16 lb. absolute, it was automatically steam-sealed; a water seal was, therefore, not absolutely necessary, but was installed as an additional precaution.

Referring to the variation of load during tests, as the Willans line up to best load is straight, and after best load is approximately straight at a different slope, the only point where swinging load would have any effect would be at, or near, the best load, since with a straight Willans line the average water rate for swinging loads is the same as the water rate at a definitely fixed load equal to the average.

Referring to the investigations on the separator: the conditions found were not surprising, considering that practically similar experiences were obtained in the matter of moisture separation from low-pressure steam in connection with the low-pressure turbine at 59th Street, in 1909 and 1910. The first separator installed on No. 1 unit at 59th Street, was about 7 ft. by 14 ft., full of baffles; the results were, practically no separation of moisture. The baffles were removed and it was found that the quality immediately jumped from 92 per cent to 95 per cent or 96 per cent using a plain tank.

Separators Nos. 4 and 5 were designed merely as plain tanks, 8 ft. in diameter and 32 ft. long, containing nothing but protection for the water in the bottom of the separator, and accomplished separation to 99 per cent quality and over. From the consideration of the sizes of these separators, and the amount of steam passed, it appears evident that similar separation is quite out of the question for the 74th Street turbines. It seemed impossible with any baffle separator to remove anything but the water which is running along the sides or bottom of the pipe. The last 2 per cent of "fog" can be removed by only one method, i.e., low velocity (not over

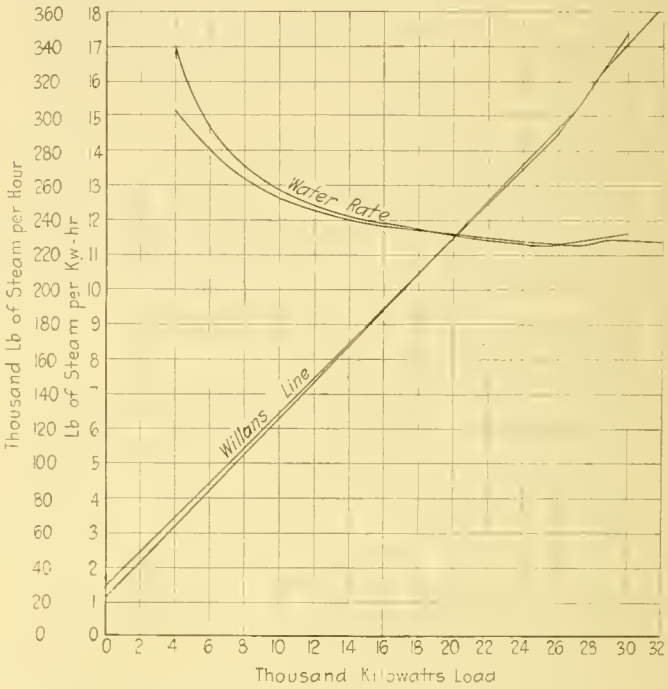

FIG. 20 WILLANS LINE AND WATER RATE FOR 30,000 KW. TURBINE. GUARANTEE AND TESTS

215 lb. absolute; 120 deg. fahr.; 29 in. vacuum; 30 in. barometer.

3,000 ft. per min.), and space, allowing time for the small drops to coalesce into larger drops and rain out by gravity.

Referring to the curve of water rates, Fig. 7, as Mr. Hodgkinson has remarked, some of the curious features of the curve are due to exaggerated scale of the plotting. As he has also pointed out, it is very desirable to make use of the Willans line for fairing the curve. When it is noticed that the total water consumption at any given load may vary 3,000 or 4,000 lb. between different tests, it seems apparent that the unusual curvature represented, up to 26,000 kw., is not justified, but the water rate curve drawn from the straight Willans line will pass just as fairly through the points and give results more in accord with ordinary expectations. Fig. 19 drawn with straight Willans line in accordance with the above shows a maximum variation either side of the average of 0.5 per cent. All of the test points lie within the area of this curve, which is 1 per cent of the total water in width. No commercial tests that have been run up to the present time have ever come closer to the mean than this. It, therefore, seems unnecessary to look for new laws to fit these curves when the old ones fit very well.

Fig. 20 shows how closely the test results follow the general predictions of the guaranteed results. The same objection holds true in some degree to the remainder of the curve, although the first part of the rise from 27,000 to 31,000 occurs very nearly in accordance with the curve obtained direct from the Willans line. It is doubtful if there is such improvement in water rates in passing 31,000, as the curve shows. Mr. Hodgkinson's point that the hydraulic efficiency of this machine is near the crest of the curve is perfectly true, but it must be remembered that when operating at maximum load on the secondary valve, there are only 32 stages in operation, instead of 38, the first eight being entirely blanketed at this time. Therefore, although the hydraulic efficiency of the stages may be as good as at best load, the efficiency could not be quite as good, especially as the first eight stages are revolving idly in high pressure steam, and the exit loss is increased. However, as has already been said, these variations of the curve as drawn, from water rate curves placed back from the Willans line, are really very slight in actual mount.

I think that not only are Mr. Stott and his associates to be congratulated upon these remarkable results which have so closely justified the preliminary calculations, but especially Mr. Hodgkinson for the extraordinary excellence of design which, up to the present date, represents the high water mark of turbine engineering.

Francis Hodgkinson. I would like the privilege of replying to Mr. Pigott's discussion. He refers to the advantage of examining turbine tests by means of plotting total steam against load. This desirability has already been referred to in my previous discussion in which I also pointed out the small amount by which the test points departed from the Willans right line law. The departure from this, however, was nevertheless there and not to be ignored. The tests were repeated too many times for the matter to be relegated to ordinary errors of test.

I do not concur with Mr. Pigott's conclusion as to the effect on steam consumption of the overload valves, that is, valves which permit the turbine to carry greater load by bypassing certain elements of the turbine. The curve of hydraulic efficiency, and by this I mean the efficiency that is the result of relation between steam and blade velocities and blade angles, is of the order of the curve, Fig. 21. With the angles ordinarily employed, the highest efficiency is theoretically reached at about 90 per cent velocity ratio. It is readily conceivable that a turbine might be designed so that the velocity ratio with full steam pressure at the primary admission might be arranged to have a velocity ratio of considerably over 100 per cent. Then with full pressure applied to the secondary admission, the steam consumption might actually be better than with full pressure applied to the primary admission only, if the turbine is operating at somewhere near the same speed in each case. This is a feature which is frequently made use of in marine work in order to obtain high efficiency at cruising speeds. The above, however, does not refer to this specific case as the turbine under discussion is designed for a velocity ratio approximating 75 per cent. The amount of the turbine by-passed by means of the secondary admission is a small proportion of the whole turbine so that the effect on the so-called hydraulic efficiency is small and hence the performance with full pressure on the primary admission only and full pressure on the secondary admission is not materially different, there being intermediary points of poorer performance.

It is customary nowadays for turbines to be sold at a maximum continuous rating corresponding to that of the generator. This, however, has very little to do with the capacity of the turbine itself as the most important thing in the design of the turbine is the capacity at the point of best steam consumption. It is not difficult to provide means of carrying proportionately heavy loads in excess of this at higher steam consumption.

In case of small street railway companies, the point of best steam consumption may be but a relatively small proportion of the maximum rating to enable the power house to carry heavy peaks for brief periods of time. At other power houses, such as the large Edison stations, a maximum load is carried practically all the time the unit is operating, in which case the point of best efficiency should approach the maximum continuous load.

The effect of imposing more load on the turbine than that

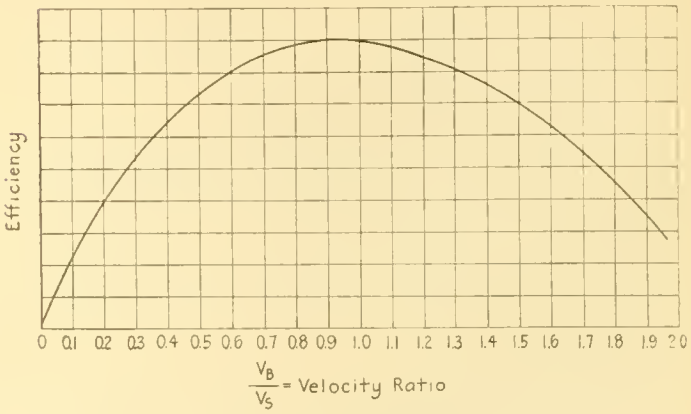

Fig. 21 Curve Showing Order of Hydraulic Efficiency for Turbine

due to full steam pressure being applied to the secondary admission or other overload valves, if there be any, is to cause the turbine to slow down. Loads as high as 36,000 kw. were observed during the early operation of these machines, but these were probably in error. The test records show pressures at the secondary admission of 200 and 201 lb. gage respectively for 31,986 and 32,348 kw. respectively.

John P. Sparrow. I cannot add anything to the admirable paper that Messrs. Stott and Finlay have presented to us this evening in the way of either criticism or comment, but in line with Mr. Stott's historical review, I will give a few items in connection with the plant of the New York Edison Company.

Of the two Waterside Stations, one was built in 1900 and one in 1906. The original equipment in those stations was 152-650 horsepower boilers, designed for hand firing, the grates burning No. 3 buckwheat coal. The development that has taken place in turbines and in the high boiler capacities has resulted in an increase in capacity over the original 140,000 kw. to 250,000 kw., and we still have capacity for 100,000 kw. more, with a very moderate boiler rating of 250 per cent, which means we have between 450,000 and 500,000 kw. available boiler capacity if we go to the present day methods of operation.

I would like to ask Mr. Stott, briefly emphasizing Mr. Reinicker's remarks, as to the thermal efficiency of the station. We are interested in large turbines, we are all in-

terested in high boiler capacity, and we have had quoted results of 16, 17, 17¼, and in some cases 17.5 per cent thermal efficiency. As I understand the 74th Street Station, these three units carry practically the entire output of the station, therefore, any figures which Mr. Stott might give us would give us comparison with the best practice that has been quoted up to date.

John W. Thomas. The author has brought out quite prominently the large capacity it was possible to install in the existing space and on existing boiler equipment. One would infer from his remarks that this was largely due to the increased efficiency of the turbine; whereas, I believe the reason for the increase to be largely due to the boiler room and equipment.

I believe the old station was designed for boilers to operate approximately at rating, and the boiler capacity was put in on this basis. To-day, with the underfeed stoker it is possible to run the boilers at a much higher rating. Mr. Stott gets something like 300 per cent of rated capacity in everyday operation, which, I believe, is the one largest item in the increased capacity of existing equipment.

In line with this, we have just installed at New Orleans a 900 h.p. Babcock & Wilcox boiler, with underfeed stoker, on which, with the ordinary operating crew and in regular operation, we have been able to get 450 per cent. This boiler is a duplicate of twelve other boilers in the plant, which were put in from 1904 to 1908, equipped with overfeed stokers. We find that the new boiler will deliver as much steam to the plant as it is possible to get out of three of the old boilers of exactly the same size.

One gentleman asked the question, "How much coal is consumed in the plant described in the paper?" The coal is burned; that is the province of the underfeed stoker. In the boilers mentioned above, we have been able to burn about 16,000 lb. per hour.

Selby Haar asked whether any endeavor was made to use the pitot tube type of steam meter as a check on the methods of measuring the feed water, and Mr. Finlay replied that the venturi type was used but not the pitot, and they checked up very closely; indeed, about one-half of one per cent was the actual variation.

Thomas N. Roberts. What happens to the steam curve when an overload is put on the generator? The rating of the machine is given in kilowatts, and the machine is running, according to the curves, usually something a little above that. The term "maximum rating" has entered into the rating of electrical apparatus in the last few years, and this term would lead us to perhaps apply it also at this point to the turbine, where it falls off in ability to hold up under an added electrical load. The question then arises, if 25 per cent additional to this normal rating is added, in the way of an electrical load, what will happen to the steam and other characteristic curves?

F. W. Dean. Mr. Stott has told us that in the case of reciprocating engines, he had 5,000 kw. rated power driven by a certain number of boilers, without superheat, and in the case of the turbine he had 30,000 rated power driven by this same number of boilers with superheat. As a matter of interest, I would like to know how much coal in each case was used per kilowatt-hour.

E. H. Foster. It would be interesting to know whether the question of substituting reheaters for the superheaters in the high-pressure turbine was considered.

Norman G. Reinicker. In Table 2, I notice that the vacuum decreases with the decreasing load. I was wondering if that was due to increasing air leakage, because in most turbines, as the load decreases, that is, as the quantity of steam to be condensed decreases, the condenser would give better vacuum, because it is running under load.

The paper says that this leakage has been corrected, more or less, and I was wondering what it is at these lower loads, —how fast it increases?

I was also wondering what the station load factor is, and what the economy of the station was with the turbines all running, and using the exhaust steam into the main turbine, and the heat from the generator going back into the boilers. That is what we are interested in in utilizing these large machines in power stations.

Henry J. Stott. Mr. Roberts asked what would happen if we added 25 per cent overload on the generator. Of course, obviously, the turbine would begin to shut down. Nothing else would happen except that there would be a reduction in speed. The actual limit of load the unit will carry, without loss of speed, is apparently about 33,000 or 34,000 kw. We have actually carried 32,500 on the test, and maintained full standard frequency, 25 cycles, but beyond that, somewhere between 33,000 and 34,000 kw., the turbine begins to drop in speed. If you added 25 per cent on to the 30,000 kw., you would bring the turbine down somewhere about 15 per cent in speed.

In regard to the coal per kw-hr. on the engines before the turbines were put in at all, mentioned by Mr. Dean, we were running about 2.5 lb. of coal for the plant, averaged at the end of each month. That included, of course, everything, all auxiliaries, coal handling apparatus, and everything else. In other words, the total coal used per month divided by the kw-hr. output, or delivered to the feeders leaving the power house (what we call the net output), would result in a figure of approximately 2.5 lb. of coal per kw. That was before the turbines were put in. Since the turbines were put in, and while they have been carrying practically all of the load too, with the steam mains leading to the engines still alive for emergency purposes, the coal consumption is approximately 1.5 lb., a drop of 1 lb. per kw., as the result of the installation of the big turbines. The thermal efficiency of the station for the monthly average is approximately 17 per cent.

In reply to Mr. Foster regarding reheaters between the high and low-pressure turbines, that practice has been abandoned, as previous investigations in connection with the engines show no improvement, and there is probably none.

Mr. Reinicker asked why the vacuum went down with the load. That is undoubtedly due to air which at that time we were unable to overcome, but later, with more care and experience and the use of a gasometer, we have been able to eliminate that trouble.

I would like to say one word of congratulation to Mr. Hodgkinson, who is the designer of this machine, which is a very radical step in turbine design, and I do not think it would be fair to conclude the presentation of the paper without paying a special tribute to his originality and also the great engineering skill and courage he has displayed in carrying out the design.

Society Affairs

Engineering Survey

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National Defense and International Peace

Business and Patriotism

A Non-partisan Appeal to the Nation

THE WHITE HOUSE
Washington

April 21, 1916.

To the Business Men of America:

I bespeak your cordial cooperation in the patriotic service undertaken by the engineers and chemists of this country under the direction of the Industrial Preparedness Committee of the Naval Consulting Board of the United States.

The confidential industrial inventory you are asked to supply is intended for the exclusive benefit of the War and Navy Departments, and will be used in organizing the industrial resources for the public service in national defense.

At my request, the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Chemical Society are gratuitously assisting the Naval Consulting Board in the work of collecting this data, and I confidently ask your earnest support in the interest of the people and government of the United States.

Faithfully Yours, Woodrow Wilson

COMMITTEE ON INDUSTRIAL PREPAREDNESS
OF
NAVAL CONSULTING BOARD OF THE UNITED STATES

IN CO-OPERATION WITH

THE AMERICAN SOCIETY OF CIVIL ENGINEERS
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
THE AMERICAN INSTITUTE OF MINING ENGINEERS
THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
THE AMERICAN CHEMICAL SOCIETY

ENGINEERING SOCIETIES BUILDING
29 WEST 39th STREET, NEW YORK

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SOCIETY AFFAIRS

COUNCIL NOTES

At the meeting of the Council on May 12, 1916, the following were present: D. S. Jacobus, *President*, John H. Barr, R. M. Dixon, *Chairman Finance Committee*, Arthur M. Greene, Jr., Henry Hess, Charles T. Main, Spencer Miller, I. E. Moultrop, *Chairman Publication Committee*, H. de B. Parsons, J. E. Sague, John A. Stevens, Max Toltz, E. H. Whitlock, Wm. H. Wiley, *Treasurer*, and Calvin W. Rice, *Secretary*.

The President reported the appointment of A. T. Brown, Ambrose Swasey, E. J. Armstrong, J. A. Brashear, J. A. Matthews, P. J. Fickinger, E. P. Bates, E. N. Trump, F. G. Tallman, A. W. Smith, W. C. Brown, F. R. Hutton, W. B. Cogswell, H. H. Suplee, Wm. H. Wiley, and F. A. Halsey as Honorary Vice-Presidents to represent the Society at the funeral of John E. Sweet, Honorary Member, Past President and Founder of the Society.

W. H. Bixby, H. A. Gillis, G. M. S. Tait and W. A. E. Doying were appointed as Honorary Vice-Presidents to represent the Society at the Conservation Congress.

J. S. Hyde and H. H. Davis having resigned as Directors of the Industrial Preparedness Census, Messrs. P. M. Hammett and F. P. Fisher were nominated State Directors for Industrial Preparedness for the States of Maine and Oklahoma respectively.

The President announced the appointments of H. G. Stott and H. L. Gantt on the Committee on Standardization, to fill vacancies caused by the resignations of J. H. Barr and Charles Day.

Interpretations of the Boiler Code Committee, Nos. 59 to 66 inclusive, were approved and ordered published; they will appear in the July Journal.

At the request of the Joint Conference Committee of the National Engineering Societies, another member from this Society, Dr. Jacobus, was added to the representatives of our Society, Charles Whiting Baker and Arthur M. Greene, Jr.

A. L. Williston, *Chairman*, C. H. Fish, C. W. E. Clark, A. C. Ashton and W. G. Starkweather were approved as a Section Committee in Boston. J. W. Roe and F. L. Mackintosh were approved as members of the New Haven Section Committee, to succeed L. P. Breckenridge and H. Y. Brewer. The President and Secretary reported having made addresses regarding Society affairs before the Sections in Philadelphia, Buffalo, Providence and that they had planned to address a meeting in Detroit, Baltimore, Chicago, Milwaukee and St. Paul.

Actions of the Executive Committee were confirmed. One of these related to requesting for the Pan-American Committee, through the columns of The Journal, the names of members of the Society who have had actual experience in South and Central American countries.

CALVIN W. RICE, *Secretary*.

NATIONAL SOCIETIES AND LOCAL SECTIONS

An informal discussion was held at the house of the American Society of Civil Engineers, on the evening of April 19, 1916, on the subject:

"What relation should exist between the National Engineering Societies and the local sections or associations of their members, and, in the interests of the profession, what should be the attitude of both of the above to other local engineering societies or clubs?"

By invitation, members of the other three National Engineering Societies were present, and past and present officers and members of these societies gave the history and experiences of the sections of their organizations.

A full account of the discussion appears in the May Proceedings of the American Society of Civil Engineers. Many of the remarks made were of direct interest to our members, and those by Dr. Jacobus, together with a very brief abstract of those by some of the other gentlemen who spoke, are reproduced below.

ELMER L. CORTHELL, PRESIDENT AM. SOC. C. E. (by letter). —In this carefully considered outline plan, the objects kept in view are the *Solidarity* of the engineering profession in the United States and the *Independence* of its individual Society Units.

ELEMENTS

A—"*Joint National Conference Committee*" of the five National Engineering Societies—Civil, Mechanical, Electrical, Mining, and Marine Engineering and Naval Architecture.

B—"*Joint Local Conference Committees*" of the Associations or Chapters of the Societies above named located at population centers of the country (including members in districted areas) constituting a connecting "live wire" with the

C—*Local Engineering Societies*.

SCOPE AND DUTIES OF EACH ELEMENT

1—(A) (Joint National Conference Committee) will embrace all general and National Engineering subjects, problems, and policies, transmitting to (C) (Local Engineering Societies), through (B) (Joint Local Conference Committees) information, and receiving from (C) through the same channel their desires and suggestions.

2—The National Societies, through their Joint Local Conference Committees, will encourage their members to apply for membership in the Local Engineering Societies, and the latter will, through the Joint Local Conference Committees, encourage their members, on the other hand, to apply for admission in the National Societies—and all Societies through the same channel will urge engineers not now members of the Society (the number being considerable) to apply for membership in *some* Society—with the view to consummating effectively the solidarity of the entire Profession, numbering, it is estimated, more than 60,000.

3—*Technical Literature*.—Papers of general, National or international interest to be, generally, presented to the National Societies; but those of Local, Municipal, and State interest to be presented to the Local Engineering Societies—as the former demand a National distribution and the latter a local circulation.

4—All Societies—National and Local—through the intermediary of the Joint National Conference Committee and the Joint Local Conference Committees to work for the promotion, protection, and advantage of every one of its 60,000 members—from the National, State, Municipal, and individual point of view—in matters of legislation—National, State and Municipal—in civic and patriotic measures—in employment of the Engineer and in the publicity necessary and proper to bring to the notice and appreciation of the public at large—and the Natonal, State, and Municipal Governments, the duty, ability, and determination of the Engineer to assert and assume his rightful place in the body politic as a useful, interested and patriotic citizen.

5—The plan above outlined, if carried into full and effective execution, will redound to the public welfare and to the

general and personal advantage of the Engineer, and it will soon prove to the Nation that his fundamental purpose is not altogether to "make a living, but to live a life" of high endeavor and usefulness, and with the motto "*Service and Self Sacrifice.*"

Paul M. Lincoln, Past-President, A.I.E.E., Mem.Am. Soc.M.E.—A point on which we have labored considerably in the local Sections of the American Institute of Electrical Engineers is the matter of coöperation between the local Sections of our Institute and the other engineering bodies in those localities. It is a matter which has been talked over to a very considerable extent, and we have a large amount of experience on it. It has always been my endeavor and aim, so far as I have been able to guide the Sections, to insist that the spirit behind the relations between the local Sections of the American Institute of Electrical Engineers and the other engineering bodies in any locality, shall be one of coöperation rather than antagonism.

Antagonism will never get us anywhere, whereas coöperation is the thing for which we are all striving; so it has always been my endeavor to work for that coöperation. It has always been my feeling that there was no cast-iron way of bringing about coöperation in any local Section, that the methods of bringing about that coöperation were necessarily local problems, and had to be worked out in each locality for itself.

The object, of course, of all these meetings and affiliations among the various engineers and engineering societies is to enhance the value of the engineer in his particular locality, and to give him a wider influence in general, and particularly in civic affairs.

Dr. D. S. Jacobus, President Am.Soc.M.E.—The subject before us to-night, which has been so ably discussed, is one of the most important, if not the most important, before the Engineering Societies at the present time; it is so important that I hope to be able to appear before all the Sections of The American Society of Mechanical Engineers during my term as President in an endeavor to obtain the views of the membership at large.

There was a good representation from the Sections from all parts of the country at the recent meeting of our Society in New Orleans, and in conferring with members from many different districts, it would appear that there is a closer coöperation between the members of the different Sections than there is between the governing boards of the Societies. Our governing boards should get together, and the quicker we do so the better it will be for us. It certainly would be a good move to have a joint meeting of the Committees of the Sections of the several Societies, as suggested by your President, Dr. Corthell.

I agree that there should not be too many restrictions in the management of the Sections, especially at this time when we have not established a definite policy. Every Section has special problems of its own to deal with and must use its own methods. Our management should be broad and such as to inspire loyalty and foster coöperation. I was much gratified in meeting the members of the different Sections to find them enthusiastically in favor of coöperation, and it is, therefore, a most opportune time for the managing boards of our Societies to get together and devise a means whereby this may be accomplished in the best way for all concerned. Our members have shown such a fine example in coöperation that it only needs a little encouragement from headquarters to spread this spirit throughout the country and thereby enhance the interests of the entire profession. I hope, therefore, that Dr. Corthell will call us together without delay.

In addition to the geographical Sections, The American Society of Mechanical Engineers has forty student branches, numbering about 1000 student members. Young men form the life of any society, because later they will fill our places. As we grow older, we appreciate more and more that the capital of youth is a most valuable asset; in managing the affairs of our Societies, therefore, we should keep our young men well in line, for in them lies the future strength of our organizations.

W. L. Saunders, Mem.Am.Soc.M.E., Past-President A.I.M.E.—The Institute inaugurated the local section policy about five years ago. We have today fifteen Sections, our experience being that a Section is an element of strength, adding a limb to the main body and contributing toward the general interest and prosperity of the Institute. Through Sections the membership is largely increased.

Another advantage derived from Local Sections is that the influence of the Institute may be used through its Sections to benefit the mining industry as it affects different parts of the country.

The policy of the Institute has been to invite representatives from the Local Sections, who may be visiting New York, to attend the meetings of our Executive Committee and Board of Directors. The advice given by members of the Institute coming from different sections of the country has been wholesome and beneficial. It brings them in touch with the policy and the officers of the Institute, and it brings the management in touch with the special conditions which exist in different sections of the country.

C. D. Marx, Past-President, Am.Soc.C.E.—I think one of the most important things in connection with the local organizations is the social factor. It is good to read papers; it is good sometimes to have papers read to you, but I think it is far better that the men who are doing the work of the world today should be brought together into common contact. You cannot know a man and not like him as a rule, and the fact that, in the past, we have not had the opportunity of knowing our fellow members, of knowing our fellow engineers, working along other lines, has, to my mind, been a serious detriment, and has prevented that recognition of the engineer on the part of the community, which engineers were not even willing to extend to one another.

J. F. Coleman, M.Am.Soc.C.E.—The spirit of coöperation among the engineers is surely abroad in the land. It is apparent that many members of the profession in all branches have been giving much thought to this question, and more particularly during the current year.

As it appeals to the speaker, from the practical standpoint, coöperation among engineers might be divided into five general headings:

First.—The coöperation between the National Engineering Society and its members, more especially those whose residences or places of business are remote from Society Headquarters. It would appear that this kind of coöperation may only be brought about by the local sections or chapters which have been mentioned by every preceding speaker. It is highly necessary that the coöperation between the governing board of the National Society and its members should be as complete as it is possible to make it, as otherwise the National Society cannot hope to achieve its fullest usefulness.

Second.—The coöperation of the National Engineering Societies with each other. This is hardly less important than the first kind of coöperation mentioned.

Third.—Coöperation between the National Engineering Societies and Local Engineering Societies.

Fourth.—Coöperation of Local Engineering Societies with each other; and.

Fifth.—Coöperation of local members of National Societies with each other, or, perhaps, it would be better to say coöperation between individual engineers.

The desire for coöperation of the National Engineering Society with its own members appears to be indicated by the organization of local sections or chapters.

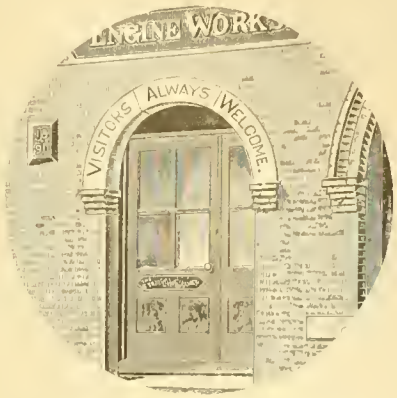
The spirit of coöperation between National Engineering Societies and Local Engineering Societies is only beginning to make itself evident. The same may be said of the coöperation of Local Engineering Societies with each other.

George F. Swain, Mem.Am.Soc.M.E., Past-President, Am. Soc.C.E.—It has occurred to me, in listening to what has been said tonight, that there is a deeper side to all this subject of coöperation, which we all desire to bring about. The object of this is to increase the prestige and the influence of the profession, to get for ourselves all that we can in the way of position and influence and power and wealth, if you like, and also to make our profession of the greatest real use to the community. These are all legitimate objects, for any man or any society or any profession.

JOHN EDSON SWEET

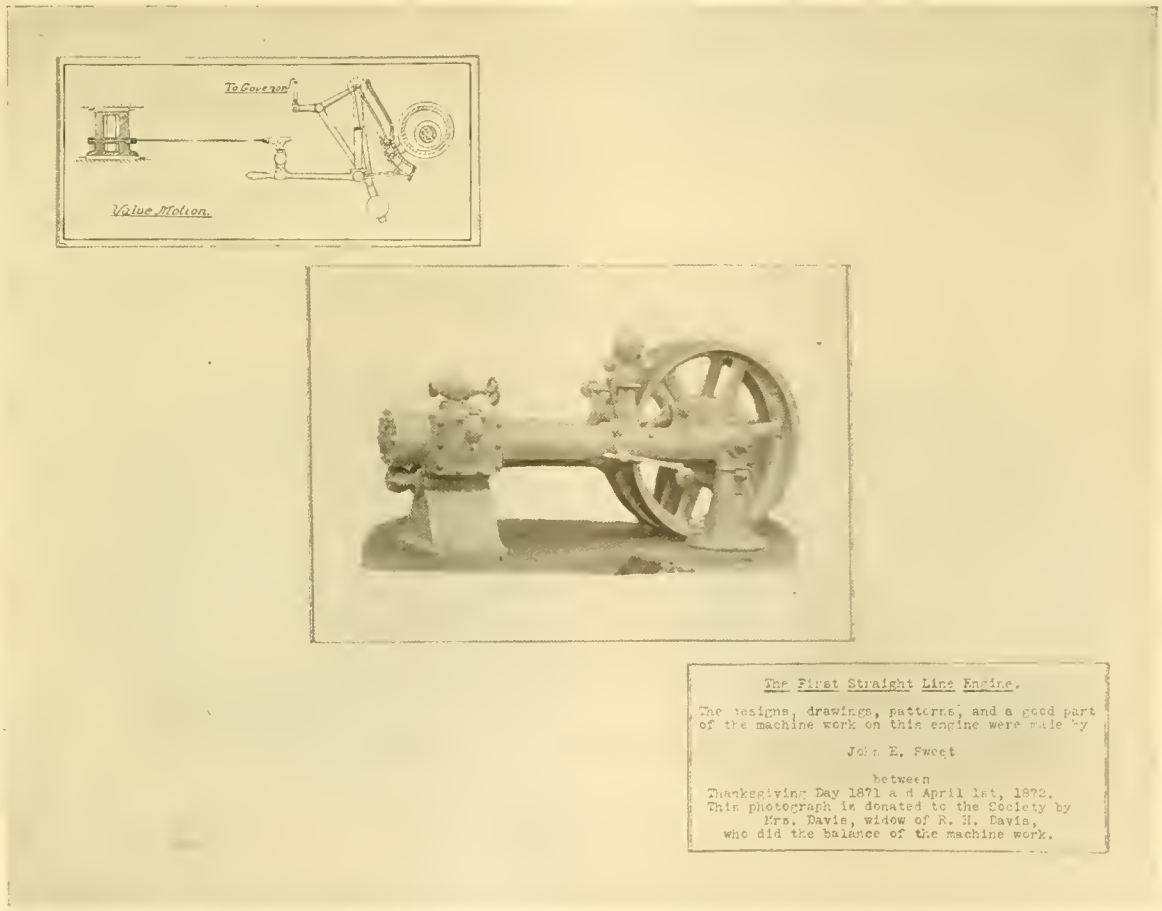
JOHN EDSON SWEET died suddenly at his home at Syracuse, N. Y., on the evening of May 8, at the age of 83 years. He was the founder of The American Society of Mechanical Engineers, its third President, an Honorary Member, and recipient of the John Fritz Medal for his "achievements in machine design and pioneer work in applying sound engineering principles to the construction and development of the high-speed steam engine."

Dr. Sweet's prominence as a national figure dates from his connection with the Sibley College of Mechanic Arts of Cornell University, in 1873. His connection with this institution lasted only until 1879, and in that brief period he rose from a position of obscurity to one of prominence, which he ever after maintained. It was a case of the man and the hour. Mechanical engineering as a department of organized education was a new thing. In it there were no precedents, and regarding it there was almost universal skepticism. Its plans, its scope and its aims were unformed even among its friends, and its friends were few. The field was fallow, and into it came, almost by accident, the personality of this untried and unknown man.



EMBLEM, CHARACTERISTIC OF THE LIFE OF JOHN E. SWEET

His work was two-fold; first, that of a teacher, and second, of a pioneer in mechanical construction. As a teacher, the immediate results of his work will necessarily die with his students, but as a pioneer he laid enduring foundations. Previous experience in England had shown him the fundamental importance of the work of Whitworth, which, because of our then happy-go-lucky methods, had found little appreciation on this side of the Atlantic. Combining an appreciation of Whitworth's advanced standards of accuracy with original conceptions of fundamentally correct principles of construction of a kind far surpassing Whitworth's work, he established a school of construction of far-reaching influence. Along with this went an application of art in design—not the art of ornamentation, but the highest



REPRODUCTION OF PICTURE OF FIRST STRAIGHT LINE ENGINE IN THE ROOMS OF THE SOCIETY

The History
of the
Mechanical Experience.
of John E. Sweet,
Engaged from 1850 to 1861 at
carpenter & joiner work and archi-
tecture as apprentice & office boy,
journeyman, foreman & superintend-
ent, builder and architect.
Draftsman and pattern maker
in Machine and R. R. Shop up to '62.
Inventor & Draftsman at the Lon-
don Works, Birmingham, England
up to '64.
Designer of Machinery at the
Onondaga Steel Works until '67.
Inventor and Draftsman in
Europe to '68.
Superintendent of the Mower
and Reaper Works at
Syracuse 3 years.
Supt. of Bridge Building
until '73.
Professor of Practical
Mechanics at the Cornell
University, Ithaca 6½ years.
At present engaged in
building Steam Engines
as President and Super-
intendent of the Straight
Line Engine Co.
Correspondent of Scientific
and Technical Papers
since 1858.

(Reproduction of Professor Sweet's simple statement, in his own handwriting, in his application for membership in the Society.)

of all, and in engineering work the only true art, that of perfect adaptation to purpose—that has never been surpassed.

Analysis of a successful teacher's methods is always difficult, and the greater the success the greater the difficulty. Of Professor Sweet's methods there was little organization and less formality. For their prototype we must go back to the schools of the Greek philosophers, who gathered their students about them and taught by a process which was one of absorption rather than acquisition. Without compulsion, students gravitated to him as pieces of iron to a magnet. Those who came under his influence felt that they enjoyed a precious privilege.

Dr. Sweet was born at Pompey, near Syracuse, N. Y., October 21, 1832. His father, Horace, was a farmer and his mother was a member of the well known Avery family, distinguished by its mechanics and inventors. He was educated at district schools and in 1850 was apprenticed to John Pinkerton in the carpentry and joinery trade. When through with his apprenticeship and with $49 in his pocket saved from his meagre earnings he obtained a position in the architect's office of Elijah T. Hayden of Syracuse, in the belief that to become a successful carpenter one must first learn the principles of drafting.

A second winter was spent in the office of C. O. Holyoke, an artist and an admirer of Ruskin, who directed the boy's thoughts to the channel of sound construction and the principle of suiting the construction to the use. He was soon convinced, however, that regardless of how much he might admire art the faculty in his makeup which was worth cultivating was in the direction of mechanics. But to what an extent in later years did he combine so beautifully art with mechanics!

For ten years he was engaged in carpentry and the making of construction drawings for buildings. In that time and place there was small opportunity for the display of architectural talent but nevertheless one of his first pieces of work was a design for a barn which won the first prize in a competition established by the farm paper, the *Rural New Yorker*. It was probably one of the best of its type of buildings ever worked out. A description, with illustrations, and a statement of the conditions of award, appeared in the *Rural New Yorker* in its issue of February 5, 1859. The committee in reporting stated that it "found quite a multiplicity of designs having many excellent features but many were quite too expensive for ordinary farmers and entirely beyond their ability to erect, and only adapted to the able and wealthy who cultivate and embellish their country homes for pleasure and beauty rather than profit." The selection of the Sweet drawings was made, on the contrary, because the barn was "designed to meet the wants of the great majority of farmers as they now exist in the country, adapted not alone to the stock raiser, dairyman or grain grower, but to all these combined and for general farm purposes, including not only beauty and structure but the greatest amount of convenience, cheapness and adaption to all the wants of the majority of farmers." It was prophetic of the architect's work in succeeding years that the prize design was unique and individualistic and adapted to the requirements of the "great majority" of users.

When the Civil War broke out young Sweet was supervising the erection of a hotel at Selma, Ala., which he had designed and which was planned to be one of the best in the South. Being a Yankee he sensed an uncomfortable situation and, as he expressed it, one rainy day he decided to leave while the "leaving was good." Incidentally, this change of location marked a change in his activities, which were thereafter almost entirely in the direction of mechanical construction, engineering, and teaching.

In the summer of 1862 he attended the London Exhibition, spending some months also on the continent and the remainder of the year in the patent office of Hazeltine, Lake & Co., securing a patent on a nail machine in which the Patent Nut & Bolt Co. of Birmingham, England, took an interest. He worked for the latter concern as draftsman while superintending the construction of the machine.

Upon his return to America and again at a later period he was associated with Sweet, Barnes & Co. of Syracuse, where he designed a large number of machines, tools and appliances.

About this time he designed and had built a typesetting machine. It operated like a typewriter, the keys making an impression on a continuous paper pulp matrix, from which the stereotype plates were to be cast. The machine was never perfected but it was one that Dr. Sweet always felt had good possibilities.

In 1867 he again went abroad to attend the Paris Exposition, where his typesetting machine and other appliances were shown.

From 1871 to 1873 he was mainly occupied in bridge building for Howard Soule of Syracuse. In the fall and winter of 1872 he did most of the work of preparing the plans and constructing the first Straight Line Steam Engine; and from 1873 to 1879 was the period with Cornell University.

In connection with this account is a reproduction of a picture of the first Straight Line engine which now hangs in the rooms of The American Society of Mechanical Engineers. This engine was built with a fly ball governor acting upon a peculiar form of link motion.

The second engine, built at Cornell by Dr. Sweet and his students and later exhibited at the Centennial Exposition in Philadelphia in 1876, embodied the combination of a shifting eccentric with a governing weight opposed by a spring, the whole being built into the fly-wheel of the engine. With respect to this Henry Harrison Suplee writes:

This idea was not original with Professor Sweet as various attempts had been made in Europe to design such a governor, notably by Mr. Arthur Rigg, but all such attempts had been unsuccessful owing to the fact that the action of gravity upon the weight was reversed with every revolution of the fly-wheel, thus producing an oscillating movement which, combined with the varying centrifugal force and the action of the spring, gave an irregular movement which was fatal to precise governing.

In Professor Sweet's design the governor weight was so arranged as to be precisely balanced by the weight of the shifting eccentric and its attached parts so that the only variable force was that of the governor weight which depended entirely upon the speed of the engine, and this made accurate governing possible.

In later years many forms of shaft governors involving both centrifugal and inertia forces were designed but it is believed that in every case the makers of such devices recognized the necessity of using the fundamental principle originally designed by Professor Sweet so that to him the steam engineer is indebted for the successful shaft governor.

The Cornell engine in its essentials was substantially as the machine is built today. It contained the embodiment of the three point self-adjusting support for machines, and is the best exemplification up to the present time of the "straight line" principle in machine frame construction. From time to time niceties of details have been perfected, such as the long cross-head with short guides, one of the principles which Dr. Sweet demonstrated was conducive to long wear, although contrary to the usual practice in machine construction.

Fig. 1 Speed Lathe by Professor Sweet, with Characteristic Features

Figs. 2 and 3 Medal Awarded Sibley College for Exhibit Including Straight Line Engine

The following notes and photographs in connection with some of his other work at Cornell University have been secured through the kindness of Dean Albert W. Smith.

Fig. 1 shows a small speed lathe built by Professor Sweet in the Sibley Shops about 1877, which shows the characteristic design of supports and the reduction of bed flexure by bringing in the right-hand leg and thus allowing the bed to overhang with a parabolic outline. This last feature was adopted by many machine tool builders soon after that date.

Figs. 2 and 3 are reproduced from a bronze medal in the possession of Sibley College awarded at the Centennial Exposition in Philadelphia in 1876 for the exhibit of the College, which included Professor Sweet's second Straight Line engine, the first one having been built before he came to Cornell. This medallion was placed upon the front wall of the Straight Line Engine Works in Syracuse, N. Y.

Fig 4 is a machine for grinding cylinders, designed and built in the shops of Sibley College about 1874, several years before the Universal Grinder was put on the market by The Brown and Sharpe Mfg. Co. Professor Sweet designed plug and caliper gages, which were ground upon this machine. A set of plug gages, probably the first to be produced in this country, was ground for the Newton & Cox Company, manufacturers of twist drills, of Cleveland, Ohio, in the spring of 1878.

This machine shows the characteristics of the straight lines and oval section of Professor Sweet's designs; also the long bearing surfaces of the wheel-carrying carriage upon the ways of the bed. It is probably the first instance of the use of dead centers both in the head stock and tail stock for grinding surfaces. It will be noted that a bar connects the top portions of the head and tail stock so that when swung for grinding tapers they remain in absolute alignment.

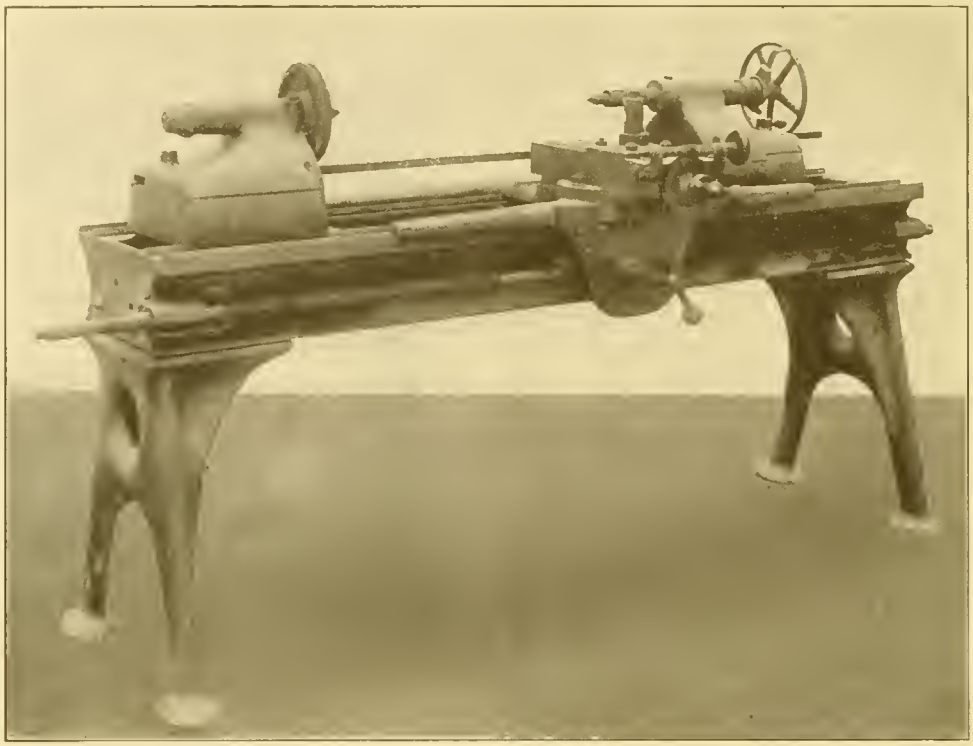


Fig 4 Professor Sweet's Machine for Grinding Cylinders, 1874

At Sibley College, also, were built the first American-made Gramme dynamo and the well known Cornell measuring machine which F. A. Halsey has said "may almost be called a mechanical classic."

Dr. Sweet resigned his scholastic work at Cornell to engage in the manufacture of his engine at Syracuse. The Straight Line Engine Company was formed in 1880. The business started in a small way in a rented building and a few years later a foundry was added and in 1890 a new, and at that time, a unique, shop building was constructed with saw tooth roof, one of the first of its type in this country. The plant has since been somewhat extended and the business has grown normally, never to a large size but maintaining a high grade of workmanship and exemplifying the originality of its head and founder.

As with the engine which was the controlling product of this plant and the design of the building itself, many of the tools, appliances and processes have been of the greatest interest to mechanics and a source of pleasure to those who have accepted the "Visitors Always Welcome" sign over the entrance at its true value and have inspected the plant under the guidance of Dr. Sweet.

One of Dr. Sweet's hobbies was his design of an engine lathe with screw cutting gears in position under the head stock; one of these was built for the Straight Line Engine Company by the students of the University of Wisconsin. The details were so strikingly original that they were described in a series of articles in the *American Machinist* beginning under date of May 30, 1889.

Another machine, which for a better name was designated a "traversing machine," was of the planer type, but with a vertical rotating spindle in place of the usual planer tool. The platen had both a power feed and a quick return by hand. The same was true of the cross rail and of the cross head. The machine was, therefore, capable of doing nearly all kinds of planing, milling, boring or drilling without changes or rearrangement. In an article upon the machine which Dr. Sweet prepared he says characteristically, "The bed is a complete box having solid top and bottom as well as sides, which has been proven by experiment to be 50 per cent stiffer in a vertical direction, 20 times stiffer sideways and 13 times more rigid against torsional strains than the ordinary side plate and cross girder system." The box construction was used for the uprights and the platen as well.

From young manhood Dr. Sweet was a frequent contributor to various journals, and his writings have always displayed that intellectual freedom and clearness which was so characteristic of the man and which, coupled with his lovable nature, gave him so magnetic a personality. During his first trip abroad he contributed letters of travel to a home paper and a series of articles to *The Engineer*. He also prepared manuscripts which later were used by Zerah Colburn when he established London *Engineering*. His best known contributions, however, have been in the columns of the *American Machinist*, to which he contributed frequently, mostly in the way of short articles that were always stimulating in their originality.

It is a pleasant thought that many of Dr. Sweet's greatest pleasures and certainly his greatest satisfactions came to him in the ripening years of his life through his friendships, through his ability to participate in the work of his liking, and in consequence of many recognitions of esteem and appreciation. Perhaps the most cherished recognition was the organization in 1901, by some of his former students, both of Cornell and at the Straight Line Engine Works, of an association of "Professor Sweet's Boys." They were men mostly beyond the meridian of life, who gathered with him year by year on the occasion of his birthday and from long distances, for an annual dinner at Syracuse.

The initial move, made by Dr. Sweet, for the establishment of The American Society of Mechanical Engineers was a letter written January 18, 1880, calling for a conference of prominent men in the mechanical engineering field. The letter read as follows:

11 Eldridge Street, Syracuse, N. Y.
January 18, 1880.

Dear Sir,

It having been suggested by several prominent engineers that a national association of mechanical engineers would be desirable, and a meeting for the purpose of taking steps to organize such a society being in order, your presence is hereby requested at the office of the *American Machinist*, 96 Fulton Street, New York, the sixteenth day of February, 1880, at 1 o'clock sharp, at which time the necessary steps for organizing such an association will be made.

Any inquiries in regard to the meeting will be cheerfully answered.

Please avoid allowing this to be made public.

Very truly yours,
(Signed) John E. Sweet.

Honors were showered upon him, but always against his protest. At the time of the inception of the Society he was offered the presidency, but declined in favor of others whom he—mistakenly and characteristically—considered better fitted for the office; only after considerable pressure would he accept this honor and he served as President of the Society in 1884. He was elected an Honorary Member in 1904, and in 1912 the Society commemorated his eightieth birthday by a dinner at its Annual Meeting; this was the first gathering of this kind in the Engineering Societies Building. In 1914 he was awarded the John Fritz Medal and on January 30, 1914, Syracuse University conferred upon him the degree of Doctor of Engineering.

At the meeting of the Council of the Society, May 12, 1916, President Jacobus appointed the following friends of Dr. Sweet, among them many life-long associates, as Honorary Vice-Presidents to represent the Society at his funeral: A. T. Brown, Ambrose Swasey, E. J. Armstrong, J. A. Brashear, J. A. Matthews, P. J. Fickinger, E. P. Bates, E. N. Trump, F. G. Tallman, A. W. Smith, W. C. Brown, F. R. Hutton, W. B. Cogswell, H. H. Suplee, Wm. H. Wiley, and F. A. Halsey.

AN INTERESTING ANNOUNCEMENT

The Warner & Swasey Company, of which Ambrose Swasey, Past-President of the Society and donor of the initial gift to The Engineering Foundation, is president, and Worcester R. Warner, also Past-President of the Society, is vice-president, announces the completion of the 72-in. reflecting telescope designed and constructed for the Dominion Astronomical Observatory, Victoria, Canada.

This telescope is the largest completed instrument in existence. The block of glass for the reflector was started over from Antwerp about a week before the European War broke out, and work on the reflector has progressed without delay since that time.

When completed, the 100-in. reflector for the Mount Wilson Observatory will be the largest. Work on the installation of this has been delayed on account of inability to procure the tremendous steel members required for the observatory. It is believed that this big telescope will enable us to photograph one hundred million new stars!

In connection with the names of our distinguished members who have carried to successful completion this marvellous piece of work, it is appropriate to mention that of Past-President Brashear, whose most signal achievement has been in connection with the design and development of the spectroscope for astronomical uses, and who completed in 1888 the spectroscope for the 36-in. telescope of the Lick Observatory.

CONFERENCE COMMITTEE

The Joint Conference Committee of the National Engineering Societies has been increased by adding one member from each of the five constituent societies. President Jacobus has been added to the representatives of our Society, Charles Whiting Baker and Arthur M. Greene, Jr.

ENTHUSIASM IN BALTIMORE

Initial meetings of members of the Society in Baltimore to consider petitioning for a Section there, and also of the students in the engineering department of Johns Hopkins University with respect to forming a student branch, were held on May 24. The former meeting was held at the Engineers' Club and the latter at the University. Calvin W. Rice, Secretary of the Society, was present at both meetings and was gratified to find splendid interest.

Johns Hopkins University does not specialize in its courses until the senior year, and it has, moreover, a live engineering society, consequently it is not easy for the students to determine previous to the senior year whether or not they wish a student engineering branch of a national society. There was so much enthusiasm shown at the student meeting, however, that a committee was appointed by Prof. A. G. Christie, the chairman of the meeting, to make a preliminary organization and report in the fall.

At the meeting of members in the Engineers' Club, the Secretary reviewed the history and growth of sections of the Society. He emphasized the fact, as he has done in each of the cities where there is a local club or engineering society, all efforts should be made to build up the local engineering society, and that only after that has been assured may any thought be given to the national societies—that the object of a Section of the national society is to enhance jointly the local society by bringing to it not only the interest of the members

of the national society who are not members of the club, but also the financial contribution which the national societies make for the holding of section meetings. The aggregate of these contributions from all of the national societies would make a substantial increase in the income of the local societies and, in the second place, the burden of maintaining an engineering center would be distributed.

RESEARCH COMMITTEE

The following communication from the Chairman of the Research Committee to a member is of interest as bringing out clearly the objects of this important Committee, as well as giving the present status of the Committee's work:

The object of the Research Committee is to promote the investigation and phenomena, operations, or results of experiments concerning fundamental laws on which engineering practice is based, and to place such data in permanent and basic form. The general committee meets at stated intervals to consider suggested research subjects and to appoint sub-committees to do the actual work of research. Generally, the chairman of the sub-committee is a member of the general committee, but not necessarily so. The present sub-committees are those on fuel oil, materials of electrical engineering, safety valves, worm gears, lubrication, clinkering of coal, steam flow meters, laboratory systems and methods; and a committee on investigation of machine tools is under consideration.

The chairmen and members of the sub-committees either carry on research in their particular field, themselves, by coöperation with manufacturers, or else to have the work done by an interested manufacturer. In general, the expense of the research is borne, therefore, by the interested parties and not by the Society.

Up to the present time the committee has not presented any final reports, but the work on worm gearing is well under way, and also that on steam flow meters, the writer being, incidentally, chairman of this committee. As research work is usually lengthy final reports in less than two or three years are not to be expected. As noted in the definition of the activities of the committee, the work may consist in some cases merely of collation of existing data and putting it in usable form, rather than original research.

BOILER CODE AND COTTON MANUFACTURERS

By invitation of the National Association of Cotton Manufacturers, S. F. Jeter, Mem. Am. Soc. M. E., and member of the Boiler Code Committee, read a paper on the Boiler Code of The American Society of Mechanical Engineers before the meeting of the Association in Boston, April 26 and 27. The paper dealt with the need of uniform rules governing the construction of steam boilers throughout the United States and why the users will benefit by such uniformity. It further showed how the A. S. M. E. Boiler Code meets this need.

After the reading of the paper the Association passed the following resolution:

Whereas, The American Society of Mechanical Engineers, having prepared a satisfactory code for the standardization of boiler construction to promote safety of human life and economy in operation.

It Is Hereby Resolved, that the Association approves the said boiler code and recommends its adoption by states and municipalities where boiler laws are in force or may be enacted.

PAN-AMERICAN COMMITTEE REQUEST

The Pan-American Engineering Committee of the National Engineering Societies, recently organized for the promotion of greater engineering and scientific intercourse and the general welfare of the engineering profession in Latin America and the United States, requests a list of members of the four national engineering societies who have had actual experience in South and Central American countries, and those members of our Society who have had such experience are invited to send their names to the Secretary of the Committee, M. P. Lavis, 50 Church St., New York City, together with the names of the countries with which they are familiar.

The purpose of this request is to acquire information and data which may be of use to the committee in formulating its plans.

MILITARY ENGINEERING LECTURES

The movement for the provision of free lectures on military engineering subjects spread last month to Pittsburgh, where, under the auspices of the Engineers' Society of western Pensylvania, Lieut. Col. F. R. Shunk, Major P. S. Bond, Major J. C. Oakes, and Capt. C. L. Sturdevant, all of the Corps of Engineers, U. S. Army, and Arthur L. Humphrey, Mem. Am. Soc. M. E., vice-president of the Westinghouse Air Brake Company, have given five lectures. The subject of Mr. Humphrey's lecture was Mobilization of Material and Industrial Resources. Elmer K. Hiles, Mem. Am. Soc. M. E., secretary of the Engineers' Society of Western Pennsylvania, superintended the arrangements for the lectures.

The Committee on Military Engineering Lectures in New York, J. Waldo Smith, Mem. Am. Soc. M. E., *Chairman*, announces that as a result of the lectures given under the auspices of this committee an Engineers' Training Battalion of about 500 men has been organized with a view to its members qualifying for an Engineer Reserve Corps. These men have been drilling twice weekly at the local armories under the instruction of the National Guard officers. About 270 members have enrolled for the Plattsburg camp.

Major General Wood has consented to review the battalion on June 1. The Committee believes that the organization and training of this battalion is one of the most valuable results of the military engineering lectures

PREPAREDNESS PARADE

A unique demonstration in favor of preparedness in the form of a great citizens' parade was held in New York City on May 13. The parade was reviewed by Mayor Mitchel, Major General Wood and Rear Admiral Usher. Over sixty trades and professions took part, and there were upwards of 125,000 citizens in line.

Engineers were invited to parade as *engineers*, and contingents of civil engineers, mechanical engineers, electrical engineers and mining engineers were formed. In all seven thousand engineers, members of the national engineering societies and others, took part.

The arrangements for the Engineer's Division were under the auspices of the Military Engineering Lectures Committee, J. Waldo Smith, Mem. Am. Soc. M. E., *Chairman;* the Marshal of the Engineers' Division, Merritt H. Smith; the Recruiting Committee, Charles Warren Hunt, *Chairman* and the Parade Committee, Arthur S. Dwight, *Chairman*.

The Engineers Society of Buffalo, at its final meeting of the season, held on May 4, reëlected all its present officers, John Younger, Mem. Am. Soc. M. E., president; W. A. James, Mem. Am. Soc. M. E., and Jesse G. Melendy, Mem. Am. Soc. M. E., vice presidents; Wm. J. Gamble, Mem. Am. Soc. M. E., secretary, and William M. Dollar, Mem. Am. Soc. M. E., treasurer.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON AFTER JULY 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. Unless objection is made to any of the candidates posted by July 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary about August 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ARISON, Edgar E., Vice-President,
The Emerson Co., New York
BENHAM, Webster L., Ch. Engr.,
The Benham Engrg. Co., Oklahoma City, Okla.
BLONCK, W. A., Pres.,
W. A. Blonck & Co., Engrs., Chicago, Ill.
BRADFORD, James S., Insptr.,
E. I. du Pont de Nemours & Co., Wilmington, Del.
BUNZEL, Ervin, Designer, Power Plant,
Armour & Co., Chicago, Ill.
BUTLER, Joseph F., Advisory Asst. to Purchasing Agent,
Nichols Copper Co., Bayside, L. I., N. Y.
CRANE, Holden I., Industrial Engineer,
With E. M. Chace, Cincinnati, Ohio
CRANE, R. T., Jr., Pres.,
Crane Company, Chicago, Ill.
EASON, John J., Asst. Supt., Mech. Div.
Panama Canal, Balboa, C. Z.
EGGERT, William H., Supt. Construction,
Zaremba Co., Buffalo, N. Y.
ELLICOTT, Charles R., Assistant Eastern Manager,
Westinghouse Air Brake Co., New York
FALK, Harold S., Genl. Supt.,
The Falk Co., Milwaukee, Wis.
FARQUHAR, Percival, President,
Brazil Rwy. Co., New York
HAMILTON, Ernest A., Asst. Mgr. Sales,
Nelson Valve Co., Philadelphia, Pa.
HARPER, Herbert D., Instr. in Elec. & Mech. Design,
Board of Education, Vocational School for Boys, New York
HILDEBRAND, Harry D., President,
Hope Engineering & Supply Co., Pittsburgh, Pa.
HOGLE, James A., Consulting Mining Engineer,
Salt Lake City, Utah
HUPFEL, Adolph G., Treas.,
The J. C. G. Hupfel Brewing Co., New York
INGRAHAM, Alexander, Pres.,
Willford Mfg. Co., Minneapolis, Minn.
JOHNSON, Eads, Cons. Marine Engineer and Naval Architect,
New York
KRIEGEK, Arthur H., General Manager,
Kieselguhr Co. of America, New York
LANGFORD, George, General Superintendent,
American McKenna Process Co., Milwaukee, Wis.
LEARY, George, Pres. and Genl. Mgr.,
Morris & Cumings Dredging Co., New York
LEINERT, Wenzel, Consulting Engineer, New York
LEONARD, Harry S., Vice-President,
Winchester Repeating Arms Co., New Haven, Conn.
LUBBERT, George L., Operating Engr.,
Filtration Plant, City of Baltimore, Md.
NEWSOM, Horace H., Factory Manager,
Perfection Spring Co., Cleveland, Ohio
PANCOAST, Joseph D., Asst. Supt. Construction,
Zaremba Co., Buffalo, N. Y.
POULTNEY, Edward C., Machine Tool Dept.,
British Ministry of Munitions, New York
ROBINSON, Edwin W., Pres. and Genl. Mgr.,
Punxsutawney Fdy. & Mch. Co., Punxsutawney, Pa.
ROBINSON, Barton J., Proprietor and Manager,
B. J. Robinson's Machine Wks., Vicksburg, Miss.
SCARFE, Geo. E., Cons. Eng., Nevada City, Cal.
SCHLOSS, Newton L., Cons. Mech. and Elec. Engr., New York
SIMMONDS, John D., President,
Simmonds Engineering Co., Iola, Kan.
SKINNER, Joseph A., Treasurer,
William Skinner & Sons, Holyoke, Mass.
STANSFIELD, Frank H., Supervisor of Eff. Work,
Bridgeport Brass Co., Bridgeport, Conn.
SWAN, Ervin D., Mechanical Engineer,
Lidgerwood Mfg. Co., New York
TAURMAN, Alphonso, Supt. Rolling Stock,
Virginia Rwy. & Pwr. Co., Richmond, Va.
THOMPSON, Isaac T., Testing Engineer,
The American Well Works, Aurora, Ill.
TUPPER, Frederick G., Assistant Engineer,
South-Eastern Underwriters' Assoc., Atlanta, Ga.
TWOMBLY, Alexander H., Sanitary and Industrial Engineer,
Twombly & Henney, Engrs., New York
VAN GIESON, Wickliffe B., Special Draftsman,
Celluloid Co., Newark, N. J

FOR CONSIDERATION AS ASSOCIATE-MEMBER OF JUNIOR

AMORY, Clement G., Treas.,
Gas Engine & Pwr. Co. and Chas. L. Seabury & Co. Cons., New York
BOARDMAN, Albert J., Supt.,
Terre Haute, Indianapolis & Eastern Traction Co., Indianapolis, Ind.
BOWMAN, Mark C., Lieut. (JG),
United States Navy, Washington, D. C.
CUNNINGHAM, Francis, Mechanical Engineer,
with John A. Stevens, Cons. Engr., Lowell, Mass.
CUTLER, Max E., Ch. Engr. of Works,
Whiting Mfg. Co., Bridgeport, Conn.
DAVIDSON, William A., Engineering Department,
The Singer Mfg. Co., South Bend, Ind.
EASTON, Lynn B.,
with Henry R. Worthington, St. Louis, Mo.
EKSTROM, Hugo L., Asst. Supt.,
H. C. Dodge, Boston, Mass.
FITZ PATRICK, William J., Head of Wood Work Dept.,
Scranton Tech. H. S., Scranton, Pa.
GUTEKUNST, Frederick, Superintendent,
Eddystone Ammunition Co., Eddystone, Pa.
HAYS, Lewis T., Tramway Engr.,
U. S. Steel Products Co., Pacific Coast Dept., Seattle, Wash.
HICKERSON, George A., Supervising Engineer,
McKesson & Robbins, New York
KATZ, Edgar J., Asst. Ch. Engr.,
De La Vergne Mch. Co., New York
KLAER, Henry J., Treasurer,
Rost Wetherill & Co., Inc., Chester, Pa.
LAKE, Charles W., Draftsman,
H. Mueller Mfg. Co., Decatur, Ill.
LANG, John B., Director,
Messrs. John Lang & Sons, Glasgow, Scotland, and with British Ministry of Munitions, New York
LEONHARD, Albert T., Mechanical Engineer and Secretary,
The Paterson Parchment Paper Co., Passaic, N. J.

MIKESH, Martin A., Designer,
Fairmont Gas Engine & Rwy. Motor Car Co., Fairmont, Minn.
MONKS, Tom N., Safety Engineer, Portland, Ore.
NOLAN, John H., Operating Engineer,
General Chemical Co., Bayonne, N. J.
NORTON, Edwin K., Manufacturer,
Standard Tin Plate Co., Canonsburg, Pa.
OLSON, Gustaf B., Special Experimenting,
Remington Arms & Ammunition Co., Bridgeport, Conn.
PLANK, William J., Draftsman, Mech. Div.,
The Panama Canal, Balboa, C. Z.
RHAME, Frank P., Engineering Examiner,
Municipal Civil Service Commission, New York
SCHMIDT, Bruno M., Asst. Ch. Draftsman,
Winchester Repeating Arms Co., New Haven, Conn.
SCHULTZ, Charles H., Engineer,
The Hero Manufacturing Co., Philadelphia, Pa.
SCHUMACHER, John A., Safety Engr.,
Prudential Casualty Co., Indianapolis, Ind.
STRIPE, William C., District Stoker Engineer,
Westinghouse Elec & Mfg. Co., Pittsburgh, Pa.
WARBURTON, Robert L.,
with Kieselguhr Co. of America, New York
WEBB, Clifford L.,
with Henry R. Worthington, St. Louis, Mo.
ZINK, Robert E., In charge of Design,
Leonard Construction Co., New York

FOR CONSIDERATION AS JUNIOR

BORDWELL, Ralph L., Supt. Constr.,
Sulzberger & Sons Co., Chicago, Ill.
BOYD, Hugh M., Assistant Engineer,
Punta Alegre Sugar Co., Caibarien, Cuba
BRESLAV, Jack,
with Terry Steam Turbine Co., Hartford, Conn.
BULTMANN, Robert A. W., Draftsman,
American Products Co., Long Beach, Cal.
COLVIN, Charles H., Engr., Aeroplane Dept.,
Sperry Gyroscope Co., Brooklyn, N. Y.
DEW, Donald H.,
with Remington Typewriter Co., Syracuse, N. Y.
GOOD, Edison B., Student,
University of Colorado, Boulder, Colo.
HAVILAND, John R., Asst. Ch. Draftsman,
L. O. Koven & Bro., Jersey City, N. J.
HOSKINS, Stephen P., Instr., Mch. Design and Mech. Drawing,
West Virginia University, Morgantown, W. Va.
KEES, Daniel, Vice-President and Superintendent,
F. D. Kees Mfg. Co., Beatrice, Nebr.
KIMMEL, Alfred W., Mechanical Engineer,
The Platt Iron Works Co., Dayton, Ohio
KNERR, Lewis E., Mech. Draftsman, Mech. Div.,
The Panama Canal, Balboa, C. Z.
LINDBERG, George I., Asst. Ch. Mech. Engr.,
Pickands, Mather & Co., Duluth, Minn.
LUDEMANN, John E., Assistant to Engineer of Tests,
New York Edison Waterside Stations, New York
McCLINTOCK, Clyde H., Student,
University of Colorado, Boulder, Colo.
MORCH, John J., Student,
Columbia University, New York
NATHAN, Herbert P., Draftsman,
with John H. Murphy Iron Works, New Orleans, La.
POLEK, Joseph, Genl. Foreman, M.M. Drawing Dept.,
Cartridge Shell Dept., E. W. Bliss Co., Brooklyn, N. Y.
QUAST, Walter F.,
U. S. Naval Experiment Station, Annapolis, Md.
RAINEY, Charles S., Inspection Foreman,
Remington Arms Co., Eddystone, Pa.
ROSS, Henry B., Mechanical Draftsman,
Sargent & Lundy, Chicago, Ill.
RUPRECHT, Walter E., Secretary and Treasurer,
Charles F. Mattlage & Sons, New York
SAWYER, Wilfred D., Student,
University of Colorado, Boulder, Colo.
SEYBOULD, Eugene, Assistant Foreman,
The Niles Tool Works, Co., Hamilton, Ohio
SHAW, Herbert G., Mechanic,
with Winchester Repeating Arms Co., New Haven, Conn.
SHELLEY, Herbert V., Student,
Penn State Colege, State College, Pa.
STAFFORD, Norman L., Jr.,
with Remington Typewriter Co., Syracuse, N. Y.
SWETTING, J. Rodney, Student,
University of Wisconsin, Madison, Wis.
WALSH, Walter V., Draftsman,
Henry Hope & Sons, New York
ZEIGER, Nelson A., Engrg. Dept.,
L. O. Koven & Bro., Jersey City, N. J.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

BELL, John E., Consulting Engineer, New York
BUCK, Turney E., Draftsman,
Westinghouse Elec. & Mfg. Co., Pittsburgh, Pa.
LAIRD, Wilbur G.,
with Henry L. Doherty, New York

PROMOTION FROM ASSOCIATE-MEMBER

MOORE, Edwin Adee, Superintendent,
Gas Eng. Div., Fairbanks-Morse & Co., Beloit, Wis.

PROMOTION FROM JUNIOR

McCANN, Warren E.,
with American Rolling Mill Co., Middleton, Ohio
McCORMACK, Leonard J., Superintendent,
Schuylkill Silk Mills, Reading, Pa.
SCHMIDT, George G., Engr.,
Positive Differential System Co., New York
TUTTLE, Walter I., Secretary,
Frank Mossberg Co., Attleboro, Mass.

SUMMARY

New applications	102
Applications for change of grading:	
Promotion from Associate	2
Promotion from Associate-Member	2
Promotion from Junior	4
Total	110

AVERAGE AGE AND POSITIONS OF APPLICANTS ON BALLOT CLOSING, MAY 22, 1916.

Average age of applicants:	
Members	40
Associates	36
Associate-Members	32
Juniors	25
Executives:	
President, Vice-President, Treasurer, Director, Member of Firm, General Manager	8
Professor, Associate-Professor, Instructor	
Gen'l Superintendent, Superintendent, Assistant Superintendent, Mechanical Superintendent	8
Consulting, Contracting and Constructing Engineers	4
Chief Engineer, Asst. Chief Engineer	5
Mechanical Engineer, Engineers, Assistant Engineers	25
Chief Draftsmen, Asst. Ch. Draftsmen, Designing Engineers, Estimators	8
Managers, Asst. Managers, Sales Managers, Sales Engineers	8
Other classifications	23

PERSONALS

THIS department is intended for items about members of the Society, their professional work and incidents concerning them which may be of interest to the membership in general. Items are solicited upon important engineering developments in which members have been associated, and also newspaper clippings or manuscripts of addresses delivered by members at meetings of any kind are desired. It is hoped that every member of the Society will furnish an interesting item occasionally for publication in The Journal.

APPOINTMENTS

C. W. Lyon has become affiliated with the Lyon Concrete Products Company of Evanston, Ill., in the capacity of president.

Clarence W. Vogt has recently been appointed general manager of the National Foundry and Machine Company of Louisville, Ky.

Arthur D. Little will have charge of the new Canadian Research Bureau which is being established by the Canadian Pacific Railway.

Arthur N. Blum has become associated with Henry Disston and Sons, Philadelphia, Pa., in the capacity of technical adviser and chief engineer.

Henry Souther has been appointed, by the Secretary of War, consulting engineer in the aeroplane division of the United States Signal Corps.

William F. Taaudt, eastern sales manager of the Taber Pump Company, Buffalo, N. Y., has been appointed vice-president and general manager of the company.

Cornelius T. Myers, engineer of The Timken-David Brown Company of Detroit, Mich., manufacturers of worm gears for motor cars and general work, has been appointed manager of the company.

Earle B. Norris has been appointed industrial commissioner of the Association of Commerce, St. Paul, Minn. He was until recently associate professor of mechanical engineering at the University of Wisconsin, Madison, Wis.

Samuel M. Vauclain has been elected a director of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. He is vice-president of the Baldwin Locomotive Works and a director in a number of companies.

Bertram G. Welchans has been appointed general superintendent of Stanley G. Flagg and Company, Pottstown, Pa. His former position with the company was that of mechanical engineer, in charge of manufacturing and machine design.

F. L. R. Francisco, consulting engineer, New York, has been named by Mayor Thompson of Chicago as the city's representative on the Board of Supervising Engineers of the Railway Terminals Commission. Mr. Francisco succeeds Mr. Bemis.

Henry M. Lane has been retained as consulting engineer of Leyshon and Lane, Inc., which has recently been organized to take over the oven and special foundry equipment business which has grown out of Mr. Lane's foundry research work. The H. M. Lane Company will continue as a consulting organization under the personal charge of Mr. Lane.

Charles E. Bragoon has been appointed assistant to the general superintendent of the Sandusky Portland Cement Company, Cleveland, O., and is making special investigation of kiln temperature relative to the output and cost of clinkers. He is also investigating economies in general, in connection with the design and operation of the company's plants.

At a meeting of the board of directors of the Yale and Towne Manufacturing Company held on April 27, Joseph A. Horne, one of the directors, was elected to the position of second vice-president, retaining also his present position and title of general superintendent. Mr. Horne, who has been over 24 years in the company's service, has the entire management of the works at Stamford, Conn., and of all manufacturing operations of the company, including those of its Canadian plant at St. Catharines, Ont.

ANNOUNCEMENTS

Sidney A. Reeve has opened a consulting engineering office at 120 Broadway, New York.

Foad W. Harris announces the formation of the firm of Graham and Harris, patent attorneys, with offices in the Higgins Building, Los Angeles, Cal.

A. L. Riker, vice-president and chief engineer of the Locomobile Company of America, was elected a director of the National Automobile Chamber of Commerce.

Robert R. Fisher, factory clerk with the Albaugh-Dover Company, Chicago, Ill., has accepted the position of efficiency engineer with the Walden W. Shaw Livery Company of the same city.

At the final meeting of the season of the Engineering Society of Buffalo, the present officers were re-elected. They are: John Younger, president; W. A. James and Jesse G. Melendy, vice-presidents; W. J. Gamble, secretary, and W. M. Dollar, treasurer.

W. S. Quigley announces the organization of the Quigley Furnace Specialties Company, New York, as successors to the Quigley Furnace and Foundry Company. Mr. Quigley is president of the new corporation which comprises two departments, the furnace specialties department and the engineering and contracting department.

Herbert C. Hale, formerly district manager of the Ridgway Dynamo and Engine Company, Cleveland, O., has announced the incorporation of The Hale-Stephan Company, Cleveland, O., which will represent the Taylor Stoker, the Ridgway Dynamo and Engine Company, the Vulcan Soot Cleaner Company and the Engineer Company.

Robert A. Carleton, for many years inspector of construction with the Edison Electric Illuminating Company of Boston, Mass., and Albert E. Mace, have resigned their positions with the company and have organized a construction company to be known as the Carleton-Mace Engineering Corporation and will specialize in central station and industrial power plant installation and electric transmission systems, with headquarters in Boston.

CHANGES OF POSITION

Joseph E. Young has accepted a position in the maintenance engineer's office of the American Steel Foundries Company, Sharon, Pa.

William A. Armes, industrial and power plant engineer, has become identified with the Samuel M. Green Company of Springfield, Mass.

William J. Kenney, chief engineer of The Under-Feed Stoker Company, Chicago, Ill., has become associated with the Moloch Stoker Company of the same city as president.

Morris D. Douglas, salesman with The Midvale Steel Company of Philadelphia, Pa., will become associated with the Han-Yeh-Ping Coal and Iron Company, Hanyang, China, after June 15.

John H. McNally has left the employ of the City of Philadelphia to accept the position of Philadelphia manager of the Huber Hand Stoker Company, Inc., of New York.

H. H. Maxfield, master mechanic of the Pennsylvania Railroad Company, Pittsburgh, Pa., is now superintendent of motive power of the company, with headquarters in Pittsburgh, Pa.

Franklin W. Gilman has accepted a position with the B. F. Sturtevant Company, Chicago, Ill. He was until recently assistant chief engineer of the Western Electric Company, New York.

Martin H. Ray, formerly connected with the Department of Public Safety of Philadelphia, Pa., as consulting engineer, has entered the employ of the Crocker-Wheeler Company, Ampere, N. J.

Lewis L. McLaren, until recently connected with the Wisconsin Steel Company, South Chicago, Ill., as steam engineer, has accepted a position with the Illinois Steel Company, Gary, Ind.

F. Donald Fenhagen, assistant engineer with Henry Adams, consulting engineer of Baltimore, Md., has accepted a position with the Bennett Company, Frankford, Philadelphia, Pa., as designing engineer.

Philip G. Haines, formerly in the employ of The Laidlaw-Dunn-Gordon Company, Cincinnati, O., has become associated with the engineering department of the Goodyear Tire and Rubber Company, Akron, O.

Craig Adair, until recently in the employ of The Baldt Steel Company of New Castle, Del., as mechanical engineer, has become associated with the Penn Marine and Ordnance Castings Company, Inc., Philadelphia, Pa.

John F. Mahoney has resigned his position as draftsman with the Telegraph Bureau of the New York Fire Department to accept a similar position with the motive power department of the Interborough Rapid Transit Company.

C. Leslie Barnum has resigned his position as mechanical engineer of J. B. King and Company, New Brighton, N. Y., to accept a position on the staff of John H. Williams, efficiency engineer of New York.

Axel E. Berggren has become identified with the American Blower Company of Detroit, in the capacity of salesman. He was until recently in the employ of the Faultless Rubber Company, Ashland, O., as mechanical engineer.

Robert G. Bennett has been appointed assistant master mechanic of the Cumberland Valley Railroad at Chambersburg, Pa. He was formerly inspector of the test department of the Pennsylvania Railroad, Altoona, Pa.

Loyd E. Shirley has accepted the position of vice-president and general manager with the Garland Manufacturing Company, Des Plaines, Ill. He was formerly connected with the C. S. Bell Company of Hillsboro, O.

Frank R. Lawatsch has severed his connections with the Guerber Engineering Company of Bethlehem, Pa., as engineering draftsman, to accept the position of ordnance draftsman at the Sandy Hook Proving Ground.

Byron F. Stowell has resigned as superintendent and mechanical engineer of the Van Norman Machine Tool Company, Springfield, Mass., to become master mechanic of Barney and Berry, Inc., skate manufacturers of the same city.

T. Carlile Ulbricht, who has been connected with the Havana Electric Railway, Light and Power Company, in various capacities, for the past 2½ years, has resigned to become assistant to the president of the American Steel Company of Cuba.

Charles W. Tubby has been appointed St. Paul sales manager of the Worthington Pump and Machinery Corporation, which has recently been reorganized. He was formerly district manager of the International Steam Pump Company, St. Paul, Minn.

Fred W. Waterman, chief engineer and acting manager of the Lorain, Ohio, plant of the National Tube Company, will hereafter be manager of the company's new tube plant to be constructed at Gary, Ind.

Charles E. Newbold, consulting engineer of the Craignish Estate, Princes Town, B. W. I., has accepted the position of assistant field manager and mechanical engineer with Leaseholds, Ltd., of Trinidad, B. W. I., which is developing the oil fields in the island.

William T. Clark has become affiliated with the Traylor Engineering and Manufacturing Company of Allentown, Pa. He was formerly in the employ of the Automatic Machine Products Company, Brooklyn, N. Y., in the capacity of general manager.

D. T. McLeod, for the past 16 years connected with the United Coke and Gas Company, American Coke and Gas Company and the Otto Coking Company, has opened an office at 50 Pine Street, New York, as consulting engineer in by-product coke oven plants.

C. A. Swiggett has accepted a position with the Western States Portland Cement Company, Independence, Kan., in the capacity of superintendent. He was formerly connected with the Iola Portland Cement Company, Iola, Kan., as mechanical engineer and assistant superintendent.

Robert A. McKean, for some years structural engineer for the Jones and Laughlin Steel Company, Pittsburgh, Pa., has resigned to accept a similar position with the Riter-Conley Manufacturing Company, now owned and operated by the McClintic-Marshall Company, Pittsburgh, Pa.

Grenville A. Harris, after 16 years of continuous service with Takata and Company, New York, has resigned his position as chief engineer and has accepted a similar position with the American Steel Export Company of New York, having entire charge of its newly established engineering and machinery department.

AUTHORS OF PAPERS, ETC.

W. M. Welch has contributed an article on Natural Gas Resources and Supplies to the May issue of the *Natural Gas Journal*.

C. E. Knoeppel has contributed an article entitled Industrial Lessons from Germany to the May issue of *The Engineering Magazine*.

C. F. Hirshfeld is the author of an article on Cleaning Condenser Tubes which is published in the May 16 issue of *Power*.

Clifton W. Wilder is the author of Power for Urban Transportation, which appears in the May number of *The Engineering Magazine*.

A. A. Potter is the author of an article entitled Producer Operation and Testing, which appears in the May 2 issue of *Power*.

Fred H. Wagner, gas by-product lecturer at Johns Hopkins University, is the author of a book entitled Coal and Coke.

Arthur C. Scott's second article on Lubrication of Station and Industrial Machinery is published in the May 13 number of *Electrical World*.

H. L. Gantt has contributed an article on Engineering Schools and Industrial Methods, to the May number of *The Engineering Magazine*.

A. Lewis Jenkins is the author of Empirical Formulas for the Proportions of Lathes which appears in the May 4 issue of *American Machinist*.

George L. Fowler is the author of an article entitled Hydrostatic Tests of Corrugated Culverts, which appears in the May 13 issue of the *Electric Railway Journal*.

John S. Unger presented a paper on Rail Manufacture at the spring meeting of the American Iron and Steel Institute, held in New York City, May 26 and 27.

W. DeWitt Vosbury is the author of a brief article on Small Sewage Pumping Station for Park Site which was published in the May 6 number of *Engineering Record*.

John A. Mathews presented a paper on The Electric Furnace in Steel Manufacture at the May 26 and 27 meeting of the American Iron and Steel Institute, held in New York City.

Dabney H. Maury contributed an article entitled Huge Circular Reservoir in Dubuque Protects Congested-Value Business District, to the May 6 issue of *Engineering Record*.

Edward H. Tenney is the author of a book recently published on Test Methods for Steam-Power Plants, a reference book for the use of power-station engineers, superintendents and chemists.

Wm. L. D'Olier presented an illustrated paper entitled The Progress and Development of the Art of Sewage Treatment at the May 25 meeting of the Engineers' Club of Trenton.

C. B. Auel, director of standards, processes and materials at the Westinghouse Electric and Manufacturing Company, has contributed an article on Methods of Figuring Costs to the May issue of *The Electric Journal*.

Howard E. Coffin, Chairman of the Committee on Industrial Preparedness of the Naval Consulting Board, has contributed an article on Organizing Industry for National Defense to the May issue of *The World's Work*.

NECROLOGY

CHARLES A. FRANCIS

Charles Albert Francis was born in Mansfield, Mass., July 19, 1866. He received his early education in the schools of Mansfield and served an apprenticeship with the Mansfield Watch Tool Company there. From 1884 until 1890 he was machinist, tool and model maker for L. L. Pollands of Worcester, Mass. In 1890 he was mechanician for the Department of Physics in Clark University in Worcester; he remained there until 1894 when he was chosen for the same position at the University of Chicago, which he held until 1899. Between 1899 and 1903 he was tool maker for the Veeder Manufacturing Co. at Hartford; special mechanician at the Yerkes Observatory, and foreman of the Meter Department of the Diamond Meter Co. in Peoria, Ill., and was also with the Pratt & Whitney Co. in Hartford. In 1903, he became Instructor and Master Mechanic at the Higher Technological School in Tokio, and in 1913 he accepted a position as foreman at the General Electric Co. of Pittsfield, Mass., but left in 1915 to go with the Remington Arms Co. of Bridgeport, Conn. He became a member of the Society in 1905. Mr. Francis died at his home in Bridgeport, January 14, 1916.

HOWARD D. HESS

Howard Drysdale Hess was born at Philadelphia, September 6, 1871. He received his education at the Central High School in Philadelphia and at Lehigh University, from which he graduated with the degree of mechanical engineer in June, 1896. Following his graduation he was appointed general manager with the Eastern Steel Company at Pottsville, which position he held for one year, resigning to accept a position in the faculty of Drexel Institute, where he served two years. During 1904 he served on the faculty of Kansas University at Lawrence, and from there went to Cornell as assistant professor of machine design. In 1910 he was made professor of machine design, which position he was holding at the time of his death. Professor Hess was a member of the Engineers' Club of Philadelphia, Sigmi Zi honorary fraternity, and the Town and Gown, University and Cosmopolitan Clubs of Ithaca. He became a member of this Society in 1903. He died in Buffalo on April 22.

JOHN EDSON SWEET

Professor John Edson Sweet died at his home in Syracuse on Monday, May 6, at the age of eighty-three. An appreciation of Professor Sweet is published elsewhere in this issue of The Journal, and the facts of his life are only briefly summarized here.

He was born in Pompey near Syracuse October 21, 1832. His only opportunity for schooling was in the district schools of that time. As a boy he worked on a farm, and later became a carpenter's apprentice. He was an architect and builder in the South for several years, but on the outbreak of the Civil War in 1861 he returned to the North. From this time until 1873 he was an inventor and mechanical draftsman; at the latter date he was appointed Director of Shops in Sibley College. In 1879 he left Cornell to establish the "Straight Line Engine Company" in Syracuse; he was president of this company from its establishment until his death.

Professor Sweet was one of the founders, and was the third president of the Society. In 1914 the John Fritz Medal was awarded to him "for his achievements in machine design, and for his pioneer work in applying sound engineering principles to the construction and development of the high-speed steam engine," and in the same year Syracuse University conferred upon him the honorary degree of Doctor of Engineering.

Thus he received honors in recognition of his great ability as an engineer. But his great life work consisted in his influence over men to cause them to think straight and to live honorably. All who were his students at Cornell or elsewhere—for he was a teacher all his life—have always felt for him the highest respect and deepest affection; and his death brings to them all a sense of personal loss. The world can so ill afford to lose those rare men of sane brain, sound judgment and big heart who love to serve their fellow men.

MAX M. SUPPES

Max M. Suppes was born at Johnstown, Pa., February 18, 1856. He received his education in the common schools at Johnstown, and learned the machinist's trade in a machine shop there.

He went to Troy, N. Y., in 1879 as master mechanic for the Rensselaer Iron & Steel Works (later the Troy Iron & Steel Works). Here he was associated with Capt. Robert W. Hunt, and helped develop the first automatic rail mill for rolling Tee rails. From Troy he went to Braddock in December, 1887, as assistant master mechanic of the Edgar-Thomson Works. He only remained at Braddock about a month, returning to Johnstown on February 1, 1888, to be master mechanic of the Johnson Steel Street Rail Company, which was being built by Messrs. A. J. Moxham and Tom L. Johnson. In the fall of the same year he became manager of the rolling mill department of the plant. Here he assisted very largely in the development of the method of rolling girder rails.

Early in 1894 when Messrs. Moxham and Johnson decided to build a Steel Plant at Lorain, Ohio, and move the girder rail mill at Johnstown to Lorain, he was appointed general manager of the new plant and put in charge of the construction of it. Active construction operations began at Lorain in July, 1894, and the first heat of steel was blown April 1, 1895, and the first steel rolled in the blooming mill a few weeks later; in other words, the plant was built in a period of ten months. This Lorain Plant was first known as the Johnson Company, then as the Lorain Steel Company; was later taken over by the Federal Steel Company; it is now The National Tube Company of Ohio.

Through all these changes and the continued expansion of the plant, Mr. Suppes continued to be the manager until the date of his death, March 27, 1916.

He was a man of very marked engineering ability. He was of an inventive turn of mind, evidence of which is amply given in the large number of patents issued to him, many of which are in use in various steel mills. In 1883 he installed the first tables in front of rolls on a rolling mill. He developed the first arrangement for rolling steel out of heating furnaces. Other rail mill and blast furnace improvements originated by him are well known, such as his weighing device for rolling mills, leading spindle and coupling for rolling mills, roll adjusting mechanism for rolling mills, stock distributing and collecting apparatus for blast furnaces, etc. His expansion joint for engines is used on a great many reversing engines. One of his later developments was a stock handling and storage arrangement for open hearth furnace plants.

He was a member of the Iron & Steel Institute (British), the American Iron & Steel Institute, also of the Masonic Order and Royal Arcanum. He became a member of the Society in 1890.

DARWIN ALMY

Darwin Almy was born in Tiverton, R. I., on February 28, 1848, and died in Providence on March 9, 1916. He attended the local schools in Tiverton until about sixteen years of age and then took up work on his father's farm until 1868. Afterwards, he became interested in menhaden fishing and was master of one of the first fishing steamers out of Tiverton.

In 1874, he went to Providence and formed a partnership for the manufacture of jewelry, which was abandoned, however, about two years later. After this, he returned to the fishing business.

In 1878, he entered the employ of the Herreshoff Manufacturing Co. at Bristol, R. I., and had charge of the boiler department and also the advantage of taking part in numerous trial trips of fast steam yachts. During the first part of this time, the Government conducted there a series of experiments under Admiral Zellar and Admiral Isherwood on engines and boilers and through this association became very much interested in steam engineering.

In 1890, he took out his first patents on the boiler which bears his name, and organized the Almy Water-Tube Boiler Co. of which he was the head until his death.

He was a member of the American Society of Naval Engineers, Society of Naval Architects and Marine Engineers, Providence Association of Mechanical Engineers, Chamber of Commerce of Providence, Central Club of Providence, Bristol Yacht Club and Rhode Island Yacht Club. He became a member of the Society in 1893.

SOCIETY MEETINGS

IT is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

LOS ANGELES, MARCH 28

On March 28, the Los Angeles Section of the Society had a very successful meeting at which Prof. W. H. Clapp delivered his paper on Motor Trucks and Their Use in Southern California. This paper was ably discussed by Carl Breer, F. H. Coble and others.

MINNESOTA, APRIL 14

On April 14, a joint meeting of the Minnesota Section was held with the American Institute of Electrical Engineers and the American Society of Civil Engineers at the University of Minnesota. A. L. Rohrer, electrical superintendent of the Schenectady Works of the General Electric Company, gave an illustrated talk on the Electrification of the Butte, Anaconda & Pacific Railway and George H. Hill, assistant engineer of the Railway Traffic Department of the General Electric Company also spoke on the Electrification of the Chicago, Milwaukee & St. Paul Railroad. M. E. Simpson, mechanical superintendent of the Minneapolis Steel Machinery Company, spoke on the Manufacture of High Explosive Projectiles, and Edwin Rollman, Captain, Cadet Corps of the University of Minnesota, on the Method of Firing Projectiles. Both of these talks were illustrated.

CINCINNATI, APRIL 21

Members of the Cincinnati Section of the Society were the guests of the Engineers' Club of Cincinnati at the regular meeting on April 21. The paper of the evening was read by Fred W. Hinkle on Prehistoric Engineering in Southwestern Ohio. A brief abstract of Mr. Hinkle's remarks appears below:

The southwest quarter of Ohio is interesting to students of archaeology because of the great number of prehistoric mounds and earth-works that it contains. Especially interesting are the great works on the hill tops which from their construction and location appear to be fortifications, and the so-called "geometrical" works which usually occupy lower lands on the second and third river terraces.

Unfortunately, they were constructed in many instances on the present sites of our cities, or rich farm lands which have now been long under cultivation, so that many of these great works are either entirely or in a large part destroyed. It is to be regretted that our pioneers did not take steps to preserve more of them for posterity.

Some of the most extraordinary works were constructed upon the present sites of Newark, Marietta, and Portsmouth, and some portions of these have been preserved in public parks. While the works on the site of Cincinnati were not as intricate or numerous as these, they were of considerable extent and represented circles, ovals, parallel walls and simple mounds in one of which, that at Mound Street, was found the famous Cincinnati Tablet.

The geometrical works may be roughly described as combinations of great earth circles, ovals, squares, octagons, conical mounds and parallel walls. Some or all of these occur in combination in the same works covering large areas. Works of this character in the vicinity of Cincinnati are the Turner Group just east of Newton, Ohio, and the group lying east of and on the watertower hill at Milford. Both of these are in part destroyed by the encroachments of civilization.

The articles found in the depositories of the mounds of the Turner Group typify the highest culture of prehistoric peoples in Ohio. Among the most interesting are terra-cotta figurines of men and women; ornaments of copper or meteoric iron, sometimes covered with gold or silver; painted effigies of animals cut out of mica; stone bowls carved in the shape of animals and thousands of river pearls in the shape of beads. The Turner Group people were evidently of the high culture of those who erected the Tremper Mound near Portsmouth, recently opened by Mr. Mills of the Ohio Archaeology Society, whose illustrated monograph on the excavation of this mound is extremely interesting and valuable.

Of the hill top fortifications, there is a small one at the mouth of the Big Miami, which is splendidly preserved, and should be made a public park. The greatest of all is Fort Ancient which is owned and preserved by the State and is a lasting monument to its builders. It should be visited by all who are interested in seeing what extraordinary labors could be accomplished by people whose only implements were of stone, bone and wood.

The most mysterious earth-work in the State is the Serpent Mound in Adams County, and is preserved by the State in a public park.

By whom and when these earth-works were erected must ever remain a mystery. No evidence of a written language has been discovered and there is little if anything in the works themselves or the articles found in them to point to their age. Some of them may have been erected by the ancestors of historic Indian tribes but this is mere theorizing. Whoever the builders of the "geometrical works" and the hill top fortifications were, we must admit they possessed extraordinary industry and a considerable degree of engineering skill.

PHILADELPHIA, APRIL 23

A meeting of the Philadelphia Section of the Society was held on April 23, and was preceded by an informal dinner. After the dinner, Professor Fernald, chairman of the Philadelphia Section introduced Dr. D. S. Jacobus, President of the Society, who addressed the members on Society Affairs.

Dr. Jacobus illustrated his talk with numerous lantern slides showing how the funds of the Society are expended. He showed tables, extending over a period of years which gave the cost per member of the various items and called attention to the fact that the expenditures have always been kept less than the income and that the mortgage on property in New York has been nearly paid off. The amount of money devoted to local sections was shown and also a comparison of the costs of the various items for the mechanical engineers with the corresponding costs for the electrical, civil and mining engineers. There were also numerous photographs of the Engineering Societies Building in New York.

Dr. Jacobus invited discussion and suggestions from all present and there was a general discussion by Messrs. Fernald, Henderson, Taylor, Hess, Yarnall, Carter, Sinclair, Parker, Jackson, Cadwallader and others present. Two points were brought out in the discussion; *first*, the desirability of providing means to make members feel at home when visiting headquarters in New York and *second*, some ways of overcoming the disadvantages of publishing matters in both The Journal and in the Transactions. Mr. Hess moved that The Journal be published more frequently if possible and if sufficient material be available, that it be published weekly. The motion was carried.

BUFFALO, APRIL 26

A meeting of the Buffalo Engineering Society was held on April 26 at the Hotel Statler. The subject of the meeting was National Preparedness and the speakers were Elmer A. Sperry, Mem. Am. Soc. M. E., and of the Naval Consulting Board and Calvin W. Rice, Secretary of the Society.

Mr. Sperry, who is the inventor of the Gyroscopic Stabilizer, spoke on the work of the Naval Consulting Board. He paid a great deal of credit to Howard E. Coffin of the Board who is spending time and money furthering the interests of the nation in a preparedness way. He has established various bureaus through which the resources of the country are being estimated and arranged in order for a time when they will be needed. In the interests of emergency transportation for instance, he has conferred not only with the heads of railways, but with other interests which might be useful. Even automobiles are listed and owners of pleasure vehicles are taken account of after the fashion of the efficiency methods of the German Government. Mr. Sperry said that the spirit of the naval officers towards the Naval Consulting Board is cordial, though at first there was a little hostility apparent.

Mr. Sperry is chairman of the torpedo committee of the Board and he told of the development of that instrument of warfare from the time when it would go only a few hundred feet and waver to the perfected device of today which goes absolutely straight as far as it goes at all and is effective as far as several thousand feet.

The subject of Mr. Rice's talk was Industrial Mobilization. He said that we have brought the army and navy together but it is up to the people now to see that Congress affords the country sufficient funds to put it in a state of preparedness. He told of a plan to have munition orders placed in all factories doing an annual business of $40,000 or more, these to be just small orders to develop ability to produce in time of need. These industries are to be inventoried between May 1 and May 20 and in order that the members of the engineering societies will meet with no opposition, advertisements are to be used during that time to explain the situation and aim to all the members of the Society.

We are unprepared in this respect at present because we have accepted orders for making rifles and have been making them for export for more than a year and not one rifle has as yet been shipped. They have been rejected for one reason or another. One firm has on its property, 5000 rejected rifles. The number of rifles necessary has been shown during the European War, where it has taken four rifles to one soldier—one in use, one away for repairs, one overheated and the fourth out of order in some way or other.

One other thing is necessary. The engineers who have certain qualifications should offer their services for the duties with which they are best acquainted and should not be drafted as privates for there are those who have no special training who can go as privates.

In answer to a request from Mr. Rice, Mr. Sperry told of the method of choosing cadets for the military and naval academies. He said that the machinery of war and the method of operation are hard to understand and that a man must have a mechanical sense. Mr. Sperry said that he would not appoint a cadet without first ascertaining what he did between the ages of ten and seventeen. If he spent his time reading books or playing baseball, he would be no good so far as appointment would go but if he had always been trying to build a machine, if he had clocks about on the floor, he would be a likely candidate. Cadets are to be appointed this year in larger numbers than heretofore.

Civil and mining engineers can be of greater service in the army than mechanical and electrical engineers, who are needed in the navy. There are some wonderful boats in the Philadelphia Navy Yard which are out of commission because we have not the officers and the skilled men to handle them; if we had skilled mechanical and electrical engineers a few officers could handle these vessels.

PROVIDENCE, MAY 3

The first annual dinner of the Providence Engineering Society, recently reorganized from the Providence Association of Mechanical Engineers to include a wider membership, was held on May 3, at which Henry A. Wise Wood spoke on Preparedness. There were other speeches emphasizing the value of greater coöperation among the various branches of the engineering profession.

Those who spoke in addition to Mr. Wood, were President Faunce of Brown University, Mayor Gainer of Providence, Arthur H. Annan, president of the Providence Engineering Society, Luther D. Burlingame of the Brown & Sharpe Company, Calvin W. Rice, Secretary of the Society, Prof. Hardy Cross and Dr. Charles F. Scott, who is the head of the Sheffield Scientific School at Yale University. Frank B. Gilbreth acted as toastmaster.

Mr. Wood told his audience that as a body of men accustomed to close thinking they could appreciate the danger to which the country is being put because so many people are thinking about the question of preparedness with their hearts instead of their heads. From his observation, as a former member of the Naval Consulting Board, he criticized American political representatives for not listening to expert opinion. He cited a case of an admiral who tried to get two draftsmen at $30 per week in order to put certain submarines into condition; his recommendations were cut, while large sums were voted for post offices for which there was no need.

A novel touch to the proceedings was provided by the committee on arrangements. A large American flag was played on with a calcium light as Mr. Wood began to speak. As the light was flashed on, everyone present rose and sang The Star Spangled Banner.

President Faunce congratulated the engineers on the newly organized society which has for its purpose not only the bringing together of all branches of the profession but also the close connection of engineering with the good of the community,—the making easier of civic service on the part of the engineers.

Mayor Gainer spoke briefly in the same vein, telling the society that in his official capacity he had been made to realize how intimate the connection is between municipal progress and the work of the engineer.

Calvin W. Rice, Secretary of the Society, sketched the growth of the idea of coöperation among engineers and gave as instances of the new phases of their service, the proposed auxiliary corps of civilian engineers and military training in all technical schools, and two amendments to the Army bill now before Congress which were secured through the efforts of The American Society of Mechanical Engineers.

The Committee on Arrangements was composed of J. Ansel Brooks, chairman; Arthur H. Annan, Milton H. Brondson, John R. Freeman, John A. Gledhill, Russell C. Lowell, William H. Paine and Alfred H. Whatley.

LOS ANGELES, MAY 4

The Los Angeles Section of the Society has lately adopted the policy of holding a luncheon meeting each week and having some member or non-member talk for ten minutes at each meeting. The meetings have so far been very successful.

On May 4 the subject discussed at the luncheon meeting was that of Industrial Preparedness. W. W. Smith, chairman of the Section presided and made a brief address in which he called attention to the fact that the European War has taught us that thorough organization is far more efficient in obtaining results than great masses of men at the front, and that for this reason, the organizing of the engineers of America for defense has become a movement of great importance.

He outlined the general plan of this movement stating that it includes the five technical societies of engineers and read a letter from President Wilson in which he gave hearty approval to the general plans.

A letter from Howard E. Coffin, chairman of the Committee on Production, Organization, Manufacture and Standardization of the Naval Consulting Board was read. He expressed the urgency of the work proposed by requesting that quick action be taken in appointment of the necessary field men etc., and that the telegraph wires be used as a matter of saving valuable time.

The plan provides for the making of a thorough inventory of American industries for the first time in the nation's history in order to determine just what each unit may be able to do in the way of manufacturing munitions of war; then the placing of this vast power behind the army and navy through the placing of government orders with factories in each section of the entire country so that they may have the drill of actual experience. There is also included the organization of labor, so that it may be definitely known just what available labor resources are on hand that they may be withheld from enlistment in time of general call, to render even more valuable service in the manufacturing of the necessary supplies.

The program includes the placing of orders in time of peace by the Government for an annual minimum production of munitions of war to be paid for at reasonable but not an excessive basis of profit and to spread out these orders over the entire United States so that no one territory will have a monopoly thereof.

California has five State directors in this movement each representing one of the divisions of engineering. C. W. Merrill of San Francisco is the chairman for the mechanical engineers.

NEW YORK, MAY 9

The regular meeting of the New York Section of the Society was held on May 9, at which was presented a paper on Report Upon Efficiency Tests of a 30,000 kw. Cross-Compound Steam Turbine by Henry G. Stott and W. S. Finlay, Jr. The paper with the discussion which followed its presentation is published elsewhere in this issue.

At this meeting, a committee was chosen to prepare a constitution and by-laws for the government of the New York Section. The members of this committee are: Fred R. Low, chairman; Robert T. Kent, Frederick A. Scheffler, James A. Kinkead and H. G. Stott.

BIRMINGHAM, MAY 12

A meeting of the Birmingham Section of the Society was held on May 12. The officers of the Section who have been serving this past year were reëlected for the coming year: R. E. Brakeman, chairman; C. B. Davis, vice-chairman; Paul Wright, secretary and treasurer.

A general discussion took place concerning recent letters

that have been received from the State Committee of the Naval Consulting Board. Following this, the members discussed letters which had been received from Thomas E. Durban, chairman of the Uniform Boiler Law Society. It was decided that the Section should do what it could to aid in the securing of the adoption of the Boiler Code in the state of Alabama and the following committee was appointed to keep in touch with the matter and to report from time to time its progress to the Section: Richard Faull, *chairman;* H. A. Moon, W. P. Caine, F. G. Cutler.

ST. LOUIS, MAY 20

A dinner was held by the St. Louis Section of the Society on May 20, at the Missouri Athletic Club, at which fifty-one members and guests were present. W. A. Layman, president of the Wagner Electric Company was the speaker and his subject was Mobilization of American Industries for National Protection.

Mr. Layman's talk went into the general subject of our lack of industrial preparedness, and brought out very forcibly the fact that while we might be able to get together one or two million men in six months, it would easily be two years before we were able to maintain a force of even one million in the field. He cited many instances of failure to even start delivery of munitions by American concerns within a year of the time promised, due to the lack of men, material, tools and gages, the last lack being, perhaps, the most serious of all.

He pointed out the fallacy of the argument that many manufacturers were anxious for preparedness, because of the supposedly huge profits to be made. On the basis of his figures, excepting perhaps the powder manufacturers, most of those firms who have gone into the munitions proposition have done so at a loss, particularly those holding contracts made when times were dull; now they have to face a rising market both in prices of material and labor.

He brought out strongly the industrial preparedness of Germany for the present conflict, and the almost criminal action on the part of the British labor organizations in their unwillingness to sacrifice anything for their country, in order to increase the output of needed munitions.

After the close of Mr. Layman's address, there were brief talks by others on the same subject, and Professor Ohle and Mr. Day told of the New Orleans meeting of the Society on April 11-14.

Following these talks, an election of officers for the ensuing year was held. Following the established custom, the two last Chairmen of the Section, Edward Flad and F. E. Bausch, became members of the new Committee. The new members elected were L. A. Day, of the Saint Louis Water Works; L. Gustafson, superintendent David Rankin School of Mech. Trades; H. R. Setz, chief engineer of the Fulton Iron Works.

PHILADELPHIA, MAY 23

The last meeting for the season of the Section in Philadelphia was held Tuesday evening, May 23, at the Engineers' Club. Professor R. H. Fernald presided.

The paper of the evening was by Lieut-Commander H. C. Dinger, U.S.N., on Efficiency of Propulsive Machinery and Late Developments in Naval Engineering. Besides reviewing in an able manner the progress of engineering in the Navy, the speaker made an appeal to the engineering profession to coöperate in all ways to better place our country in the state of preparedness.

In connection with this timely request, the Secretary of the Society, Calvin W. Rice, spoke with special earnestness and promised the fullest coöperation in fact and in the spirit with which this request on the part of representatives of the Navy was made.

Following the paper the Chairman-elect of the Section, E. B. Carter, who also has the honor of being President-elect of the Engineers' Club for the ensuing year, was presented.

The obligation is, therefore, that our Section in Philadelphia, through its Chairman, shall make itself especially useful in assisting to get the entire engineering profession in Philadelphia and vicinity to center around the Engineers' Club.

As an earnest of this coöperative spirit, prior to the meeting Professor R. H. Fernald, the retiring Chairman of the Section, gave a dinner at the University Club, to which invitations had been extended to the officers of all the local technical organizations, including the President and Secretary of The Franklin Institute, the President-elect of the Engineers' Club, the Chairman-elect of the Section of the Am.Soc.M.E., the Chairmen of the Sections of the American Society of Heating and Ventilating Engineers, of the Illuminating Engineering Society, of the Society of Automobile Engineers, of the Association of Members of the American Society of Civil Engineers, of the American Institute of Electrical Engineers, and the Technology Club of the Massachusetts Institute of Technology. With the exception of the Technology Club and The Franklin Institute, all of the above societies were represented, together with the full committee of the Am.Soc.M.E. Section. The guests were as follows: Messrs. E. B. Carter, J. D. Cassell, G. S. Crampton, H. C. Dinger, H. E. Ehlers, E. S. Foljambe, J. E. Gibson, W. R. Jones, Calvin W. Rice, J. A. Steinmetz, E. B. Temple, and J. H. Tracy. In honor of the speaker of the evening, Rear Admiral Parks, and Commander S. E. Moses were also invited. The occasion was very enjoyable and presaged a successful forthcoming season. The spirit of coöperation was manifest throughout the evening.

BOSTON, MAY 23

The last meeting of the season of the Boston Section of the Society took place on May 23, at the Engineers Club Hall. E. G. Bailey, president of the Bailey Meter Co. of Boston, presented the subject of Measurement of Steam Flow to Determine Boiler Output or Prime Mover Capacity and the Measurement of the Condition of Fuel Beds in Order to Control the Efficiency of Boilers. Lantern slides were used to illustrate the points brought out by Mr. Bailey, who is an authority on these most important subjects.

In the discussion which followed the paper, Walter S. Burke, Supt. of Bldgs. & Grounds at Harvard University, spoke of the meters used to measure steam flow and also of those used to measure the condensation in connection with the purchase of steam from the Boston Elevated Railway by Harvard University, which purchase amounts to some $40,000 per year. The net B.t.u. are computed and paid for on the basis of heat supply. Mr. Burke mentioned particularly the CO_2 method of calibrating meters as being very valuable, affording a convenient and close method of determining just what results the flow meter is giving. Where meters have been placed in series, they have been found to register alike, one serving as a check on the other.

With the Bailey-Weir meter, results within a small fraction of 1 per cent of the actual weighed water were registered. Mr. Burke considered Mr. Bailey's method of handling the fire by means of charts for the use of firemen very important.

A. B. Duncan of the Harmony Mills stated that they used a number of steam meters and believed that they saved at least

25 per cent due to the use of these meters to show the requirements of the various departments.

F. S. Uhling spoke regarding the CO_2 recorders and John A. Stevens of Lowell gave experiences in the use of meters especially with regard to connecting several sources with a single meter for measurement with suitable valves to cut off different sections of the plant. He also mentioned a case where an expensive meter was put in to be used only once a month to test steam consumption of turbines.

The subject was also discussed by Mr. Dodge, head of the Meter Dept. of the General Electric Co., Geo. I. Rockwood, Chas. T. Main and Mr. Delano of the Edison Co.

STUDENT BRANCHES

Members of student branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate delivery of The Journal.

BUCKNELL UNIVERSITY

On May 1, 1916, the regular meeting of the Bucknell University Student Branch of the Society was held, at which E. V. Anderson gave a talk on The Use and Application of the Automatic Double Cushioned Triple-Acting and Non-Return-Valves. Mr. Anderson explained how they insure safety both to the plant in which they are installed and the men employed by automatically operating in case of accident due to the bursting of boiler tubes or other ruptures either in the boiler main steam line or branches. Boilers equipped with such valves, Mr. Anderson said, will operate at a uniform pressure and at an increased efficiency, and are a necessary safety device in a plant or power station.

After the talk Messrs. Hartman, James and Hay gave short discussions on the subject of the valves as they found them in plants and stations where they have been employed.

COLORADO AGRICULTURAL COLLEGE

The Colorado Agricultural College Student Branch held a meeting on April 24, at which Professor Cammack gave a talk on a steam pipe covering test, which he conducted as a thesis for graduation from Iowa State College. This test was made to determine the efficiency of various thicknesses of magnesia pipe covering on different sizes of steam pipes. Tests were made to find the saving of heat with both single and double coverings. The test was made with a special system of piping for supplying the steam to the test pipe and for drawing off the condensed water from the test pipe.

There were four separate sizes of test pipe used, varying from one inch to seven inch pipes. Two different thicknesses of covering were used for each test pipe, and records were taken every two minutes during a run of two or three hours. The condensed water was weighed at regular intervals throughout the test and the efficiency was determined from the comparison of covered with bare pipes. The efficiency was first calculated in percentage, and the actual saving in money was also calculated for both coverings for all sizes of pipes used in the test. The tests showed a greater saving made with the larger sizes of pipes, although a very great saving was made by covering any or all of the pipes.

KANSAS STATE AGRICULTURAL COLLEGE

A meeting of the Kansas State Agricultural College Student Branch held on April 27 was a joint meeting with the A.I.E.E. members. The papers which were presented were prepared by the students in electrical enginering who had visited the various power plants in Kansas City during the inspection trip on April 13 and 14. The papers were discussed by the students in mechanical engineering.

LEHIGH UNIVERSITY

A meeting of the Student Branch of Lehigh University was held on April 6. The first speaker was Lieut. E. P. Finney of the United States Navy, who is at present stationed at the Bethlehem Steel Works to oversee the guns and armor plate being made for the Government. Mr. Finney spoke on The Organization of the Battleship. He said that as the battleship is the most important unit in the fleet, its organization represents one of the highest types of scientific management. The ruling officer is the captain, who has supreme authority. To carry out his orders, there is next the executive officer, who really acts as general manager of the ship. The rest of the men on board are grouped under various divisions: the navigation department, ordnance and gunnery department, medical and supply department, and the engineering department.

All the enlisted men are divided into two divisions: the deck force, whose duty is to take charge of the fighting, and the engineering force, who have charge of the running of the ship. The deck force is separated into divisions, each of which has charge of a certain turret or number of guns. Every one of these divisions has its own commanding officer, and he is responsible for everything done by the turret which he is commanding.

The most valuable and instructive duty of the ship is target practice. Problems of actual battle are always used, and maneuvering is done the same as in actual fighting. The targets are usually at a distance of 20,000 yards from the ship. They are set upright on rafts, and are 50 ft. wide and 30 ft. high.

In target practice, organization shows up in the highest degree. The crew of each gun must be experts and the men who control the turning of the turrets must be absolutely sure in their work. In battle all the turrets must be fired together, which requires absolute team work.

As to the duties of the various departments, the ordnance and gunnery department takes care of the battery and ammunition, and the ordnance officer has charge of target practices. The duty of the navigation department is to look after the directing of the ship in its course. As there are about 1200 men on board each ship to be fed, looked after, and clothed by the medical and supply department, the duties of these men are not very light. Lastly, the engineering department includes all the men who run the boilers, the engines, and the rest of the machinery of the battleship.

Another part of ship organization is that it must be ready for shore work. The battleships at Vera Cruz were practically useless because landing could not be made easily. For shore work, a landing crew is necessary and a reserve crew to man the guns on board ship.

In the landing crew there is one battalion consisting of one company of artillery and the rest infantry. At a given signal every man knows where to go, and in the short time of half an hour everything is made ready for landing.

A. V. Bodine, M.E., '15, who is now connected with the Winchester Repeating Arms Co., New Haven, Conn., was the second speaker. His subject was Scientific Management. He said that industrial engineering and industrial management are steadily drawing closer together and rapidly becoming complementary elements in the professional work of a great number of mechanical engineers. For several years there has been industrial activity in the United States, and the great conflict now waging in Europe, which is taxing American factories to their utmost capacity, has brought attention to the need of Scientific Management in our shops.

Many people wonder what Scientific Management really is. Morris L. Cooke has said, "Scientific management is not something that can be bought in a box. It is not something in the nature of a drug that one takes and feels better. It is not a card index. It is dependent upon no single mechanism, nor is it a combination of any number of mechanisms. It is not a system of keeping costs, nor is it a method of paying wages." What then is this thing that has caused so much discussion in the industrial world? It is the search all along the line that reveals conditions which do not conform to definite law and principle; and having found them, makes them conform to what is right.

Before starting to make any changes in the organization of a company, there are certain matters that should be carefully considered: *First,* the importance of choosing the general type of management best suited to the particular case. *Second,* that in all cases money must be spent, and in many cases a great deal of money, before the changes are completed which result in lowering cost. *Third,* that it takes time to reach any results worth aiming at. *Fourth,* the importance of making changes in their proper order, and that unless the right steps are taken great danger from deterioration in the quality of the output and from serious troubles with the workmen, often resulting in strikes.

Scientific management provides: *First,* a careful analysis to determine, before work is undertaken, exactly what is to be accomplished; *second,* the determination of the best way to accomplish the work in the quickest time at the lowest cost; *third,* the employment of the best machines, best facilities, and the best men available to carry out the work in the best way, as previously determined; *fourth,* cordial coöperation between employers and employees in order that both may put forth the best efforts to secure low production costs; and, lastly, an accurate record of the cost of the work in such detail that the various elements of cost may be quickly determined.

A meeting of the Branch was held on May 11, at which C. H. Schuttler spoke on Stresses in a Conical Tank. He presented the theory of the stresses and the results derived, basing his theory on a tank which he himself designed for the Bethlehem Steel Company. Following the lecture, the students were shown a tank made of rubberized cloth, which sustained the theory and the results which Mr. Schuttler had derived.

At this meeting the following officers were chosen for the coming year: G. M. Levy, president; F. M. Porter, secretary; G. T. Custer, treasurer, and G. K. Bishop, librarian.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Student Branch of the Massachusetts Institute of Technology held their annual banquet and final meeting of the year on April 25 at the Engineers Club. Reports of the officers, showing what the Branch had done during the past year, were read and the results of the election of officers for the coming year were given out. Those chosen for office were as follows: W. L. Pryor, chairman; A. P. Dunham, vice-chairman; E. W. Rounds, secretary; S. Sewall, treasurer, and R. W. Logan, F. A. Stearns and A. E. Windle, the governing board.

Prof. E. F. Miller, Mem. Am. Soc. M.E. and honorary member of the Branch, gave a short talk outlining the advantages of membership in The American Society of Mechanical Engineers and advised all members of the local branch to become members of the Am. Soc. M.E. as soon as possible.

Prof. R. B. Wilson spoke on Success. He emphasized the fact that a man need not be a genius to succeed and that opportunity and the ability to make use of it is as much a factor in success as genius. F. W. Hobbs, '89, president of the Arlington Mills, told of the present opportunities for the technically trained man and also why a man should be a member of the Am. Soc. M.E.

POLYTECHNIC INSTITUTE OF BROOKLYN

The Student Branch of the Polytechnic Institute of Brooklyn held a joint meeting with the Student Branch of the A.I.E.E., the Chemical Society and the Alumni Association, which was in the form of an annual dinner, on May 1. The transcontinental telephone was the big feature at the dinner. Maj. Gen. Leonard Wood and Lieut. Commander Jessop were both present. A receiver was at every plate and the diners could hear talk with Pittsburgh, Chicago, San Francisco and the intermediate cities on the line. The University of California was holding a meeting the same night, and members of the faculties of both institutions held a conversation. General Wood and Lieutenant Jessop addressed the University of California students on Preparedness, and their remarks were received with great enthusiasm. A duet was sung over the phone, a soprano singing in Berkeley, California, and a baritone singing in New York.

Mr. Theradi and Mr. Schmidt of the New York Telephone Company explained the workings of the line and its development. The guests included Dr. D. S. Jacobus, President of the Society, J. J. Carty, president of the A.I.E.E., and Dr. Nichols of the Nichols Copper Company.

RENSSELAER POLYTECHNIC INSTITUTE

The Student Branch of the Rensselaer Polytechnic Institute held a meeting on May 2, at which H. deB. Parsons, emeritus professor of practical engineering and a manager of the Am. Soc. M.E., gave a very interesting illustrated lecture on Perpetual Motion and other Engineering Fallacies. Mr. Parsons said that most all mechanical fallacies were founded upon the principles of magnetism, capillary attraction or the laws of gravitation. He showed a number of slides of mechanical devices which had been built, and pointed out how each was designed to make use of one or other of the above principles. These devices, he said, purposed efficiencies greater than unity, which, of course, is obviously impossible.

Mr. Parsons then spoke of the use of liquid air as a source of power and of bisulphide vapor as a medium to replace steam for the operation of engines. He then gave a brief description, accompanied with slides, of the various attempts which had been made to propel boats by a jet of water. One of the first boats which was designed to utilize this principle was built by Dr. Jackson. It was 110 ft. long and was expected to reach a speed of 30 knots an hour. Upon test, however, this boat failed to give the expected speed, and was only able to attain a speed of 5 or 6 knots an hour. In 1896 the Bazin roller boat was constructed in France. This boat was built with large lenticular wheels and designed to roll on the water at about 22 knots an hour. Like the first mentioned boat, however, this also failed to give the expected speed, and only attained a speed of about 6 knots.

Mr. Parsons then spoke briefly of the Fontaine Locomotive built by the Grant Locomotive Company of Paterson, N. J., and concluded his lecture by giving a short description of the Keely Motor. This motor was a machine invented by John W. Keely, a carpenter, who was born in Philadelphia in 1837 and died there in November, 1898, purporting to furnish motive power at a minimum expenditure of energy. It began to attract attention in 1874, and for several years excited wide interest. Its inventor made many startling claims and predictions for the success of his motors, asserting that they were destined to revolutionize mechanics. Several hundred thousand dollars were subscribed for the stock of the company formed to control the invention, and while the nature of the machine was kept a carefully guarded secret, it was widely exploited and attracted considerable attention. Various exhibitions were given, with some remarkable features; but the promised developments never appeared, and after the inventor's death the fraud was thoroughly exposed, it being shown that the force was supplied by a hidden compressed air apparatus.

THROOP COLLEGE OF TECHNOLOGY

The Throop College of Technology Student Branch held a meeting on April 28, at which R. O. Catland, '15, and Junior Member Am. Soc. M.E., spoke on a New Light Weight High Compression Aeroplane Engine which is being built by the Griffith Machine Company. The engines will probably be used on the new Martin aeroplanes. The motors are of the eight cylinder V type, 4⅝ in. bore by 7 in. stroke, and weigh about 485 lb. The cylinders are turned separately from solid stock, and after being fitted on the crank case they are ground to 3/16 in. thickness. A pair of cylinders is enclosed in a pressed steel water jacket made in two parts and welded in place. There are two intake and two exhaust valves for each cylinder. Due to careful designing of cylinders and water jacketing, the compression pressure is very high in this engine. The mean effective pressure has been calculated to be about 116 lb. per sq. in.

Much use is made of oxy-acetylene welding in the construction, the water jackets, exhaust and intake manifolds and the valve seats being welded.

During a recent test one of the engines developed 183 h.p. at 1375 r.p.m.

UNIVERSITY OF CALIFORNIA

At a special meeting of the University of California Student Branch held on April 13, 1916, G. W. Dickie, Vice-President of the Society, delivered an address on the subject of Work. He told of the various problems that young engineers would meet upon graduation, and showed the need of technical men in the foundry business. In concluding, the speaker touched the problems confronting the national board of engineers which was recently appointed to investigate the manufacturing resources of this country.

On April 18, 1916, the final meeting of the year was held. The following officers were elected for the coming year: Prof. L. B. Langille, honorary chairman; H. Greenwood, chairman; H. S. Bean, vice-chairman; H. G. Oliver, treasurer, and M. D. Penfield, treasurer. Following the election of officers the following papers were presented: The Development of Manual Training Instructors, by E. R. Foster, '17, and The Theory of Splashes and Methods Employed in Their Analysis, by B. R. Vanleer, Instructor in Hydraulics.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch of the Society held a meeting on March 24, at which C. W. Heath, Chief Smoke Inspector of the City of Cincinnati, addressed the Branch. He told of the work of his department, the methods employed in handling different situations and the results obtained. He also told of the different smoke consuming devices and of the necessity of their proper use for results. His lecture was illustrated by means of lantern slides and moving pictures.

At a meeting of this Branch on April 27, M. Boyd Gordon, Member of the Branch, presented a paper on A New Type of Valve for Unaflow Engines. He described the workings of the valve and the ease of manufacture and the advantages which it is hoped this valve will have over others.

UNIVERSITY OF ILLINOIS

A meeting of the University of Illinois Student Branch was held on May 10, 1916, at which motion pictures were shown of manufacturing processes in the Ford Motor Car factory, and also of the American Railway Ditch Digger.

UNIVERSITY OF MINNESOTA

The University of Minnesota Student Branch held its regular monthly meeting on April 29, 1916. C. W. Tubby, Chairman of the Minnesota Section of the Society, gave an instructive and interesting talk on Pumping Machinery.

WASHINGTON UNIVERSITY

Last fall the Student Branch of Washington University formulated a new plan for its meetings, which was to have the students give papers before the Branch. This plan has been worked out and has proved to be very interesting as well as instructive. The Branch has had some outside speakers, however, among whom are the following: Thomas R. Beebe of the Oxweld Acetylene Company, who gave a demonstrative talk on oxy-acetylene welding and cutting. Members of the Branch were allowed to try their skill with the cutting torch and made to feel some of the difficulties encountered by the oxy-acetylene workers on particular classes of work.

Henry Gulick of the Moore-Jones Brass Company delivered a very interesting talk on Engineering Bronzes. Mr. Gulick, who is an expert on bronzes, told of some of the difficulties attending the fulfillment of requirements of certain specifications regarding tensile strength, hardness, etc., and also how to get around them.

Osborn Monnett of the American Radiator Company, who is an authority on boilers and boiler settings, gave an illustrated talk on The Elimination of Smoke with the Use of Any Soft Coal.

Some of the papers which were given by student members were the following: The Mallet Articulated Compound Locomotive by Walter H. Kurtz; Lodge and Shipley Lathes by Charles V. Brady. This was illustrated by lantern slides from the Lodge & Shipley Company. The Solution Theory of Metals presented by Harold C. Keyser, and Keokuk Power Plant by Percy N. Lubke. This was also illustrated with slides.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Soceity the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

These advertisements are placed by members of the Society or persons vouched for by members. The Society is pleased to act as a "clearing house" in these matters but is not responsible for any result.

In forwarding applications, stamps should be enclosed for their transmittal to advertisers; and applications from non-members should be accompanied by a letter of reference or introduction from a member, to be filed by the Society.

Engineer. Technical graduate preferred, experienced in the design of open feed water heaters, softeners, etc. Good position to right man. Write fully giving details of experience and references.—102.

Draftsmen—preferably men experienced in apparatus layout especially chemical apparatus and plants. Location New York.—267.

Chief Draftsman. Mechanical engineer with manufacturing experience on products similar to sewing machines and cream separators. Man thoroughly experienced in design of jigs, tools, fixtures and special machines for manufacturing parts on interchangeable basis. Salary to start $175 a month to thoroughly competent man.—268.

Cost Man, thoroughly familiar with estimating from blue prints, stock records, detail and final costs, etc.; good personality required and ability to handle men; must be capable of analyzing costs into operations. A systematizer is not wanted, but one who can maintain the present system and get results. Location New England.—270.

Estimator, experienced in grey-iron and steel castings, pattern and machine work. Position calls for accuracy above everything else. Location Maryland.—273.

Draftsman, capable of working with an inventor in the designing of automatic machinery. Location New Jersey. —274.

Safety Inspectors. Two or three young M.E. graduates for accident and indemnity company. Reply through No. 275.

Salesman for soot blowers for marine trade; should have a fairly good acquaintance with shipbuilders and owners; familiarity with marine boilers desirable.—276.

Draftsman, with technical training and considerable experience in design of air compressors. Salary $1200 to $1400 a year. Location Colorado.—280.

Tool Designer to take charge of tool drafting department, in concern manufacturing small interchangeable parts; man

preferred who has experience in tool design for concerns making typewriters, adding machines, electrical apparatus, etc. In reply state age, nationality, former places of employment, experience and salary expected. Location New England.—288

Chief Engineer. A man of generally well balanced mind and natural executive ability, good technical training, either college or self-taught. About ten years experience in automobile engineering and particularly in the branches of the profession pertaining to the engine design, carburation and production, qualifying him to take charge of production to the end of turning out thoroughly standardized parts, within necessary limits, and at a minimum cost; personal resourcefulness to devise new methods and ability to design interchangeable parts. Name confidential. Apply by letter.—289.

Sales Engineer, good personality, reasonably pleasant manners and tact, whose education has fitted him to meet engineers of vehicle manufacturers; applicant should have had five to eight years practical experience along the lines involved in power production, power requirements for the different gears, the relations and relative efficiency of gear ratios and carburation; should thoroughly appreciate the value of coöperation between himself and the other departments of the enterprise, and members of the various departments. Name confidential. Apply by letter.—290.

Associate Professor in Experimental Mechanical Engineering in large engineering school in Atlanta, Ga., wanted next September. Must have recognized engineering degree and teaching experience or extensive practical experience in experimental and research work. Give full details of education, post-graduate work and practical experience, including references.—293.

Machine Designer. A high grade machine designer or chief draftsman. Must be thoroughly versed with machine shop, drawing room, foundry and pattern shop practice. Write fully, giving details of experience, salary expectations, etc. Location Midle West.—295.

Engineer, experienced in design and construction of brass and other alloy foundries; state salary and experience. Location, New York.—297.

Draftsman, originality required, with some shop experience and a knowledge of shop technique; including design of small machines, detailing of repair parts for hydraulic presses and pumps, lay out of high pressure lines and enough skill to select and adapt conveyors from the manufacturers catalogues. Salary $125 per month to start. Location Canada.—298.

Technical Graduate in Mechanical Engineering, who has been out of college at least one year; to work in engineering departments and specialize along combustion and steam lines. Location Maine.—299.

Engineer of Tests and of Reports; one who has had wide experience in the testing of materials in construction and can prepare reports covering such tests. Good salary for the right man, but must fill requirements of education, experience and personality. Prefer man between thirty and forty years of age, who is at the present time employed, and who has made good where he is. Location Pennsylvania.—300.

Salesman and Sales Manager for new aeroplane company; must be high grade salesman as well as organizer of salesmen. Apply by letter.—301.

Mechanical and Electrical Engineer, who is a capable machine designer, wanted as assistant to the general manager of an old established company, making a line of machines used by metal manufacturers. The company expects to redesign its line and to do experimental and development work in connection with adapting its product to more extensive use. State age, education, experience and salary expected. Location New England.—303.

High Grade Machinery Salesman wanted by old established company making a line of machines used by metal goods manufacturer. Position involves large amount of travelling in the East, Middle West, etc. Qualifications desired: pleasing personality, energy, ambition, enthusiasm, imagination and ability to sell and to keep every customer satisfied. One who has demonstrated his ability along these lines. In reply give age, full record, and salary desired. A good position is offered at once, with interesting possibilities for the future. Headquarters New England.—304.

Chief Engineer with extended experience in both pleasure automobile and motor truck construction. Write The Timken Roller Bearing Company, Canton, Ohio.—307.

Engineers. Firm of industrial engineers, foundry and metallurgical specialists, desires two or more men to assist in laying out foundry plans and looking after work; one prospect will involve a continuous foundry with considerable equipment and handling appliances.—308.

Laboratory Assistant for department of physics in an Eastern technical school. Candidate should be willing to start at the bottom and grow up with the work. Salary $800 to start. No teaching experience required.—309.

Designers, experienced jig and fixture designers for automobile work. Large company in Middle West. All new equipment. Good opportunity.—312.

Master Mechanic to supervise tool, jig, fixture, design and maintenance for concern in Detroit doing brass work exclusively and employing about 60 toolmakers in tool room. Location Middle West.—322.

Practical Engineer to assist in design, building and putting into operation of tools for sheet metal work in general, and can-making tools of all varieties in particular. Thorough technical education a necessity. Preference given to man with experience in sheet metal work and in can-making. Salary $1800 per year, to be advanced as warranted by increased efficiency and familiarity with work. Location New York.—323.

Engineer having extensive experience in conveying machinery, able to handle layouts of equipment and methods and produce satisfactory and efficient results. Location Ohio.—324.

Assistant Shop Engineer familiar with woodworking machinery, to look after production side of work and upkeep. Location Vermont.—327.

Technical Graduate, 30 to 35, with practical experience in manufacture and building of steam and hydraulic machinery. Man preferred with wide shop experience, capable of directing men. Location, Ohio. Interview will be arranged only after examination of applicant's statement of qualification, records and compensation expected.—328.

MEN AVAILABLE

Only members of the Society are listed in the published notices. Notices are not repeated in consecutive issues of the Bulletin.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

Sales Engineer, graduate with six years' experience in design and manufacturing, wishes to enter firm which will train him in selling. Excellent references from present and past employers.—F-208.

Assistant Professor. Member of Am.Soc.M.E. and S.P.E.E.; at present connected with mechanical engineering department of prominent university but desires to change position; would consider similar position which offers opportunity for advancement. F-209.

Student Member, 1916, graduate in mechanical engineer-

ing, University of Minnesota; record good; desires position with engineering or manufacturing concern.—F-210.

Mechanical Engineer. Member, experienced in power plant design, heating, ventilating, industrial plants, selling experience, seeks responsible position; has had charge of men and shown executive ability.—F-211.

Instructor or Assistant Professor. Young engineer, at present in charge of courses in engineering laboratory in prominent Eastern university, experience in teaching nearly all branches of mechanical engineering, and about four years practical experience in drafting room and shop, desires position in college receiving state support, east or middle west preferred; references furnished and adequate reasons for desiring change.—F-212.

Department Head; mechanical engineer, university graduate, wide experience in efficiency work; steam engines, boilers, pumps, oil engines, water supply; especially familiar with air machinery; technical author, lecturer and editor; shop work, design and testing; also several years in sales engineering. Age 36; married, now employed, desires position offering better future. American.—F-213.

Mechanical Engineer, inventive and executive ability, A-1 references; member, twenty years experience steam, gas power, industrial and chemical plants; heating, ventilating, refrigeration, gas engines.—F-214.

Assistant to Chief Executive of Large Corporation, chief engineer or works manager, associate-member, 34 years of age broad, practical experience in electrical railway construction and operation, automobile manufacturing, machine tool building; speaks and writes French fluently, also some Spanish.—F-215.

Assistant to an Executive, 33, technical man, hard worker and strict disciplinarian, wishes to make a change; strong organizer and successful handling men. Experienced in the manufacture of heavy machinery. Best of references; valuable to executive needing man to take care of details and to see that orders are carried out.—F-216.

Master Mechanic, Shop Superintendent or Manager, about 15 years experience at the machinist trade. Will graduate B.S. in M.E. from Bucknell University in June. Familiar with scientific management and methods; good references from reliable steel manufacturing firms and machine tool manufacturers.—F-217.

Short Term Employment, June 8 to September 15, desired by mechanical engineer, student member from M.I.T. Four years designing, executive and teaching experience; heavy machine tool building, iron founding, gas engineering. —F-218.

Assistant to Works Manager or Executive Engineer; technical graduate, with varied experience in office, sales and executive work in shop and factory, desires to become identified with concern where position would develop into broad future.—F-219.

Graduate Mechanical Engineer; thoroughly familiar with heat insulating materials; experienced in design and construction of cold storage rooms and warehouses. At present employed, but desires better opportunity for advancement.—F-220.

Testing Engineer; technical graduate with four and a half years experience as assistant engineer in large laboratory testing steam machinery of all kinds, desires to make change.—F-221.

Student Member, will graduate in June in mechanical engineering from Rensselaer Polytechnic Institute, desires position with opportunity for advancement, in power plant work, heating and ventilating or efficiency work with manufacturing firm. Age 26.—F-222.

Executive or Assistant to Executive; technical graduate, (M.E.) at present employed, desirous of becoming connected with firm in or around New York City. Experience along executive, engineering, shop and sales lines. Speaks French and German.—F-223.

Assistant to Executive, Large Manufacturing Corporation, to increase output, lower costs, unify and stimulate organization, through intensive, analytical methods. Past seven years in industrial management work; as member of staff of noted efficiency engineer, as assistant to comptroller, special investigator, manager manufacturing plant, overseeing economical operation all plants $10,000 corporation; as assistant to vice-president and to general superintendent $75,000 corporation to promote more intensive and analytical methods of operation; seeks permanent connection; age 31; technical graduate; references from previous connections. —F-224.

Graduate Mechanical Engineer with experience as machinist, tool and die maker, tool department sub-foreman and foreman, tool and machine designer, design inspector, acting equipment engineer, production supervisor; thorough knowledge of mechanics, mathematics, economics, manufacturing methods, factory organization, equipment management, men; time and motion study investigations and improvements.—F-225.

Mechanical Engineer with shop, drawing room and sales experience desires responsible position with growing concern, 30 years of age, married; highest references. Available July 1.—F-226.

Mechanical Engineer, experienced in design and operation of power plants and general manufacturing machinery; specialized in boiler room management and maintenance of machinery.—F-227.

Assistant to Engineer or Instructor in Technical School. Junior member, college graduate, age 24; married; experience in drafting and shop. Desires permanent position as assistant to consulting engineer or as instructor in mechanical engineering. At present employed on valuation of common carriers. Can furnish satisfactory references.—F-228.

Chief, Mechanical or Consulting Engineer. Associate, technical education; fourteen years experience, familiar with design of industrial plants, mill buildings, ore blasting furnaces, coal washing, screening, elevating and conveying machinery, having held positions as chief draftsman, engineer of construction and chief engineer for large concerns.—F-229.

Representative for the Far East. Japanese graduate of electrical and mechanical schools, connected with telephone and railway companies of New York, wishes to communicate with American firms planning to develop business in Japan or China. Will consider agencies.—F-230.

Professor of Mechanical Engineering in a University, desired by member, age 40, technical graduate, M.E. with 17 years experience in teaching engineering and consulting work; practical experience in commercial engineering; specialized in steam power plants; for a number of years head of department of mechanical engineering in leading university. At present head of departments of mechanical and electrical engineering in university of good standing. Location abroad, China preferred.—F-231.

Mechanical Electrical Engineer, age 32, married, fourteen years manufacturing experience as workman mechanical electrical engineer and engineer-in-charge of factory reorganization work. Experienced in analyzing industrial conditions, time study and task setting.—F-232.

Efficiency Engineer, Draftsman and Designer of automatic machinery, factory and mill buildings and labor saving devices; permanent position only in vicinity of New York City considered.—F233.

Mechanical Engineer, Master Mechanic, or Assistant, Junior member, technical education, age 31, varied experience, foundry and machine shop practice; design construction, and supervision of installation of mechanical equipment of textile machinery for print works, bleacheries and cotton mills, power transmission appliances, buildings and power plants, boilers, etc.; remodeling, maintenance, efficiency and general plant

engineering, purchasing materials and equipment, correspondence, estimates, specifications, contracts and appraisals; fire service, piping, sewage disposal for steam buildings and supervising steam engine, turbines and boiler tests. Can handle men and get results. Desires to locate with concern where ability and energy are required. At present employed. —F-234.

Hydraulic Engineer, graduate Worcester Polytechnic Institute, 16 years experience in hydraulic and pumping machinery in design, manufacturing and selling departments. Best of references.—F-235.

Manager, Assistant, Superintendent, Executive or Sales Engineer. Associate, age 42, Lehigh University graduate in mechanical engineering; varied experience along mechanical, electrical and civil engineering lines involving design, inspection reports, responsible charge of construction work, plant operation, management, purchasing, etc., in connection with power, lighting plants and industrial plants, electric railways, etc. Salary, $3,000.—F-236.

Manager or General Superintendent. Shipbuilding in all branches. Marine or stationary engines, power plant machinery and installations. Steam engineering and general machinery. No mechanical undertaking too large. Can furnish best of references of ability gained by years of practical work and supervision. At present employed; confidential. —F-237.

Mechanical Engineer, Columbia University technical graduate, desires to locate with manufacturing or engineering concern in or near New York; two years power plant, shop and drafting room experience. Experienced in power plant testing, automatic machinery, installation and layout of machinery. At present employed in maintenance department of concern manufacturing automobile auxiliaries.—F-238.

Mechanical Engineer, 1915 graduate, desires position with manufacturing concern where prospects of advancement are assured; experimental engineering experience. At present employed. Location preferred, New York.—F-239.

Head of Mechanical Engineering Department in educational institution or in charge of industrial education with manufacturing company. Teacher of experience who can furnish the highest recommendations from employers and associates. Wide experience in engineering and construction; now on the engineering force of a large manufacturing company.—F-240.

Administrative or Executive position. Member; technical and commercial training, at present employed, desires to become identified with manufacturing or industrial plant in responsible position. Varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; familiar with the handling of men, drawing up contracts, purchasing equipment and material; modern methods of manufacturing and marketing product.—F-241.

Mechanical Engineer. Member, who will shortly be in New York for several months, is open to negotiate with prominent manufacturers of railway rolling stock and specialties, with a view to representing them in Europe. Please address all communications to the Society.—F-242.

Engineer and Superintendent, Cornell graduate with extensive experience in designing, purchasing, constructing and operating power plants, track work, transmission and distribution lines, car barns, office buildings, foundries, machine shops, chemical and cotton plants, tanneries, gun cotton and smokeless powder plants, factories of reinforced concrete, flat slab or mill construction, also artesian wells, structural steel, docks, piling, sewers, heating, drying and air washer systems. Salary $4,000.—F-243.

Sales Engineer. Technical graduate, twelve years selling experience, especially Government work. At present in charge of Washington, D. C., office of large machinery manufacturer; desires similar position in New York.—F-244.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

Aids in Navigation (Cummings Engine Log System). *Boston.* Gift of A. S. M. E.

Atlantic Deeper Waterways Association. Proceedings. 8th Annual Convention. *Philadelphia, 1916.* Gift of Association.

Carnegie Free Library. 23d and 27th Annual Report of Carnegie Club, Braddock, Pa. *1915.* Gift of A. S. M. E.

The Dangers of Half-Truth in the Power Plant; the Business of Making Your Own Power at a Profit. *New York, Fuel Engineering Company, 1916.* Gift of publisher.

Dean Grates, Dumping, Shaking, Stationary. Catalogue no. 7. *New York, Washburn & Granger.* Gift of A. S. M. E.

Depreciation Reserves as Affected by Property Growth, L. R. Nash. Reprinted from American Economic Review, March, 1916. Gift of Stone & Webster Corporation.

Le Facteur Humain dans l'organisation du Travail, James Hartness. *Paris, 1916.* Gift of author.

Fatigue Study. The elimination of humanity's greatest unnecessary waste. Frank B. Gilbreth and Lillian M. Gilbreth. *New York, Sturgis & Walton, 1916.* Price, $1.50. Gift of Publishers.

A book that should interest not only engineers, but laymen as well. It takes up the general question of fatigue, and describes the methods of studying fatigue and the bearing of environment, lighting, ventilation, seats and work benches on fatigue. W. P. C.

Marksmanship in Schools. *London, The Wilkinson Sword Co.* Gift of A. S. M. E.

National Commercial Gas Association. Proceedings of the 11th Annual Convention, 1915. *New York, 1915.* Gift of Association.

New York Central Railroad Company. Report of the Board of Directors to the Stockholders, 1915. *New York, 1915.* Gift of New York Central Railroad Company.

New York City Board of Water Supply. Information for bidders, forms of proposal, contract, bond and certificates, specifications and drawings for furnishing and erecting fences in the vicinity of the Kensico Reservoir, Contract 173. 1916. Gift of Water Supply Board.

——— Information for bidders, forms of proposal, contract, bond and certificates, specifications and drawing for furnishing, delivering and installing steam heating systems in the Ashokan Lower Gate and the Kensico Lower Effluent Chambers. Contract 164.

——— For furnishing, delivering and erecting traveling crane equipment in chambers at Ashokan, Kensico and Hill View Reservoirs. Contract 95.

——— For surfacing with bituminous macadam and vitrified brick block portions of the highways at the Kensico Reservoir. Contract 171. Gift of New York City Board of Water Supply.

New York State Engineer & Surveyor. Annual Report, vol. 1, 1915. *Albany, 1916.* Gift of State Engineer & Surveyor.

Oil Fuel, Ernest H. Peabody. Gift of Babcock & Wilcox Company.

The Piano Player, How and Why, P. J. Meahl. *Summit, 1913.* Gift of author.

Planning of Alaskan Ports, Paul Whitman. *Washington, 1916.* Gift of U. S. Dept. of the Interior.

Railway Regulations, John Findlay Wallace. Rand-McNally Bankers' Monthly, April, 1916. Gift of J. F. Wallace.

Report on the Feasibility and Advisability of Some Policy to Inaugurate a System of Rifle Practice Throughout the Public Schools of the Country, G. W. Wingate and A. B. Critchfield. *Washington, 1907.* Gift of A. S. M. E.

Society of Constructors of Federal Buildings. List of Members, 1916. Gift of A. S. M. E.

Society of Naval Architects & Marine Engineers. List of Members, 1915. Gift of A. S. M. E.

Some Hazards and Safety Suggestions in Connection with Construction, Inspection and Maintenance of Public Utilities, H. W. Mowery. Gift of A. S. M. E.

Stair and Sidewalk Hazards. From the report to the Mayor's safety committee by the American Museum of Safety. Gift of A. S. M. E.

Submarine Navigation, by the Aid of Cummings Engine Log System. *Boston.* Gift of A. S. M. E.

Sub-target Gun Machine, Description of. *Boston.* Gift of A. S. M. E.

Technical Board—Vessel safety to Council Committee, Harbors, Wharves and Bridges, City of Chicago. Report, March, 1916. Gift of Technical Board—Vessel Safety.

Text Book of Mechanics, Louis A. Martin, Jr. Vol. VI. Thermodynamics. *New York, J. Wiley & Sons, 1916.* Gift of publisher. Price, $1.75.

An elementary textbook for mechanical engineering students.

W. P. C.

EXCHANGES

Institution of Mechanical Engineers. Proceedings, Oct.-Dec., 1915. *London, 1915.*

The Locomotive. Vol. XXX. Hartford Steam Boiler Inspection and Insurance Company. *Hartford, 1914-1915.*

TRADE CATALOGUES

American Manganese Steel Co. *Chicago, Ill.* Bulletin 65. Manganese Steel Castings for Steam Shovels and Dipper Dredges.

Bailey Meter Co. *Boston, Mass.* Bulletin No. 5. Bailey Fluid Meter, Type C 2. *Jan., 1916.*

Baird Machine Co. *Bridgeport, Conn.* Master Bulletin. "Brief bits 'bout Baird Machinery." *Nov., 1911.*

Becker Milling Machine Co. *Boston, Mass.* Becker Vertical and Horizontal Millers. *1916.*

Continental Gin Co. *Atlanta, Ga.* Catalogue No. E-2. Continental Engines and Boilers.

——— G5, X7-E. Cotton Ginning Machinery; Continental Linter.

"Duplex" Gin Saw Filer (Wood's latest improved No. 3).

Heart of the Gin Plant. 20 pp.

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. *April, 1916.*

Goldschmidt Thermit Co. *New York, N. Y.* Reactions. Vol. 9, no. 1. *1916.*

Goodrich Co. *Akron, Ohio.* The Goodrich. *April, 1916.*

Ingersoll Rand Co. *New York, N. Y.* Form no. 3026. "Ingersoll Rogler," Class "PRE," Duplex Direct Connected, Electrically Driven Air Compressors. *March, 1916.*

Nordberg Mfg. Co. *Milwaukee, Wis.* Bulletin no. 27A. High Compression Two-Sycle Oil Engine. *Sept., 1915.*

Roebling's Sons Co. *Trenton, N. J.* Roebling Wire Rope. v. 1, no. 2.

Stephens-Adamson Mfg. Co. *Aurora, Ill.* Labor Saver. *April, 1916.*

Texas Oil Co. *New York, N. Y.* Lubrication. *April, 1916.*

Valley Iron Works Co. *Appleton, Wis.* The Beater. March-April, *1916.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

Alternating Current Electricity and Its Applications to Industry. Second Course, W. H. Trimie and H. H. Higbie. *New York, J. Wiley & Sons, 1916.* Price, $3 net. Gift of Publishers.

A textbook, with numerous problems for students. W. P. C.

American Clay Machinery Company. Catalogue no. 95. Clay Working Machinery. Gift of Leon Goldmerstein.

American Ship-Building Company. Prospectus, Based upon the Patents of Capt. Augustus Walker. *New York, 1864.*

American Year Book, 1915. Edited by F. G. Wickware. *New York-London, 1916.*

Analysis of Dyestuffs and Their Identification in Dyed and Colored Materials, Lake Pigments, Foodstuffs, A. G. Green. *London, 1915.*

Artesian Wells of Montreal. Canada. Department of Mines, Memoir 74. *Ottawa, 1915.*

Sir Henry Bessemer. An Autobiography. *London, 1905.*

Burnettizing, or the Process for Preventing the Rapid Decay of Timber by the Use of Chloride of Zinc. *Cambridge, 1876.*

The By-Products of Coal Gas Manufacture, K. R. Lange; translated from the German by Chas. Salter. *London, 1915.*

Canada. Mines Branch. Department of Mines. Description of the Laboratories. *Ottawa, 1916.*

El Canon Krupp y el Schneider de 75 milimetros, A. F. Dalmau. *Barcelona, 1915.*

Casting of Clay Wares. U. S. Bureau of Mines. Technical Paper 126. *Washington, 1916.*

Chemische Technologie des Erdöls, Richard Kissling. *Braunschweig, 1915.*

Chemische Technologie des Leuchtgases, Karl Th. Volkmann. *Leipzig, 1915.*

Circular of William A. Orcutt, Manufacturer of Orcutt's Patent Lightning Rods. *Boston, 1866.*

Coal and Coke, F. H. Wagner. *New York, 1916.*

Coal Resources of District VIII, Danville. Illinois Coal Mining Investigations. Bulletin 14. *Urbana, 1915.*

Description of Edward Massey's New Improved Patent Perpetual Log, and Patent Sounding Machines. *London.*

Dictionary of Altitudes in the Dominion of Canada, Jas. White ed. 2. *Ottawa, 1916.*

Die Differentialgleichungen des Ingenieurs, W. Hort. *Berlin, 1914.*

Directions for Designing, Making and Operating High Pressure Transformers, F. E. Austin. *Montpelier, Vt., 1914.*

Directory of Directors in the City of New York, 1915-1916. *New York, 1916.*

Effect of Preliminary Heating Treatment upon the Drying of Clays, A. V. Bleininger. *Washington, 1911.*

Explosibility of Gases from Mine Fires. U. S. Bureau of Mines. Technical Paper 134. *Washington, 1915.*

Festigkeitseigenschaften und Gefügebilder der Konstruktionsmaterialien, C. Bach und R. Baumann. *Berlin, 1915.*

Forest Protection in Canada, 1913-14. *Toronto, 1915.* Gift of Canada. Commission of Conservation.

Forging of Iron and Steel, W. A. Richards. *New York, 1915.*

Franklin Institute. Report of the Committee for the Promotion of the Mechanic Arts on the Explosions of Steam Boilers. Part I-II. *Philadelphia, 1836, 1837.*

Geology and Geography of the Galena and Elizabeth Quadrangles. Bulletin No. 26, Illinois State Geological Survey. *Urbana, 1916.*

Geology of Cranbrook Map-Area, British Columbia. Canada. Department of Mines. Memoir 76. *Ottawa, 1915.*

Glycerine, Its Production, Uses and Examination for Chemists, etc., S. W. Koppe; translated from the German second edition by W. H. Simmons. *London, 1915.*

Handbook for the Artisan, Mechanic and Engineer. Oliver Byrne. *Philadelphia, 1870.*

Handbook to the Collection of Kaolin, China-clay and China-stone in the Museum of Practical Geology, J. A. Howe. *London, 1914.*

Handling Materials in Manufacturing Plants, Robert L. Streeter. The Engineering Magazine, vol. 1, no. 6, March 1916, 26 pp., 33 figs.

Handbuch der Steinindustrie, C. Gabert, A. Spielmann and A. Steuer. vols. 1-2. *Berlin, 1916.*

Harper's Hydraulic Tables for the Flow of Water, J. H. Harper. *New York, 1916.*

Hawkin's Electrical Dictionary. *New York.*

Heizungs und Lüftungsanagen in Fabriken, O. V. Hüttig. *Leipzig, 1915.*

History of the Improvements Applicable to the Base Burning or Horizontal Draught Stove, D. G. Littlefield. *Albany, 1859.*

History of the Iron, Steel, Tinplate and Other Trades of Wales, Charles Wilkins. *Merthyr Tydfil, 1903.*

Illinois Geological Survey. Year Book for 1910, Administrative Report and Various Economic and Geologic Papers. Bulletin 20. *Urbana, 1915.*

Die Illustrations Verfahren, O. F. W. Krüger. *Leipsig, 1914.*

Die Industrie der Ammoniak und Cyanverbindungen, F. Muhlert. *Leipzig, 1915.*

Inflammability of Illinois Coal Dusts. U. S. Bureau of Mines. Bulletin No. 102. *Washington, 1916.*

Institution of Mining & Metallurgy. List of Members, March, 1916. *London, 1916.*

Instructions and Observations Concerning the Use of the Chlorides of Soda and Lime. By A. J. Labarraque; translated by Jacob Porter. *New Haven, 1831.*

Instruments for Recording Carbon Dioxide in Flue Gases. U. S. Bureau of Mines. Bulletin 91. *Washington, 1916.*

International Engineering Congress, 1915. Transactions. Vol. VII, Electrical Engineering and Hydroelectric Power Development. *San Francisco, 1915.*

Investigation of a Reported Discovery of Phosphate in Alberta. Bulletin No. 12, Canada, Department of Mines. *Ottawa, 1916.*

Kinematik. vom praktischen Standpunkte ausbetrachtet. *Cothen, 1913.* Gift of Wm. F. Jacob.

Landwirtschaftliche Maschinen, Wilhelm Koeppen. *Leipzig, 1914.*

Library of Factory Management. Vol. 1-6. Buildings and Upkeep; Machinery and Equipment; Materials and Supplies; Labor; Operation and Costs; Executive Control. *Chicago, 1915.*

Massachusetts State Forester. Twelfth annual report, 1915. *Boston, 1916.* Gift of State Forester.

Die Materialbewegung in chemisch technischen betrieben, C. Michenfelder. *Leipzig, 1915.*

Metallurgy of Gold, T. K. Rose. ed. 6. *London, 1915.*

Military Electric Lighting. Vol. I-II. *London, 1909, 1915.*

Military Preparedness and the Engineer, E. F. Robinson, 1916.

Minas Submarinas y Torpedos, A. F. Dalmau. *Barcelona, 1915.*

Mine Ventilation Stoppings, with Especial Reference to Coal Mines in Illinois. Bulletin 99, U. S. Bureau of Mines. *Washington, 1915.*

Miscellaneous Reports of Bulletin Nos. 52-60, Western Australia. Geological Survey, Bulletin No. 64. *Perth, 1915.*

Mississippi, Its Geology, Geography, Soils and Mineral Resources. Bulletin No. 12, Mississippi State Geological Survey. *Jackson, 1915.*

Mitchell's Patent Screw Piles and Moorings, Charles Manby. *London, 1852.*

Modern British Permanent Way. Treating of rails, chairs, fishbolts, fishplates, keys, sleepers, ballast, etc., C. J. Allen. *London, 1915.*

Modern Printing Machinery and Letterpress Printing, Practical Treatise upon, F. J. F. Wilson and D. Grey. *London-New York, 1888.*

Moderne Seifenfabrikation, A. Ganswindt. *Leipzig, 1915.*

National Association of Cement Users. Proceedings of the Seventh Annual Convention, 1910. Gift of Free Library of Philadelphia.

National Electric Light Association. List of Company Members, Jan. 1, 1916. *New York, 1916.*

New International Encyclopaedia, vol. 17, 18, ed. 2. *New York, 1916.*

New International Year Book, 1913, 1915. *New York, 1914, 1916.*

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W. P. C.

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the February 1916 issue of The Journal.

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A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

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AEROPLANE SURFACES, RESISTANCE.
SCREW SURFACES (PROPELLERS), CHARACTERISTICS OF RESISTANCE.
WIND TUNNEL EXPERIMENTS, DIMENSIONAL THEORY.
TOTALLY IMMERSED BODY, EQUATION OF RESISTANCE.
VISCOSITY OF AIR AND HEAD RESISTANCE OF AIRSHIP.
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SIMPLEX INTERCEPTING VALVE FOR MALLET LOCOMOTIVES.
LANCASHIRE AND WATERTUBE BOILERS COMPARED.
INCREASING VELOCITY OF GASES IN LANCASHIRE BOILER.
THOMSON-JOULE EFFECT IN AIR, AND TEMPERATURE AND PRESSURE.
STEEL TUBING, MANUFACTURE BY WELDING.
CHARTS.

THIS MONTH'S ARTICLES

The articles in the section Aviation are characteristic of the rapid and growing development of this new branch of engineering. Among this month's abstracts is found an extensive investigation on the dimensional theory of wind tunnel experiments, by Edgar Buckingham, Mem. Am. Soc. M. E., carried out at the Smithsonian Institution, while the Massachusetts Institute of Technology is shown in an abstracted article by J. S. Hunsaker to have created an apparently well-equipped laboratory for aeronautical experimentation.

In the same section will be found an abstract of a paper by Prof. G. H. Bryan on the characteristics of certain resisting surfaces and screws. This paper is of an essentially critical nature and to be fully understood must be read in connection with the previous paper by a veteran of aviation, Capt. Ferber, who made an attempt to treat the entire problem of stability of heavier-than-air machines by means of an orthogonal system of planes.

In the section on Engineering Materials will be found a continuation of an article abstracted in the previous issue of The Journal, on the influence of heat treatment on certain physical properties of steel. In the present abstract are given data on the hardness of very low carbon steel as affected by annealing at various temperatures.

In the next section, Foundry, is a discussion of the interdependent relationship of the various factors in malleable iron production. Among other things, the author gives a control chart of malleable cast iron melting and annealing operation, which may be of considerable usefulness for one who wants to make certain that he thoroughly understands every step in the production of this important material.

A brief abstract is given of a paper before the Society of Chemical Industry by Prof. William A. Bone, of England, chairman of the Fuel Economy Committee of the British Association. The appointment of this Committee which, at least in this country, attracted only very little attention, is one of the significant indications of the profound changes which the present war in Europe is likely to bring for all time to come in the industrial life of the world. While the subject of economy was always one of favorite discussion, these discussions were mainly academic because the creation of economic conditions of production involves not only the changes in methods of operation but what is more, changes in that equipment with which the world's work is done, and industries are proverbially slow in sending to the scrap heap equipment which, however uneconomical, pays dividends. The war, by its upheaval in all relations of supply and demand, has forced the industries to consider the forms of production, not from the point of view of current balances of income and expense, but as an element in the national struggle for existence in which economy of operation becomes the imperative condition of survival. It made clear that the change of industrial and trade policies, partly already accomplished and still more impending after the conclusion of peace, will require an entire reconstruction of the whole age-old structure of production, and every nation is anxious that when this reconstruction is effected it should leave its methods of creation of values as economical and as efficient as possible. The British Association, a body representing the best scientific forces of the British Empire, has, with this view in mind, created a number of committees, that of Fuel Economy being naturally of greatest interest to mechanical engineers. It is significant that the first thing to which the chairman of that Committee calls attention is a great need of further experimental research upon the chemical character of coal. It is rather noteworthy because it carries with it the open confession that we are still very ignorant of the nature and properties

of that material on which the world has been mainly dependent for its power since the days of Newcomen's engine.

In the next section is described a pipe line installation in Nevada. The interest of this installation lies in the fact that as it had to be protected against excessive cold during certain parts of the year, automatic devices have been installed of apparently a simple and quite efficient nature.

Attention is called to the section on Measuring Instruments, among other things to the abstract of the article on the fan dynamometer, by J. Lawrence Hodgson, of interest because it gives information on how the resisting torque, due to the blades of a fan dynamometer, varies with their shape and size with the diameter of the fan and the density of the fluid in which the blades rotate. In the same section is an abstract from a French periodical discussing the various sources of error which are apt to affect the measurement of the power developed by engines. It is shown that when the propeller rotates inside of a large casing as is usually done in power tests, the error may be as high as 20 per cent.

Several articles on flow of fluids through pipes and the vortex formation in the air will be found in the section Physics.

The Simplex valve for Mallet type of locomotives is described in the section Railway Engineering.

Aeronautics

The Characteristics of Certain Resisting Surfaces and Screws, G. H. Bryan

The paper discusses the treatment of the problem of stability of heavier than air machines by Captain Ferber by means of an orthogonal system of planes.

The present paper deals with the properties of a system of rigidly connected non-interfering surface elements moving in a resisting medium and obeying the sine law of resistance. The application of the results to the specification of the forces and couples acting on an actual aeroplane is, therefore, subject to certain limitations and in particular the surfaces of an aeroplane must partake of the character of "narrow planes gliding at small angles" in order that the results may become applicable as first approximations. The article is of a strictly mathematical nature and only some of the conclusions arrived at are reported here.

Every resisting system of the kind referred to possesses three principal axes at right angles, such that a wind blowing in the direction of one of these axes produces no component pressure at right angles to that axis. The axes may, therefore, be described as axes of no-lift, since the lift of an aeroplane represents the component pressure perpendicular to the wind velocity.

A system having one plane of symmetry may be represented by Captain Ferber's equivalent system of three orthogonal planes for all variations of pressure depending on *motions of translation* of the system relative to the resisting medium, and the same result holds good for any such system provided that motion in the direction of a principal axis produces no couple about that axis. When, however, the system has a motion of rotation in addition to one of translation, the forces and couples on it are no longer equivalent to those on a system of three orthogonal planes, and failure to realize this fact was one of the causes which led Captain Ferber to obtain incorrect conditions of lateral stability.

Selig Brodetsky has investigated the conditions under which the system may be replaced, not by *three* orthogonal planes, but by *six* surfaces occurring in pairs, each pair being perpendicular to one of the co-ordinate axes. Under certain conditions he finds that six surfaces can be reduced in number to five, four and three. Professor Bryan claims, however, that when rotations are taken into account, the representation of the system by any equivalent system of orthogonal planes is only possible in the case of *small* oscillations or other disturbances about a state of steady motion in a direction nearly coinciding with the principal axis.

The author considers next the resistance derivatives of screws.

A qualitative estimate of the magnitudes of these derivatives can be obtained by assuming the blades to be "narrow surfaces gliding at small angles," i. e., by supposing that they can be regarded as built up of non-interfering surface elements the resistance on which follows the sine law. The author discusses mathematically the expressions for these derivatives and shows, *first*, that it is possible to select the coefficients in such a manner that the machine should not tend to dip up or down in turning curves, and, *second*, by taking the turning axis to be horizontal, it would similarly be possible to choose its position and that of the screw so that the lateral rotations are not set up when the system is being steered in a vertical plane (*The Aeronautical Journal*, vol. 20, no. 77, p. 3, January-March 1916, 7 pp. *mt*).

Notes on the Dimensional Theory of Wind Tunnel Experiments, Edgar Buckingham

The purpose of the investigation has been to establish the conditions under which data obtained from tests on models may be applied to full-size originals.

In order that the results of observations on models shall be interpretable as definite statements about the behavior of the full-size original of which the model is a copy, certain requirements must be satisfied, and when they are satisfied the original and the geometrically similar model are said to be dynamically similar. The conditions for dynamical similarity are bound up with the general question of the possible forms of equations which describe relations subsisting among the physical quantities involved in physical phenomena.

If R be any force exerted by the ambient fluid on a body moving through it, R will depend on and be completely determined by the relative speed, the size, shape and attitude of the body and the mechanical properties of the fluid, and there must be a definite relation connecting these various physical quantities which can be described by an equation.

The properties of the fluid which determine its mechanical behavior are its density ρ, its viscosity μ, and its compressibility, but instead of the viscosity it is generally more convenient to use the kinematic viscosity $\nu = \mu/\rho$. Similarly, the speed, C, of sound waves in the fluid is fixed by the density and compressibility, so that conversely C and ρ fixes the compressibility, hence the properties of the fluid may be specified by stating the values of the density ρ, the kinematic viscosity ν and the acoustic speed, C, in the fluid.

The author deduces the following equation:

$$F\left(\frac{R}{\rho D^2 S^2}, \frac{DS}{\nu}, \frac{S}{C}, r', r'', \ldots\right) = O \qquad [1]$$

which is fundamental to the experimental study of hydrodynamic and aerodynamic forces acting on totally immersed bodies. In this equation D is some linear dimension of the body such as its greatest length, S is the constant velocity at which the body is moving, and r', r''.... are the ratios of a number of lengths to the particular length, D, which specify the shape of the body and its attitude, i.e., its orientation with regard to the direction of motion.

The simplification of this equation is possible when the motion is not rapid enough to cause any sensible compression in the fluid. In this event it is immaterial what the compressibility is so that S/C may be omitted from consideration and the equation reduces to

$$\frac{R}{\rho D^2 S^2} = \varphi \left(\frac{DS}{\nu}, r', r'', \ldots\right) \qquad [2]$$

It must be borne in mind that equation [2] would be entirely misleading if used in studying projectile resistances, but at the speeds which occur in aeronautics, with the exception of propeller tip speeds, the ratio S/C is a sufficiently small fraction to make legitimate an assumption that the air acts nearly like an incompressible fluid. This equation supplies the basis for an experimental investigation of the aerodynamic problems which occur in connection with aeronautics and aviation by means of reduced scale models.

The author shows that if a series of bodies of various sizes but of the same shape are presented to the wind in the same attitude, the equation which expresses the force exerted by the fluid on the body involves a certain function the nature of which will depend on the shape and attitude of the bodies but not on their size (provided the disregard of compressibility as stated above was a justifiable approximation).

The author finds further that the head resistance is proportional to the square of velocity and that in the equation which expresses it, viscosity does not appear. This is not equivalent to saying, however, that viscosity plays no part at all in the phenomena, for if viscosity did not exist there would be no eddies of finite size, no dissipation and, at a constant speed, no resistance. It means rather that the drag on the body by the fluid is due to the continual drain of energy needed to set up anew the turbulent eddying motion about the body and that when these eddies have once been created it makes no difference how fast they are dissipated by viscosity after the body has left them behind.

The writer further discusses the question of critical speed as it affects the head resistance of a body and shows that at a certain point the critical value may be reached where the ordinary expression for the relation between resistance and speed ceases to hold and the character of the fluid motion changes very rapidly though not discontinuously. The occurrence of a critical speed for a given body in a given attitude is paralleled by the occurrence of a critical attitude at a given speed. Just as the nature of the fluid motion and the law of resistance of a given body change rapidly at a certain critical range of speed so there are similar rapid changes in the motion of the forces at the critical angle of attack for a given aerofoil at a given speed.

The question of resistance of flat plates normal to the wind is discussed and the apparent irregularities in the variation of resistance as affected by D^2 are considered, the author suggesting that these variations are due to the fact that the compressibility of the fluid is not entirely negligible. Compression might occur locally in some parts of the field about the body to such an extent as to modify the flow and so affect the resistance.

The problem of dynamical similarity is stated as follows: Let us suppose that we are confronted with a problem of design which requires our knowing in advance the head resistance at a prescribed speed of some body, such as an airship, which is too large for direct experiment. How to get the desired information from experiments on a small model which can be made at a permissible cost?

From equation

$$R = \rho D^2 S^2 \varphi \left(\frac{DS}{\nu}, \frac{S}{C}\right) \qquad [3]$$

it is seen that whatever be the form of φ, if its two arguments have the same values during two different experiments on geometrically similar bodies, the value of φ itself will be the same in both experiments. This leads to the notion of "corresponding speeds" and "dynamical similarity." If we suppose that we require the resistance R of a body of size D at a speed S in a medium with the properties ρ, ν, and C and that we have a model of size D_m which can be run in a medium with the properties ρ_m, ν_m, and C_m, then we can run the model at a speed S_m such that

$$\frac{D_m S_m}{\nu_m} = \frac{DS}{\nu}, \text{ and } \frac{S_m}{C_m} = \frac{S}{C} \qquad [4]$$

Speeds which satisfy this last equation are "corresponding speeds" and when two geometrically similar bodies are run at corresponding speeds, they are "dynamically similar." On the other hand, it can be shown that geometrically similar bodies will be dynamically similar if their speeds are inversely as their linear dimensions. In some cases excessive reduction in scale might involve running the model so fast as to make the effects of compressibility no longer negligible, but if the original is to be run in air while the model can be run in water this difficulty may be avoided. In practice, however, under ordinary working conditions the resistance of aeroplanes and their separate structural elements are so nearly proportional to the square of the speed and the effects of compressibility are so small that for practical purposes φ in equation [3] may be treated as a constant (*Smithsonian Institution Report*, through *Aerial Age*, vol. 3, nos. 5 and 6, pp. 152 and 184, April 17 and 24, 1916, 4 pp. *t*).

The Wind Tunnel of the Massachusetts Institute of Technology, J. S. Hunsaker

Description of the installation of some of its equipment. The wind tunnel of the Massachusetts Institute of Technology essentially reproduces a similar installation at the National Physical Laboratory, Teddington, England, from which were obtained detailed plans and also the patterns from which the aerodynamical balance was made. From the work of the staff of the National Physical Laboratory, certain calculations applicable to wind tunnels generally have been reached, among them: (1) the suction side of a fan is fairly free from turbulence, (2) a fan made by a low pitch four-bladed propeller gives a steadier flow than the ordinary propeller fan used in ventilation, and a much steadier flow than fans of the Sirocco or centrifugal type, (3) a wind tunnel should be completely housed to avoid the effect of outside wind gusts, and (4) air from the propeller should be discharged into a large perforated box or diffuser to damp out the turbulent wake, and return the air at low velocity to the arm.

The wind tunnel proper is 16 sq. ft. in section and some 53 ft. in length. Models under test are mounted in the center of the square trunk on the vertical arm of the balance. Passing through the square trunk and past the model the air is drawn past a star-shaped longitudinal baffle into an expanding cone, the expansion of which is much larger than in the English tunnel.

The aerodynamical balance is essentially similar to that used in the National Physical Laboratory in England. It can be adusted to tilt for 1/10,000 lb. force on the model. In general, however, the precision of measurements is not so good as the sensitivity and in the end is limited by the steadiness

of the wind and the skill of the observer. The article describes the methods of alignment of the tunnel and alignment of vertical axes of the balance.

The velocity of flow in the wind tunnel is measured by a double Pitot tube calibrated at the National Physical Laboratory in England. Its disadvantage lies in the fact that it obstructs the channel, and where models are to be tested the channel should be kept entirely clear, hence the side hole method of measurement may be used and the article explains its principle. The pressure transmitted by the side plate is read on an inclined alcohol manometer on the Krell principle. The side plate and its manometer were calibrated together against the Pitot tube and a Chattock manometer (*The Technology*

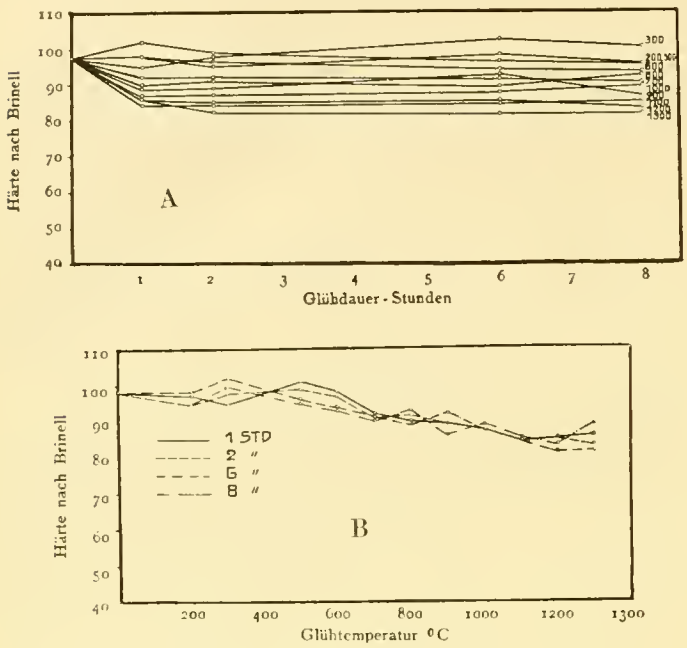

Fig. 1 Functional Relation between Hardness and Heating

Ordinates in both figures: Brinell hardness;
Abscissae in A: duration of heating in hours, in B: temperature of heating in deg. cent. In B: *Std* = hours.

Monthly and Harvard Engineering Journal, vol. 3, nos. 1 and 2, pp. 9 and 17, April and May, 1916, 8 pp. *d*).

Engineering Materials

Influence of Heat Treatment on Certain Physical Properties of Steel, A. Pomp

The article is a continuance of one abstracted in The Journal, May, 1916, page 421. In this part of the article the author presents some investigation on the hardness of mild wrought iron after annealing at various temperatures. The chief interest of the investigation lies in the fact that, as the author states, there are no published data on the hardness of this material under such conditions. It is, however, also of interest because the tensile strength and hardness of a material being approximately proportional to one another, variations of tensile strength due to heat treatment may be expected to produce concomitant variations in hardness.

H. Fay and S. Badlam have investigated the tensile strength of a low carbon steel (0.07 per cent carbon) heated in an electric muffle furnace up to temperatures of 1200 deg. cent., and have found only a very slight fall of tensile strength, viz., from 59,000 to 53,000 lb. per sq. in., at temperatures above 1100 deg. cent.

In the present test the hardness was determined by the Brinell method with a maximum pressure applied 1000 kg. (2200 lb.); diameter of the ball 5 mm. (0.196 in.); and duration of application of pressure 0.5 minutes.

The results of the Brinell test are given in Table 1 and graphically in Figs. 1A and B. Fig. A reproduces the hardness as a function of the duration of heating, the curves drawn being, therefore, lines of equal temperature, while in Fig. B hardness is represented as a function of the temperature applied, the curves being lines of equal duration of heating.

From these figures it appears that the variations of hardness with rise of temperature and increase in duration of heating up to temperatures of 600 deg cent. are only extremely slight, and do not exceed probable experimental errors. The values for hardness obtained with heating at temperatures of 700 deg cent. and up are from 5 to 10 Brinell units below those obtained with temperatures from zero to 600 deg. cent. This difference, however, is not material, and indicates only that at the higher temperatures of heating there occurs a certain, even though small, reduction of hardness,—an observation which is in accord with those previously made by Fay and Badlam.

A noteworthy fact is brought out by Fig. A, namely, that whether the duration of heating is one or eight hours, there is no material variation in the hardness of the metal.

With heating at the higher temperatures and for periods from 6 to 8 hours, a certain slight decarbonization of the materials under test could not be avoided. For example, the reduction of the carbon content in a test piece heated for 8 hours at 1200 deg. cent. amounted to 0.02 per cent. and if one considers that the total carbon content of the original material was only 0.08 per cent, the conclusion may be justified that the reduction of hardness which occurs with the rise of temperature of heating may be at least partly due to the decarbonization of the material (*Einfluss der Wärmebehandlung auf die Kerbzähigkeit, Korngrösse und Härte von kohlenstoffarmem Flusseisen*, A. Pomp, *Ferrum*, vol. 13, no. 5, p. 65, February, 1916. *eA*).

Foundry

Variable Factors in Malleable Iron Production, L. E. Gilmore

The article gives an outline showing the interdependent relationship of the various factors in malleable iron production, with some practical suggestions for the manufacture of this material.

In the production of malleable iron there are two requisites; first, the carbon of the white iron must be in chemical combination such that it is annealable; and second, the annealing must be such as will dissociate the carbon in combination as precipitated free carbon. All the variables preceding and during casting must be manipulated to attain the first mentioned condition and all the variables of the annealing operation must be regulated to produce the second requisite.

The author gives a control chart (Fig. 2) of malleable cast iron melting and annealing operations. Other variables being constant, the higher the casting temperature and the faster the rate of cooling, the greater the percentage of combined carbon. Further, the condition of the carbon is vitally influenced by the various chemical constituents of the iron, and the proper condition of combined carbon may be secured by varying percentages of silicon provided the carbon is correspondingly reduced as the silicon percentage is increased. The proper manipulation of the percentages of sulphur and man-

ganese will produce a similar effect. Finally, certain ferro-alloys have sufficient carbon to gray the white iron irrespectively of the effect of the other elements present in the alloy.

The next element is the type of furnace used, which imposes rigid limits on the chemical composition of the material. The details of construction of the furnace also determine the nature of the fuel used as well as its quality. A coke too high in ash and sulphur might make impossible the production of good malleable in a cupola. Another important factor in furnace operation is the nature and condition of the slag, as the retention or loss and the speed of elimination of certain chemical elements may be largely dependent upon the slag. The next item in furnace operation is the control of combustion, and finally, the human factor must not be lost sight of.

The author summarizes the whole subject of furnace operation in two aims, that of melting the iron in the shortest possible time at least cost, and that of producing an iron hot enough to pour the work successfully.

The next question is what mix will produce the analysis of best composition. The ideal mix is that which will produce under the conditions of furnace operation the desired composition in the melted iron as soon as the iron is hot enough for pouring. In making up the mix, besides other things, the loss or increase in each element due to furnace conditions and methods of operation must be discounted. Besides its chemical analysis, the physical condition of the scrap and pig is a variable that has an important bearing upon the use of these materials. For example, sand-coated pig requires a greater length of time for melting, and the same holds good for material in large chunks. On the other hand very small pieces of metal may be detrimental when badly rusted, as this rust must be taken care of in the slag.

The essentials of the annealing operation are, first, the maximum temperature attained; second, the length of time held above the critical temperature; and, third, the rate of cooling through the critical range. The conditions of annealing are further affected by the thickness of castings and nature of packing. The aim in the construction of the annealing furnace and application of fuel is to furnish a means for rapidly heating the castings in all parts of the oven to as nearly uniform a temperature as possible and then maintaining this temperature a suitable length of time. The variables of the annealing operation are interdependent; for instance, an increased maximum temperature and shorter holding time may accomplish the same result as a lower maximum temperature with a longer holding time. The rate of cooling through the critical range may make or mar an otherwise perfect material (*The Foundry*, vol. 44, no. 5, p. 181, May 1916, 3 pp., 1 fig. *p*).

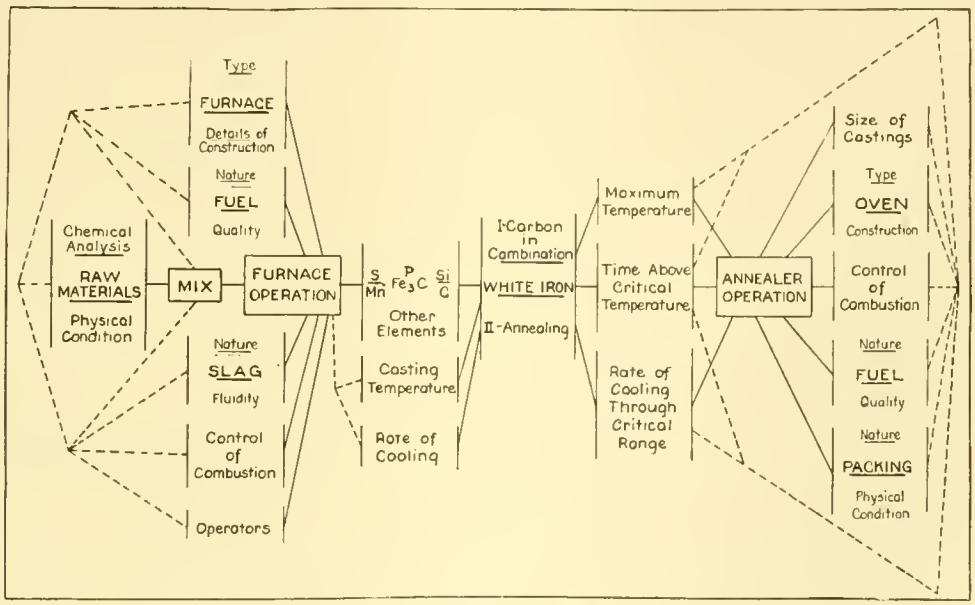

Fig. 2 Control Chart of Malleable Cast Iron Melting and Annealing Operations

Fuel and Firing

Fuel Economy, Prof. William A. Bone

In a paper before the Society of Chemical Industry, Prof. William A. Bone spoke of the work of the Fuel Economy Committee of the British Association which has been appointed to consider the subject of fuel economy from a national standpoint.

The investigations are to be conducted by a committee composed of prominent representatives of the principal industrial users of fuel as well as eminent power engineers and chemists who have made a special study of gaseous fuels and combustion. The committee has resolved itself into five sub-committees, each with its own chairman, namely, Chemical and Statistical (including the chemical nature of coal and the character of the principal British coal seams); Carbonization (including gas works, coke ovens, low temperature distillation and the utilization of products derived therefrom); Power and Steam Raising (including experiments on public power schemes); Metallurgical (Iron and Steel) and Ceramic Industries; Domestic Smoke Prevention (including problems relative to domestic heating).

The writer of the paper outlines a tentative program of the work of the committee which he as chairman considered personally advisable. He says that in the first place there is a great need of further experimental research upon the chemical character of coal about which we are still very ignorant. Concurrently with such an undertaking he advises a systematic chemical survey of the principal seams in British coal fields. He considers the use of raw coal for domestic fires, steam raising and furnace work generally, a custom which from a chemical point of view cannot be defended. He further deplores the fact that out of the 20,000,000 tons of coal carbonized in the United Kingdom for hard metallurgical coke in the year

1913, no less than 6.5 million tons were treated in bee-hive ovens involving a dead loss in values of by-products of something like £2,500,000 (*Journal of the Society of Chemical Industry*, vol. 35, no. 7, p. 389, April 15, 1916, 8 pp. [paper and discussion] *g*).

Hydraulic Engineering

Pipe-Line at the Nevada Wonder Mine, J. A. Burgess

Description of an interesting pipe line installation and the automatic devices for checking interruptions to a service carried on for certain parts of the year under exceptionally difficult conditions of weather.

The pipe line takes care of a mining and milling plant in Churchill County, Nevada, where the temperature goes at times as low as — 11 deg. fahr. The installation had to deal at first with several sources of trouble which have been gradually eliminated. Clogging of the intake by leaves was taken care of by frequently cleaning the screens and having the screen area sufficiently large. A certain amount of trouble was caused by pitting of the pipe due to an excess of alkali in the soil. A protective coating applied to the pipe at the time it was laid would have prevented this deterioration, but the coating applied by the manufacturer before shipment was partly rubbed off during transportation.

The principal source of danger is excessively cold weather. To a certain extent an increase of the rate of flow can cut out ice formed in the pipe, but at temperatures as low as 4 deg. below zero the rate of flow in the line is not sufficient to prevent the formation of ice. The only way to save the pipe in such cases is to drain the line entirely. The same remedy has to be resorted to also when the creek from which the water is taken is in danger of being completely stopped by freezing.

All of this requires an ability to know at any moment the rate of flow of water in the pipe. To do this a flow indicator was devised and placed at the intake so arranged that the rate of flow could be approximately read at any telephone receiver on the system. The details of this ticker signal apparatus are shown in Fig. 3. It consists essentially of a turbine wheel just inside of the intake end of the water main by means of which the armature of a permanent magnet is periodically removed from its poles. The interruption of the magnetic flux induces an electric impulse in a coil about the magnet. The coil is grounded at one end and attached to the telephone wire at the other and each movement of the armature produces a clicking sound in the telephone receiver that is easily heard but is not sufficiently loud to interfere with conversation. The telephone line is connected with all the company telephones so that the indicator may be heard in all offices and residences. The ticker is placed in an enclosed housing and requires no attention except occasionally a few drops of oil.

Under normal conditions the ticker sounds twenty-four times per minute. If it works faster than this it indicates either a break in the line or an open drain valve. If it sounds less than that the reduction is due to decreased flow and may be caused by several circumstances. Except in freezing weather it is apt to be caused either by air or sand in the pipe or by leaves partly clogging the screens at the intake. In very cold weather it may be caused by a shortage of water in the creek or by freezing in the pipe. Only an inspection of the intake will distinguish between these possibilities and for that pur-

TABLE 1. HARDNESS OF HEATED AND SLOWLY COOLED LOW-CARBON STEEL

Temperature of Heating, Degrees Cent./Fahr.	Duration of Heating, Hours	Brinnell Hardness	Average
		97	
		101	
		98	98
		98	
		95	
	1	99	97
		94	
	2	95	95
200/392		95	
	6	98	98
		97	
	8	99	95
		90	
	1	99	95
		91	
	2	97	98
300/572		98	
	6	105	102
		98	
	8	98	100
		102	
	1	103	102
		101	
	2	103	99
500/932		95	
	6	98	96
		93	
	8	95	95
		94	

Temperature of Heating, Degrees Cent./Fahr.	Duration of Heating, Hours	Brinell Hardness	Average
	1	102	98
		93	
	2	99	97
600/1112		95	
	6	93	94
		94	
	8	93	93
		93	
	1	92	92
		92	
	2	92	92
700/1292		91	
	6	92	91
		90	
	8	92	90
		87	
	1	90	90
		89	
	2	93	91
800/1472		88	
	6	89	89
		89	
	8	93	92
		91	
	1	89	89
		88	
	2	88	89
900/1652		90	
	6	94	92
		89	
	8	83	86
		88	

Temperature of Heating, Degrees Cent./Fahr.	Duration of Heating, Hours	Brinell Hardness	Average
	1	85	87
		88	
	2	87	87
1000/1832		87	
	6	87	87
		87	
	8	91	89
		86	
	1	84	84
		83	
	2	84	84
1100/2012		84	
	6	86	84
		81	
	8	82	85
		87	
	1	88	85
		82	
	2	85	85
1200/2192		84	
	6	83	86
		79	
	8	83	81
		83	
	1	86	83
		85	
	2	86	83
1300/2372		80	
	6	81	81
		81	
	8	82	81
		79	

pose a watchman has to be kept at the head gate during the cold weather.

Another device described in the article is a warning apparatus of simple construction installed at the delivery end of the pipe line at the storage tanks (The Nevada Wonder Pipe-Line, *Western Engineering,* vol. 7, no. 5, p. 177, May 1916, 4 pp., 4 figs. *d*).

Internal Combustion Engineering

Are Other Cycles Possible for Automobile Engines?
J. Edward Schipper

One of the effects of the fuel situation has been to cause engineers to wonder if there be not some other way than the

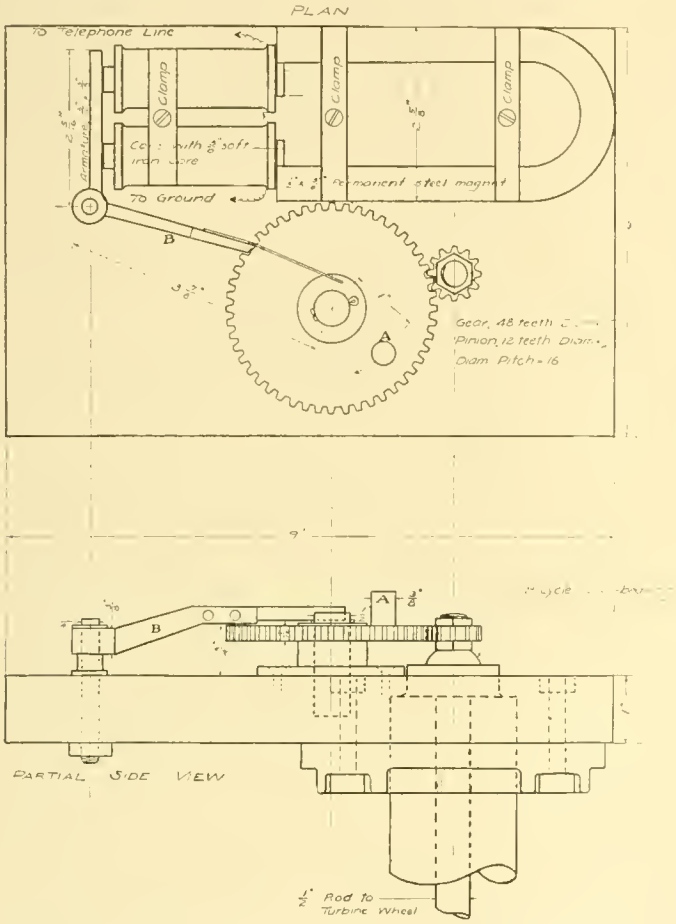

Fig. 3 Ticker Signal Apparatus for Water Pipes

Otto cycle of utilizing the heat energy in liquid fuel, especially in automobiles.

A slow combustion engine with a lower grade fuel suggests heavy, slow-moving parts not adaptable to the present day automobile. What some engineers are studying now is the constant pressure cycle, with a view to determining whether or not the conditions which hold true with the lower grades of fuel render its use commercially advantageous. While under similar conditions and with the same explosive fuel the constant volume engine is more efficient than the constant pressure, it seems possible that by carrying out the expansion line of the constant pressure type, a higher efficiency may be reached particularly at reduced throttle opening. The first thought suggested by the constant pressure engine is higher compression, which does not necessarily mean an efficiency loss because practically all of the energy necessary for compression is returned in the expansion stroke. On the other hand, such an engine necessitates a constant introduction of fuel against the maximum cylinder pressure and this in turn means a receiver capable of withstanding the higher pressures. It also means the employment of a compression pump, and the question to be determined is whether or not other gains offset this. In fact, the point for practical engineers to determine is whether or not it is possible to secure the high compression ratios in satisfactory and reliable units of the size which would allow them to be used on automobiles.

The efficiency of the present day automobile engine is extremely low. With the car running at a touring speed of 15 to 18 miles per hour and the throttle open possibly less than one-third, the thermal efficiency is somewhere around 5 per cent, which means that for every dollar's worth of fuel only five cents in power is returned. There is no doubt as to our sacrificing work at the end of the stroke by cutting off the expansion line and exhausting at high pressure. In the ordinary timing diagram the exhaust valve starts to open at fully 45 deg. before lower dead center so that the pressure will have dropped to near atmospheric by the end of the stroke. On the very high speed motors the time at which the exhaust valve starts to open is much further advanced than this and the difference of a degree or two on the timing circle is quite large when the angle between the crank and 90 deg. position is less than 45 deg.

Mention has been made recently about altering the point of cut-off of the constant volume engine as a means of holding up the thermal efficiency even when operating on partial throttle opening. This has been tried by variable cam action but has not worked out satisfactorily on account of mechanical complications. Whether or not the variable cut-off constant pressure gas engine can ever be adapted to the quick-accelerating light-weight automobile, cannot be said now. It seems very possible that the answer to the whole problem lies not in compressing the combustible mixture, but rather in compressing the air only and adding the fuel by small successive charges during the stroke. This burning charge closely parallels in many of its characteristics superheated steam. If it could be introduced into the cylinder cut-off, expanded and exhausted in much the same way as steam, it would have in many respects the advantages of the steam engine without the boiler apparatus necessary for the conversion of water into steam (*The Automobile,* vol. 34, no. 16, p. 707, April 20, 1916, 4 pp., 4 figs. *g*).

Machine Shop

Limit Gage Principles and Practical Applications,
W. H. Booth

The paper discusses the use of limit gages and tries to give a proper grasp of the purpose of their use.

The use of limit gages is essential to economical manufacturing on the interchangeable plan, especially with articles which have to be cheaply made and be entirely interchangeable. As the author points out, the limit gages are extensively used in the manufacture of munitions and a shell affords an excellent example of an article to be made as roughly as permissible and yet as good as is imperative, because, in the words of the author, "a shell is an object which in spite of its short and merry life, is used in immense numbers," and has to answer certain exact requirements.

A limit gage is not designed for the purpose of producing specially fine work, but is distinctly commercial. The term "limit" signifies the degree of departure of the work from strict accuracy permitted, and the system is based on the fact

that absolute accuracy cannot be obtained and that small departures from absolute accuracy can be worked to approximately. As absolute accuracy is very difficult and expensive to attain, practical men fix upon the amount by which any dimension may be allowed to differ from the nominal size and the piece, if properly worked to, is not so far from nominal size as the gage by which it is made. There must be no attempt to fit the piece to the "go-on" end of the gage as any such attempt increases the cost of the work needlessly and destroys the purpose of the system.

Since it is easier to vary an outside than an inside dimension, it is better to base a limit gage system on uniformity of hole than on shafts, spindles, etc., which are formed on machines like the lathe. The author discusses the matter of running fits and in this connection that of cross limits.

What makes limit gaging a success is that the parts gaged tend to average at mean sizes and by the doctrine of probability the extremes of two sets of parts do not meet.

An illustration in the article shows limit gages for various services, among them special alligator-mouthed gages and adjustable snap or caliper gages (also the Newall system). The article is apparently the first of a series (*Canadian Machinery*, vol. 15, no. 13, p. 285, March 30, 1916, 2 pp., 1 fig. *dp*).

Measuring Instruments and Measurements

Instruments for Recording Carbon Dioxide in Flue Gases, J. F. Barkley and S. B. Flagg

The paper describes a series of tests made with several different types of recorders under service and laboratory conditions, in the course of which the following details were determined: (1) The lag in recording changes of composition of a flowing gas; (2) the accuracy of each type of recorder; (3) the variable factors affecting the operation and accuracy of each type; (4) the repairs and renewals necessary; (5) the kind and amount of attention required. The purpose of the Bureau of Mines in publishing the results is to show the factors which may affect the accuracy of a carbon dioxide recorder and the manner in which the recorder should be tested.

Seven instruments were tested, three English, two American, one German and one Swiss. The paper gives a detailed description of each apparatus and results of tests obtained with it, and, further, gives useful hints as to installing the gas line and sampling pipe for any instruments (Department of the Interior, Bureau of Mines, *Bulletin 91*, Washington, 1916, 52 pages of text and an index of 2 pp., 25 figs. *eA*).

Sources of Error in Cradle Dynamometer Tests, M. Le Pen and J. Villey

The paper discusses the various sources of error which are apt to affect the measurement of the power developed by internal combustion engines on the testing stand in cradle dynamometer tests.

The principle of the measurement on the testing stand is as follows: The braking is effected by means of a fan or propeller set on the engine shaft. The engine itself is bolted to a frame which is given the freedom to oscillate about an axis parallel to the engine shaft. In order to maintain this frame in equilibrium, notwithstanding the reaction of the air on the propeller, a suitable weight P is located on a horizontal arm forming part of the frame. This arm is normal to the axis of oscillation, and the weight is at some desired distance l from the vertical plane of the axis of oscillation. If ω is the angular velocity of the propeller, the power W of the engine is determined from the formula $W = Pl\omega$. The exact formula is really $W = C\omega$ where C is the average moment *with respect to the engine shaft* of the braking forces exerted by the air, and the equation $C = Pl$, implicitly admitted as being the expression of equilibrium of the testing stand, may be actually lacking in exactness for various reasons.

In the first place, other forces may intervene in addition to those considered in this equation. These forces are the reactions of the exhaust with respect to the external air. Unless they are symmetrically distributed with respect to the vertical plane of the axis of oscillation, or unless their directions are in a plane passing through this axis, these reactions will affect the equilibrium, especially if the test is carried on with a tractor propeller utilized to cool the engine. On the other hand, even assuming that all precautions have been taken to eliminate the action of these parasite forces and their average moment with respect to the axis of oscillation, there still remains another source of error which may become very important in certain cases.

One must not confuse the axis of the engine shaft and the axis of oscillation of the testing stand, practical considerations making it advisable to locate one above the other at a distance h usually of several decimeters (1 dm = 3.937 in.). If the braking forces exerted by the air were at all times reduced to a couple, their average moment would have the same value C with respect to the axis of oscillation as with respect to the engine shaft which is parallel to it. If it is not so, they have to be equivalent at every instant to a couple, the average moment of which will still be equal to C plus the force f which has its point of application on the engine shaft. This force, f, which in magnitude and direction is a function of the azimuth ωt of the propeller, does not affect the consumption of the power produced because its point of application remains fixed, but by being transmitted by the shaft to the bearings, it affects the equilibrium of the testing stand by its moment $fh \cos \omega t$, in the same manner as a weight affects its lever. The average geometrical value of its moment is determined by a lack of symmetry of the resistances encountered by the blades of the propeller all along their circular trajectory.

The proximity of the ground and the testing stand itself create inequalities of this character which would be, strictly speaking, absent only in the case when all the obstacles encountered by the streams of air had a symmetry of revolution around the axis of the propeller. If the propeller rotates inside a large casing constituting in this way an air turbine (this arrangement is sometimes used to avoid the throwing around of oil) the lack of symmetry becomes particularly pronounced because in its materially uniform circular movement each blade when it approaches the tangential exhaust port attacks the surrounding air with a relatively decreasing velocity. Measurements carried out under such conditions on engines from 80 to 110 h.p. have shown errors as high as 20 per cent. Air currents also cause difficulties of this kind. The author states, however, that all these sources of error may be reduced to very small amounts by certain manipulations and that this method of testing agents is a very convenient process of particular advantage where it is desirable to determine from the oscillations obtained the slightest instantaneous variations of the motor couple (*Sur la mesure de la puissance des moteurs au banc-balance*, Maurice Le Pen and Jean Villey, *Comptes rendus des séances de l'Académie des Sciences*, vol. 162, no. 11, p. 383, March 13, 1916, 2 pp. *eA*).

The Fan Dynamometer, J. Lawrence Hodgson

The article gives data of some tests made with a fan dynamometer. The investigation was undertaken in order to obtain a more accurate knowledge as to how the resisting torque due to the blades of a fan dynamometer varies with their shape and size, with the diameter of the fan and with the density of the fluid in which the blades rotate.

The blades used were ½ in., 1 in. and 2 in. square and ½ in., 1 in. and 2 in. in diameter. All the tests were carried out with the fan rotating in water with the exception of one test which was taken with the fan rotating in air. In the water tests the vertical spindle carrying the fan was rotated in a covered tank of still water 20 ft. square and 5 ft. deep. The plane of the fan arm was 10 in. below the surface of the water, the coefficient of resistance having been found to be constant for the largest diameter of fan used for all depths of immersion greater than 6 in.

A separate series of tests established the fact that the torque due to the arms (μ_a) was given with sufficient accuracy by the formula:

$$\mu_a = 0.35 \times 10^{-8} \sigma N^2 r_a^4 t W \qquad [1]$$

See notation at end of the abstract.

The resisting torque (μ_b) due to the blades alone was assumed to be given by the equation

$$\mu_b = K N^2 r^3 S^2 W \qquad [2]$$

where K is coefficient which varies with the ratio r/s and with the shape of the blades which is constant for similar fans. The article reproduces a curve showing the value of K plotted against the ratio r/s as determined from the experimental results. When r/s is large, K approaches a constant value for each shape of blade. The limiting value of K for the circular blades is about 0.7854 times less than that for the square blades. A point is shown on the curve of values of K obtained from 1 in. blades in air which agrees almost exactly with the value of K obtained by rotating the same blades in water.

The horsepower absorbed by any fan can be readily calculated by substituting the value of K as given by the curves in the original article in the equations tabulated at the end of the abstract.

In fan brake dynamometers, it is customary to make the value of r/s small. The present tests show, however, that the experimental accuracy is least for the small values of r/s. Further the shape of the K-r/s curve is more easily defined from the theoretical considerations when the ratio of r/s is large and for these reasons, it is preferable to design the fans so that the ratio r/s is not less than 2.5 or 3. Round blades are to be preferred because they require no special care in alinement when being fitted to the arms.

The author gives further the following equations

$$\mu = \mu_a + \mu_b \qquad [3]$$

where μ_a and μ_b are given respectively by equations [1] and [2] above.

$$\text{H.P.} = \frac{\mu N}{63{,}000} \qquad [4]$$

In all of these equations the following notations is used:

W = Density of the fluid in which the fan rotates in lb. per cu. ft.
= 62.33 for water at 50 deg. fahr.
= 2.7 p/T for air.
μ_a = Torque due to arms alone in inch-pounds.
μ_b = Torque due to blades alone in inch-pounds.
μ = Total torque in inch-pounds.
N = Rev. per min.
S = Length of side of square blade, or diameter of circular blade in inches.
r = External radius of the fan in inches.
r_a = Radius of arms in inches.
t = Thickness of arms in inches.
K = Coefficient depending upon the value of r/s and the shape of the blade.
σ = Coefficient depending on the section of the arms.

(*The Aeronautical Journal*, vol. 20, no. 77, p. 20, January-March, 1916, 6 pp., 4 figs. *e*).

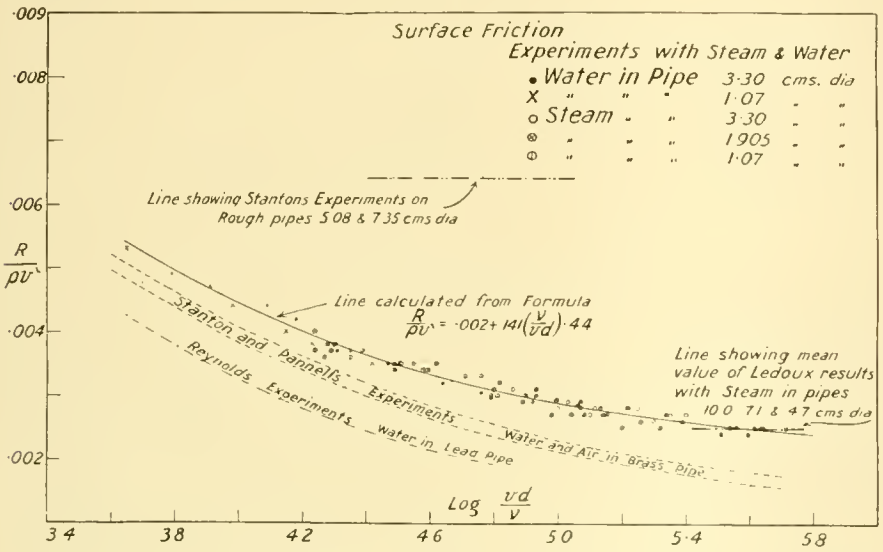

Fig. 4 Curves of Surface Friction from Experiments with Steam and Water

Physics

Surface Friction: Experiments with Steam and Water in Pipes, Cecil H. Lander

The article discusses various equations for the flow of steam and water in pipes with particular reference to phenomena of surface friction, and describes some new experiments in the same line.

The article gives a brief summary of previous work, especially that of Osborne Reynolds, Lord Rayleigh, and Stanton and Pannell (compare The Journal, 1915, p. 242).

The object of the present research was in the first place to obtain accurate data for the resistance to flow in pipes conveying steam and other vapors with a view to checking the accuracy with which Osborne Reynolds' dimensional law of flow could be made to represent the friction of these fluids. Next, the work was extended to ranges over which this law did not accurately apply and the results have been used to extend the work of Stanton and Pannell to the case of friction between steam and metal surfaces.

In the present research, the moving fluid was in most cases either dry saturated or slightly wet steam and the experimental range of velocities extended usually to 4000 cm per sec., although in a few experiments a velocity of 6000 cm per sec.

was obtained. Higher speeds were not used since extremely high speeds such as can be obtained easily with steam are associated with superheating down the pipe, making the reduction of the results obtained too complicated and unreliable. In all pipes the values of the resistance corresponding to low velocities of steam were obtained, although the work becomes increasingly difficult as the velocity decreases, and eventually reliable results become impossible owing to the serious effects of condensation.

The author describes in detail the experimental apparatus used. Steam was obtained from a large separator and a 300 h.p. Babcock & Wilcox boiler, the large capacity of the boiler rendering it easy to maintain steady pressure conditions during the trials.

The methods of reduction of the experimental values are reported in the original article in detail, the results themselves being given in the form of tables and for comparison with other experimentals in the form of curves.

In Fig. 4 the values of all the experimental results have been plotted with $R/\rho v^2$ as ordinates and log vd/ν as abscissae, where R = resistance per unit area, ρ = density of the fluid, v = velocity, d = diameter of the pipe, ν = kinematical viscosity of the fluid, all in metric units. The mean results as calculated from the formulae of Ledoux for their steam velocity are also plotted on the diagram. The resistance for the artificially roughened pipes in the Stanton experiments (horizontal line) is expressed by the formula

$$R = 4.6\, v_c^2 \times 10^{-6}$$

where v_c is the velocity at the axis. From the curve in Stanton's paper giving the radial distribution of velocity in these pipes the value of the mean velocity has been determined, the horizontal line representing the resistance in the screwed pipes reduced to terms of the mean velocity.

The author's points for steam lie with fair accuracy upon a smooth curve slightly higher than Stanton and Pannell's boundary curves for low values of vd/ν, but become proportionally higher for large values.

The author calls attention to the fact that, as has been shown by Lees, Stanton and Pannell's experiments can be represented with considerable accuracy by an expression of form

$$R = \rho v^2 \left\{ a + b\, (\nu/vd)^n \right\}$$

the constants for air and water in smooth brass pipes being $a = 0.0009$, $b = 0.0763$, and $n = 0.35$. With a modification of the constants the same expression represents the mean of the present experiments, the line in the figure having been plotted using the following values: $a = 0.002$, $b = 0.141$, and $n = 0.44$. From the general trend of their curves for high values of vd/ν, Stanton and Pannell predicted a limit beyond which the resistance would be constant and hence independent of vd/ν. This is equivalent to the resistance varying as the square of the velocity. In the steam curves owing probably to the pipes being slightly rougher, this limit would appear to be reached earlier, and the ultimate value of $R/\rho v^2$ to be considerably above that corresponding to the smooth pipes used by Stanton and Pannell. Beyond a certain limiting value of vd/ν the resistance varies as the velocity squared becomes less with the roughness of the pipe surface, until for a very rough surface the resistance varies as the velocity squared for values only exceeding by small amounts that corresponding to the critical velocity.

The present experiments are of interest because further direct evidence has been produced to demonstrate the truth of the dimensional law which has been now shown experimentally to extend to the case of saturated vapors. Further, in the present experiments a range of pressures was used for the first time extending from about 15 in. of vacuum to 200 lb. per sq. in. above atmosphere. The law of dynamical similarity has been further demonstrated. The present work, by demonstrating the truth of the law as applied to the flow of steam and water in pipes, opens up the possibility of inferring the resistance of complicated steam passages such as are met with in turbines, by tests and models according to the law of similarity. (*Proceedings of the Royal Society*, Series A, vol. 92, no. A. 640, p. 337, April 1, 1916. 17 pp., 3 figs. *etA*).

The Compressibility of Natural Gas at High Pressures

G. A. Burrell and I. W. Robertson

The paper treats of an investigation of the compressibility, at pressures up to 35.5 atmospheres, of the natural gas supplied to the city of Pittsburgh. The results are of practical value because in measuring natural gas it is the practice to assume that the product of the pressure by the volume is a constant.

Actually it has been found that the compressibility of the natural gas of Pittsburgh differs from that of an ideal gas, the deviation amounting to as much as 15 per cent at a pressure of 35.5 atmospheres. In actual practice natural gas is sometimes measured at pressures as high as 600 lb. per sq. in. and many millions of cubic feet are measured at pressures of 20 to 30 atmospheres (300 to 450 lb. per sq. in.). Hence errors of great magnitude are introduced into the measurement. For instance, suppose 100,000,000 cu. ft. of gas a day is measured at 25.6 atmospheres: according to the data found in this investigation, the gas is 11 per cent more compressible at this pressure than at atmospheric pressure, or each day 11,000,000 more cubic feet of gas is measured than is supposed. If no correction is applied in measuring the gas a distributing company that buys natural gas at high pressure and sells it at low pressure may sell much more gas than it pays for. (Department of the Interior, Bureau of Mines. *Technical Paper 131*, Petroleum Technology 31, Washington, 1916. 12 pp., 2 figs. *e*).

Turbulent Flow in Pipes and Channels.

Professor L. V. King

The present publication is apparently only part of a paper covering the subject of turbulence, and presents only the theory relating to the establishment of turbulent flow in pipes and channels.

The author gives at the outset an historical survey of the development of the theory of viscosity, and from this proceeds to a consideration of actual flow under comparatively simple experimental conditions. He treats first of a steady flow between two parellel planes and gives an equation for total flow per unit breadth and mean velocity of flow. He considers this simple case of steady motion of interest as it has been made the starting point of some theoretical treatments of the stability of laminar motion, but as far as he is aware no experiments have been carried out with a disposition of apparatus corresponding to this solution. He himself has, however, made a detailed experimental investigation of gaseous viscosity by an actual examination of the gradients of velocities themselves; and the results obtained indicate, as he states, the somewhat surprising conclusion that the parabolic distribution calculated from the usual viscous fluid theory is only a rough approximation to a much more complicated state of affairs.

He investigates next the steady motion in a pipe of *circular cross-section*, and again gives equations for the total flow and mean velocity over the cross-section. It is generally assumed that the theory of viscosity obtains its application to reality, in that the equation for the total flow obtained in this case contains all the laws found experimentally by Poiseuille, but actually a marked deviation is easily noticeable as soon as the diameters exceed a few millimeters, even at velocities considerably below what is taken to represent the critical velocity.

Shearing motion between parallel planes is dealt with next, the author giving an equation for the sheering stress F between the planes per unit area. The measure of F obtained experimentally, as well as the fundamental law of viscosity in these circumstances, relates, however, to the traction between the fluid and a solid boundary, and not to the traction between layers of fluid. The measurement is here extremely difficult, and Gilchrist points out that small discrepancies of about 0.5 of one per cent exist in the determination of the coefficient of viscosity by the various methods employed, and that these cannot be attributed to errors of experiments. Hitherto direct measurements of velocity-gradients did not appear to have been carried out, although this is now possible owing to the development of the linear hot-wire anemometer described in a previous paper by the author.

The second part of the paper treats of the stability of laminar flow in pipes and channels. It likewise opens with an historical and critical survey of the theoretical development, with particular reference to the work of Osborne Reynolds, Kelvin and Rayleigh. The author calls attention to the fact that the most recent theoretical treatment of the subject (by Hopf) tends to confirm the original conclusions as to the stability of a state of steady motion. The unsatisfactory state of knowledge on the subject at the present time is, however, clearly shown from a table of theoretical and experimental values of Reynolds' Constant K, which differ very markedly both from each other and from the generally accepted values obtained for liquids and gases.

The experimental data, however, refer to tubes of circular cross-section, whereas the simplest theoretical case refers to the flow of liquid between parallel planes on which no observations have hitherto been available. The author has, though, made a series of experiments on the flow of air, and the results indicate the existence of hitherto unsuspected conditions of laminar flow at extremely low velocities, as well as at velocities considerably higher than those which are taken to represent, according to usual interpretation, critical velocities.

By means of the linear hot-wire anemometer, developed by the author, the velocity distribution over the cross-section of a two-dimensional channel (section 0.45 cm. by 5.08 cm.) was measured for various pressure differences. Owing to the high resolving power of the instrument, it was found possible to measure velocities at intervals of 0.05 mm. over the cross-section, and in this way a velocity distribution curve representing as many as 100 observations could be obtained, the pressure difference under which the flow took place being maintained constant to 1-10 of one per cent. Even at velocities considerably below the critical velocity as usually defined, the distribution curves showed consistent and interesting deviations from the parabolic form demanded by theory: (1) The experimental curves develop well marked "humps" in the neighborhood of planes midway between those dividing the distance between the walls of the channel in equidistant parts. With increasing velocities the number of "humps" increases. (2) Although the general shape of the distribution curve is parabolic, the maximum falls very much below that demanded by the theoretical viscous flow theory, as though some factor contributed to increase very materially the ordinary kinetic theory coefficient of viscosity denoted below μ_o.

The writer explains both of the above peculiarities by the influence of transverse stationary sound waves. When the flow of a *compressible* fluid takes place under conditions which permit of the establishment of stationary modes of sound vibrations, the wave front is refracted by the velocity-gradients which exist in the medium. As rate of change of momentum is propagated along a sound ray, it follows that under these conditions the existence of compressional vibrations will result in a component of rate of change of momentum proportional to the velocity-gradient being transferred across an element of surface parallel to the direction of the flow; hence the author gives for viscosity a formula, $\mu = \mu_o + \mu_s$, defining it as the sum of μ_o, the ordinary viscosity of the kinetic theory plus μ_s, a "quasi-viscosity" due to the existence of compressional waves and proportional to the *intensity* of the wave motion. The writer believes that in the combination of compressional vibrations and shearing motion lies the origin of a vortex rotation which, as the amplitudes of the sound vibrations and their frequencies increase, may ultimately result in the formation of *finite* vortex filaments resulting finally in "turbulent motion" in the generally accepted sense of the word. The fact that the factor of compressibility appears to be of considerable importance in determining the conditions of the stability of laminar flow causes the various theoretical treatments, including those of Reynolds, Rayleigh, Kelvin, Sharpe and Orr, to lose a certain part of their value.

The author believes that still another factor may play a part in determining the instability of flow in tubes and channels, and that is the *determinateness* of the various transverse modes of sound vibrations which may be set up. In a two-dimensional channel (or channel of elongated cross-section), the nodes and loops are extremely determinate in position, and one should expect laminar flow to persist to very high velocities. In the case of a tube of circular cross-section, however, some of the normal transverse modes (e.g. those having diameters as nodes) are indeterminate in position, and in an actual case would be determined by accidental inequalities on the interior of the tube or by slight departures from circular form. It would appear that in such cases Reynolds' criterion of "sinuous" motion would be decided not by instability of steady flow in the usual sense, but by the appearance of the first transverse mode having a diametrial node. Relatively to the fluid these indeterminate modes would tend to twist around, resulting in a state of affairs which, if continued long enough, would, in spite of the stabilizing effect of viscosity, result in a complete destruction of conditions of steady flow. While the effect of the material of the tube on the critical velocity observed by several experimenters is probably largely due to the degree of mechanical finish of the interior surface, it would also seem that the acoustic properties of the walls of the tube or channel may not be without influence on the velocity gradients in the immediate neighborhood of the boundary. In the flow in tubes of large diameter, the velocity distribution over a particular cross-section is nearly always unsymmetrical with respect to the axis. (*The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*, vol. 31, no. 184, p. 322, April 1916, 17 pp., *et al.*)

Vibratory Whirls in Air, Sylvain Périssé

This paper refers to experiments on and the theory of the formation of vibratory vortices in air due to the motion of a blade wheel with the blades disposed longitudinally through the axis of rotation. It presents the conclusions reached by Charles Weyher and was read before the French Society of Civil Engineers on February 21.

For the purpose of the first series of experiments a wheel was used with longitudinal blades 0.30 m (11.8 in.) long and 0.05 m (1.96 in.) in diameter. The paper describes in detail the efforts by which the air streams were made visible.

It has been found that two kinds of air streams are formed —first, helicoidal centrifugal spires, going from the equator of the rotating sphere to each pole; and second, helicoidal centripetal spires going from the poles to the equator. When a blade wheel having a vertical axis was made to rotate over a reservoir containing water, heated so that it would evolve steam, it was found that the steam lines which rotate, at first slowly, around the vertical axis, suddenly assemble in spirals which form a spindle-shaped body with very clear delineations; this steam figure remains in equlibrium under the influence of the centrifugal forces which try to force it downwards on one hand and the centripetal forces which attract it towards the equator of the rotating wheel on the other. In this way the author has succeeded in reproducing a tornado at sea or a cyclone with its peculiar calm region in the center, and fall of barometric pressure.

A second series of experiments similar to those described above were carried out with a rotating sphere made up of circular blades located along the axis of the sphere and together forming a rigid structure capable of rotating about its axis. Here again the same air whirls were observed, asymmetrical with respect to the plane of the equator; the same intercrossing streams of air were found present, and centrifugal streams increasing in diameter but progressively decreasing in velocity while the centripetal streams increased in velocity as they came nearer to the central vacuum.

When the author placed on a needle point a little blade wheel and brought it near the rotating sphere, he found that this test wheel rotated in one direction on one side of the plane of the equator of the sphere, and in an opposite direction on the other side.

A very interesting series of experiments were tried out by means of a rotating sphere located in a room 4 to 5 m (13 to 16 ft.) on each side and 4 m (13 ft.) high. The room was devoid of furniture, and protected from air currents from the outside; the sphere was placed half way to the ceiling on an axis inclined 45 degrees and rigidly held as shown in Figure 5. The following facts have been observed:

All the bodies which happen to be in the room appear to be connected to the moving sphere through the intermediary of air streams which ceaselessly leave the sphere and return to it, these streams twisting around all these objects and acting on them by forming local whirls about them.

The figure shows a number of little balloons; all of them are in little groups and each is vibrating all the time. When the balloons are forced apart, they rapidly come back again, but if the group of balloons is brought up closely to the rotating sphere, they separate to all sides as shown by *A*. The four balloons left on the floor fall against each other without touching one another; inside of the external whirl there are several local whirls and the four little balloons behave like the molecules of a single body.

The paper describes in some detail experiments made to determine the properties of attraction and repulsion of aerial whirls as compared with magnetic bodies. It was found that when two blade wheels rotate in opposite directions, they tend to attract one another because with the air streams of the whirl form moving in the same direction between the blade wheels the air tends to become rarified between them and the external pressure makes them come together. If, however, the wheels rotate in the same direction, the opposite takes place and the tendency is for the wheels to repel one another. Next, a little fan wheel was located on an extension of the axis of a vertical wheel and arranged in such a manner that it should be either free or not free to rotate about its axis, but have all

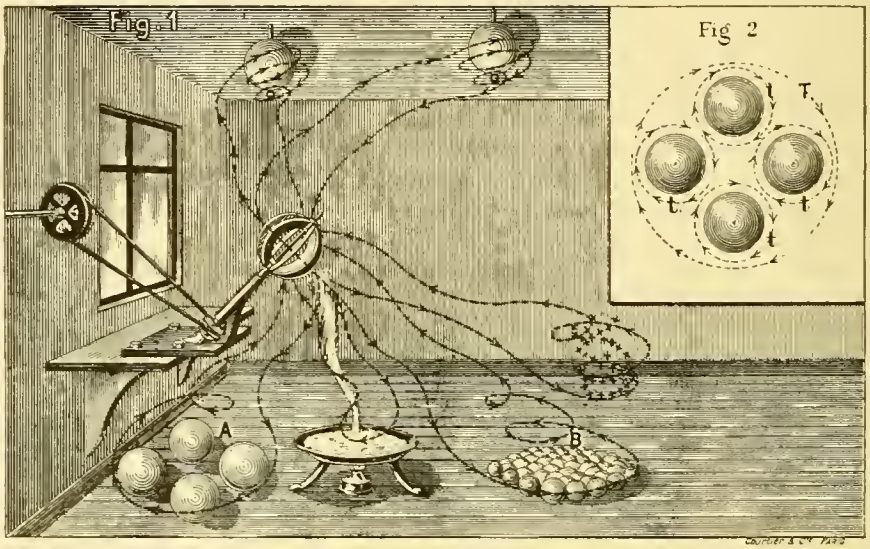

Fig. 5 Arrangement for Producing Vorticular Motion in Air

the time a freedom of vertical displacement. It was found that, notwithstanding the attraction due to the centripetal streams of the whirl formed by the rotation of the main wheel, the little wheel will not move if it be prevented from rotating, but as soon as it has restored its liberty to rotate about its axis, it will be attracted into the vortex; it will glide until it reaches the top of its axis and will acquire a motion of rotation which it will indefinitely conserve, even becoming in itself a center of a vortex capable of attracting other small wheels of a similar nature.

If fine sawdust be thrown on a screen located about a horizontal wheel, one can seen how the particles form an ellipse about the center of the wheel and one can see further how they are repelled from the center towards the two poles. In the course of time this ellipse gradually transforms into a circle about the same center.

From these experiments Weyher comes to the conclusion that the mechanism of vorticular motion is as follows: The gas does not simply rotate in a single path about its axis, but is broken up into an infinite number of streams separate from one another; each of these streams describes helicoidal screw paths, some having a right hand and some a left hand thread, some centripetal and others centrifugal. This amounts to

saying that the air streams cross one another on through the space, moving in opposite directions and mutually avoiding each other, but producing as many vibrations as there are crossings of paths, i. e., an infinite number.

An interesting experiment makes it appear very likely that this particular mechanism actually applies to the case of ether. If an air whirl be made to act upon very fine dust or very light flakes of some material and if proper arrangements have been made, one can see how, through the inter-crossing of the centripetal and centrifugal spires, the dust or flakes form a transparent ellipsoid. This ellipsoid may even be held suspended by maintaining an equilibrium between the suction (attraction) of the rotating sphere with its vertical axis on one hand and the force of gravity which tries to pull it down on the other hand.

The paper contains also interesting applications of the work of Weyher to the problems of physics of ether and wireless telegraphy made by the author of the paper, Sylvain Périssé (*Les tourbillons vibratoires*, F. D. *Le Génie Civil*, vol. 68, no. 15, p. 233, April 8, 1916, 3 pp., 4 figs. *e*).

Railway Engineering

The Simplex System of Compounding for Mallet Locomotives

While the use of intercepting valves on Mallet locomotives for the purpose of enabling the application of high-pressure steam in the low-pressure cylinders when necessary has been quite extensive, the gain that has accrued through this means has so far been discounted through the expense and trouble involved with the complicated forms of valves that have been used for this purpose.

For some time of late the Mallet type of engine gave way almost exclusively to the heavy simple non-articulated engines of the Mikado and Santa Fé types. At the present time it appears to be regaining a portion of its former favor and bids fair to be returned on a larger scale than before with the satisfactory solution of the intercepting valve difficulty.

Recently 15 Mallet type engines built by the Lima Locomotive Corporation for the Western Maryland R.R. have been provided with a form of valve which is not only claimed to meet the requirements of the conditions spoken of above but is unique in other respects. It has a novel form and position of the valve which serves both of the high pressure cylinders alike and which, being placed in a detachable casing in a transverse position on the front face of the high pressure cylinder saddle, makes possible the casting of both high pressure cylinders from the same pattern. The valve proper has but

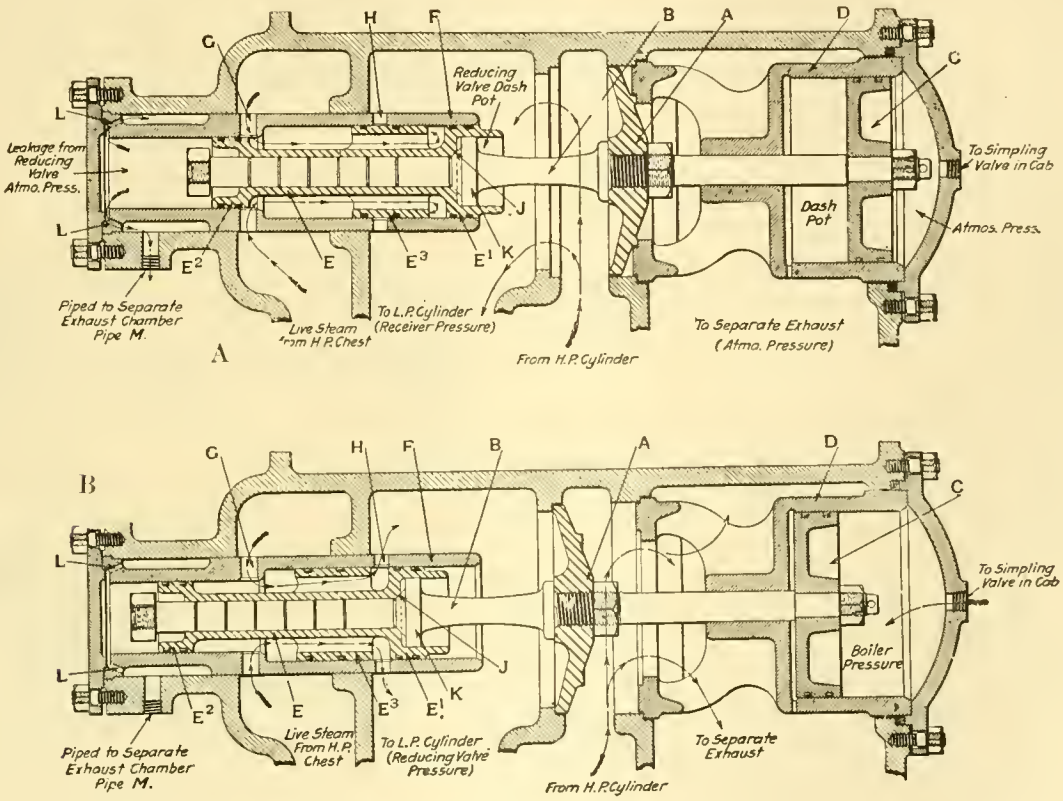

Fig. 6 Simplex Compounding System for Mallet Locomotives: A, Intercepting Valve in Compound Position; B, Intercepting Valve in Simple Position

two moving parts, the construction is entirely symmetrical about the axis of the valve stem and the valve itself is fully accessible. Figs. 6A and B illustrate the design of the valve. The casing is divided into four separate chambers called respectively, beginning at the right-hand side of the engine (left side of drawing) live steam chamber, receiver chamber, high pressure exhaust passage, and separate exhaust chamber. In the operation of the valve, steam from the high pressure cylinders is controlled by the main valve *A* causing it to flow into the receiver chamber and thence to the low pressure cylinders when the engine is working compound, Fig. A, and into the separate exhaust chamber when working simple, Fig. B. Stem *B* of the intercepting valve on which the main valve *A* is secured is continued toward the left-hand side of the engine and has fixed to this end a piston *C* which works in a cylinder *D*. Live steam is admitted to the outer face of this piston when the simpling valve in the cab is placed in "simple" po-

sition forcing the main valve into the position shown by Fig. B. The inner face of this piston, by trapping air between it and the bottom of the cylinder *D*, forms a dash pot to prevent slamming. On the continuation of the stem *B* is a sliding reducing valve *E* which has a movement of 1½ in. on the stem as well as a traverse of 3 in. with the main valve. This valve has three functions. *First*, to admit steam at reduced pressure to the receiver chamber when working simple, *second*, to force the main valve into compound position when pressure is released from the piston *C* and, *third*, to cut off the supply of live steam to the receiver when working compound.

The separate exhaust pipe which is a feature of this system communicates with an annular removable nozzle surrounding the main nozzle, the control of the power exerted by the high pressure cylinders when working simple being effected by the changing of this nozzle. The smaller the nozzle the greater the back pressure acting on the high pressure pistons. This reacts on the reducing valve and adds power to the low pressure cylinders. Thus a perfect balance of work in simple operation is effected. Back pressure in the separate exhaust chamber cannot unbalance the intercepting valve or cause it to flutter.

An interesting feature is that it is possible to operate the engine, though with reduced tonnage, even with the intercepting valve removed. Hence an intercepting valve failure cannot cause a complete engine failure which is of importance when breaking in new power (*Railway Review*, vol. 58, no. 18, p. 603, April 29, 1916, 3 pp., 4 figs. *d*).

Steam Engineering

Steam Plant Efficiency, Vernon Smith

A paper of interest, in that it gives expression to the modern views of steam power engineers in England.

The author first takes up the competition between Lancashire and water-tube boilers. He holds that where large units are desirable and where ground space is of consequence, the water-tube boiler is the proper type to install; but apart from this there does not appear to be much to justify the claim that it is a better and more efficient boiler than the Lancashire unless it be that steam can be raised quicker with a water-tube boiler when being set to work after cleaning than with the Lancashire boiler. The efficiency of an ordinary hand-fired Lancashire boiler is lower than that of a water-tube boiler working under similar conditions, but in plants equipped with suitable accessories the efficiencies are nearly the same.

Two serious impediments regarding the Lancashire boiler as it is generally worked today which seriously affect its efficiency are improper design of the furnace and the fact that it is too often hand-fired.

In order that the furnace may be efficient, the temperature should be as high as possible, and sufficient time must be allowed for complete combustion, hence a large combustion chamber built with the best quality fire-brick. On the other hand, when the gases pass from the grate of a Lancashire boiler they immediately impinge on a comparatively cold plate which reduces their temperature and allows the unburned carbon to pass off as soot. This is particularly the case where cross-tubes are fitted in the boiler flues, and with the Galloway boiler it is almost impossible to obtain smokeless results.

Too much attention has been paid to the back end of Lancashire boilers at the expense of the furnace, and reduction in temperature of the flue gases at the flue exit appear to be the chief aim. Economizers, air heaters and superheaters have been installed, and when the gases, prior to entering the chimney, have been reduced to about 350 deg. fahr., it has been considered that maximum efficiency has been attained. This is not the case so long as the old-fashioned furnace is used, which can be considered to a degree to act as a condenser. Just because the temperature of the gases at the rear of the so-called "economic type boiler" is as low as those at the rear of a water-tube boiler, the former does not become essentially as efficient as the latter because the range of temperature itself is not so great.

As an improvement on this type of boiler the author suggests a system of proper baffling which even might be carried into the side flues and operated by means of levers (Fig. 7). Of course, this baffling, the purpose of which is to increase the velocity of the gases, will require a more powerful draft.

The boiler proper should be used only as an evaporator to impart only latent heat to the steam. Live steam feed-water heaters do contribute to an increase of efficiency, in addition to which they tend to increase the evaporative capacity of the boiler and in the case of Lancashire boilers tend to

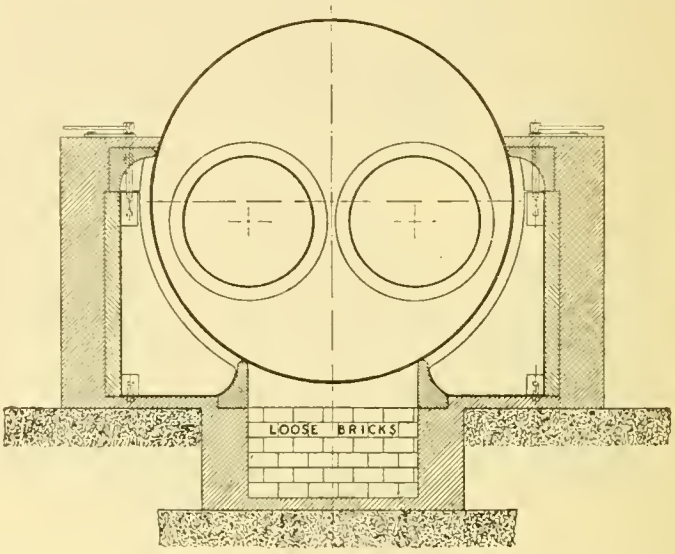

Fig. 7 Suggested Design for Increasing Velocity of the Gases

minimize the strains, owing to the large body of water this type of boiler carries.

The author appears to be in favor of the "dished end" type of construction and, among other illustrations, shows a dished end Lancashire boiler fitted with corrugated flues throughout (Cp. bibliography at end of the Engineering Survey section). (*Proceedings of the South Wales Institute of Engineers*, vol. 32, no. 1, p. 45, March 21, 1916, 39 pp., 13 figs. *dp*).

Thermodynamics

The Functional Relation Between the Thomson-Joule Effect for Air, and Pressure and Temperature, at Pressures up to 150 Atmospheres, and Temperatures from −55 Deg. to +250 Deg. Cent., F. Noell.

An extensive experimental investigation of the subject. The author comes to the conclusion that the experiments carried out do fully establish the manner in which the Thomson-Joule effect is affected by pressure and temperature within the limits indicated above.

From the results of the experiments he derives the following formula:

$$\Delta = \frac{dT}{dp} = \frac{A_1 - A_2 p}{T} + \frac{B_1 - B_2 p}{T^2} + \frac{C_1 - C_2 p}{T^3} + D_1 - D_2 p$$

where Δ is the cooling for a fall of pressure of 1 atmosphere;

T absolute temperature of the gases on the high-pressure side;

p arithmetic means of pressures on the high and low pressure sides;

dp difference in pressure between the high and low pressure sides;

dT corresponding differences in temperature;

$A_1, A_2, B_1, B_2, C_1, C_2, D_1, D_2$ are constants.

He found that at all temperatures there occurs a linear decrease of the cooling effect with the pressure.

By means of integration was found from the experimental results the fall of temperature due to the action of throttling from a high initial pressure down to one atmosphere; this fall of pressure was calculated and plotted as a curve; the latter shows that the proportionality between the cooling and the pressure difference does not hold at low temperatures and high pressures.

From the observed cooling effect was determined, for the region of tests, the specific heat of air c_p, this having been done on the basis of the values of Scheel and Heuse, and Swann for one atmosphere (*Die Abhängigkeit des Thomson-Joule Effektes für Luft von Druck und Temperatur bei Drücken bis 150 at und Temperaturen von — 55° bis + 250° C.*, Dr.-Ing. Friedrich Noell, *Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, no. 184, Berlin, 1916, 46 pp., 17 figs. *e*).

Varia

Oxy-Acetylene Welding of Steel Tubing, Charles C. Lynde

Description of a process of manufacture of steel tubing by means of oxy-acetylene welding as used by the Elyria Iron & Steel Company, of Cleveland.

The tubing produced ranges from ½ in. up to 4 in., and is made mostly from cold-rolled steel of from 16 to 20 gage. The steel passes from the reels through a felt cleaner which takes off grit and other substances that might injure the rolls or interfere with the welding of the steel. The strip first enters the forming rolls, where it is formed into the shape of a very extended W. The following rolls push down the middle hump of the W and force the steel into a circular tube with sufficient spring to make it retain its position even without the aid of the forming vise used for welding. As the tube springs into shape after the final rolling it is seized by the revolving jaws of the welding vise and held in shape while passing under the welding torch and until the weld sets. The torch consists of five flames arranged to operate axially on the tube passing under it and generate sufficient heat to weld the tube thoroughly. The dies which hold the stock during its transit under the blow-pipe are made in sections and revolve around a water-cooled chamber which prevents the heat absorbed from the oxy-acetylene flame from heating them to a temperature high enough to draw the temper. These jaw sections fit closely around the tube except for a slight notch around the top where access is given for the flame. After emerging from the welding dies the tube is drawn under a grinder to remove any burrs resulting from the welding operation and then enters the sizing rolls and thence into the pulling dies. These dies are held up against the tubing by pressure plates and are driven through the pulleys or sheaves over which they pass. The tubing is next passed through a set of straightening rolls and then cut to length by an automatic cutting device which rides with the tube during the time required for the cutting operation.

Each machine is provided with individual motor drive and a small countershaft system is carried over the various moving sections to give the most direct drive possible without interference by the belts.

For tubes slightly less in diameter than can be produced by the welding machine the tubing is fed through a swaging machine and the diameter brought to the proper limits. The swaging machine is water cooled.

A drainage pit is located under the welding machine to serve as a catch basin for the water used for cooling the welding dies and for clearing away the grinding grit. Under the swaging machines there is also a ditch cut through the floor for the installation of a drain for the cooling water. The article points out in this connection the advantage of wood block flooring. The machine was first set up without any provision for cooling the swaging dies. Experience, however, demonstrated the need for cooling, so a row of blocks was pulled up to give a buried drain without the trouble and work which would have been attendant upon putting such a break in a concrete floor. The blocks removed can be cut down and replaced over the pipe without interfering with the shop work and without leaving an obstruction to trucking.

The article describes in considerable detail the method used for generating and storing the gas (*Steel and Iron*, April 1916, p. 109, 6 pp., 4 figs. *d*).

CHARTS

Relation of Pressure, Ram Diameter and Tonnage in Hydraulic Presses, W. B. Updegraff. *Machinery*, vol. 22, no. 9, May, 1916. Chart showing relation between ram diameter, hydraulic pressure, and total pressure on ram of hydraulic jacks and presses.

Chart showing thickness of ram for various pressures per square inch and diameters. Compressive stress, 14,000 lb. per square inch.

Chart showing relation between pressure per square inch on ram diameter of ram and full load capacity of press.

Chart showing thickness of cylinder for various pressures per square inch and diameters. Tensile stress, 7000 lb. per square inch.

Circular Slide Rule for Shaft Designers, Edwin S. Oberndorf. *Machinery*, vol. 22, no. 9, May, 1916, 1 p., 4 figs. Chart with condensed instructions for its use.

The Discharge from Vertical Pipes, C. E. Grunsky. *Western Engineering*, vol. 7, no. 5, May, 1916. Chart for computing discharge of water from vertical pipes when given, rise of water at the center above top of pipe.

SELECTED TITLES OF ENGINEERING ARTICLES

AERONAUTICS

The Society of British Aircraft Constructors. Aeronautics, vol. 10, no. 131, April 19, 1916, 1½ pp.

The Wind Tunnel of the Massachusetts Institute of Technology, J. S. Hunsaker. Technology Monthly, April and May, 1916.

Berichte der Deutschen Versuchsanstalt für Luftfahrt, Wilhelm Hoff. Zeitschrift für Flugtechnik und Motorluftschiffahrt, vol. 7, nos. 5 and 6, March 25, 1916, 8½ pp., 17 figs.
Data on the tests of aeroplane wings.

Inherent Controllability of Aeroplanes, Leonard Bairstow. The Aeronautical Journal, vol. 20, no. 77, Jan.-March, 1916, 9 pp.

The Characteristics of Certain Resisting Surfaces and Screws, G. H. Bryan. The Aeronautical Journal, vol. 20, no. 77, Jan.-March, 1916, 7 pp.

The 300 H. P. Green Engine. Aeronautics, vol. 10, no. 128, March 29, 1916, 1 p., illustrated.

Note on the Dimensional Theory of Wind Tunnel Experiments, Edgar Buckingham. Aerial Age, vol. 3, no. 6, April 24, 1916, 1½ pp.

Aero Engine Design. Aeronautics, vol. 10, no. 128, March 29, 1916, 4 pp., illustrated.

AIR MACHINERY

Die Pressluftwerkzeuge der Maschinenfabrik Oberschöneweide, Ernst Preger. Der praktische Maschinen-Konstrukteur, vol. 49, no. 7/8, Feb. 24, 1916, 3½ pp., 10 figs.
Some German compressed-air tools.

Commercial Methods of Testing Air Compressors.—I, II. Addison. Mechanical World, vol. 59, no. 1531, May 5, 1916, ¾ p.

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CONVEYING AND HOISTING

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MECHANICAL EQUIPMENT USED IN THE PORT OF NEW ORLEANS

By WILLIAM VON PHUL, NEW ORLEANS, LA.

Member of the Society

THE Port of New Orleans, about 100 miles from the Gulf of Mexico, extends for nearly fifteen miles along the Mississippi River, from Westwego and Southport above the city on the northwest, to Chalmette five miles below Canal Street. The principal commercial development is on the east bank of the river, but on the west bank, opposite the city, there are wharves and landings at Westwego, Harvey's Canal, Gretna, Algiers and McLellanville.

By the peculiar laws in force, there can be no private ownership of river front property to the exclusion of the public. The State of Louisiana owns outright the larger part of the commercial front and has the right to use all of it, appropriating any land needed and expropriating any improvements on such property if placed under grants of the proper authorities.

Until 1901 the facilities of the Port of New Orleans were

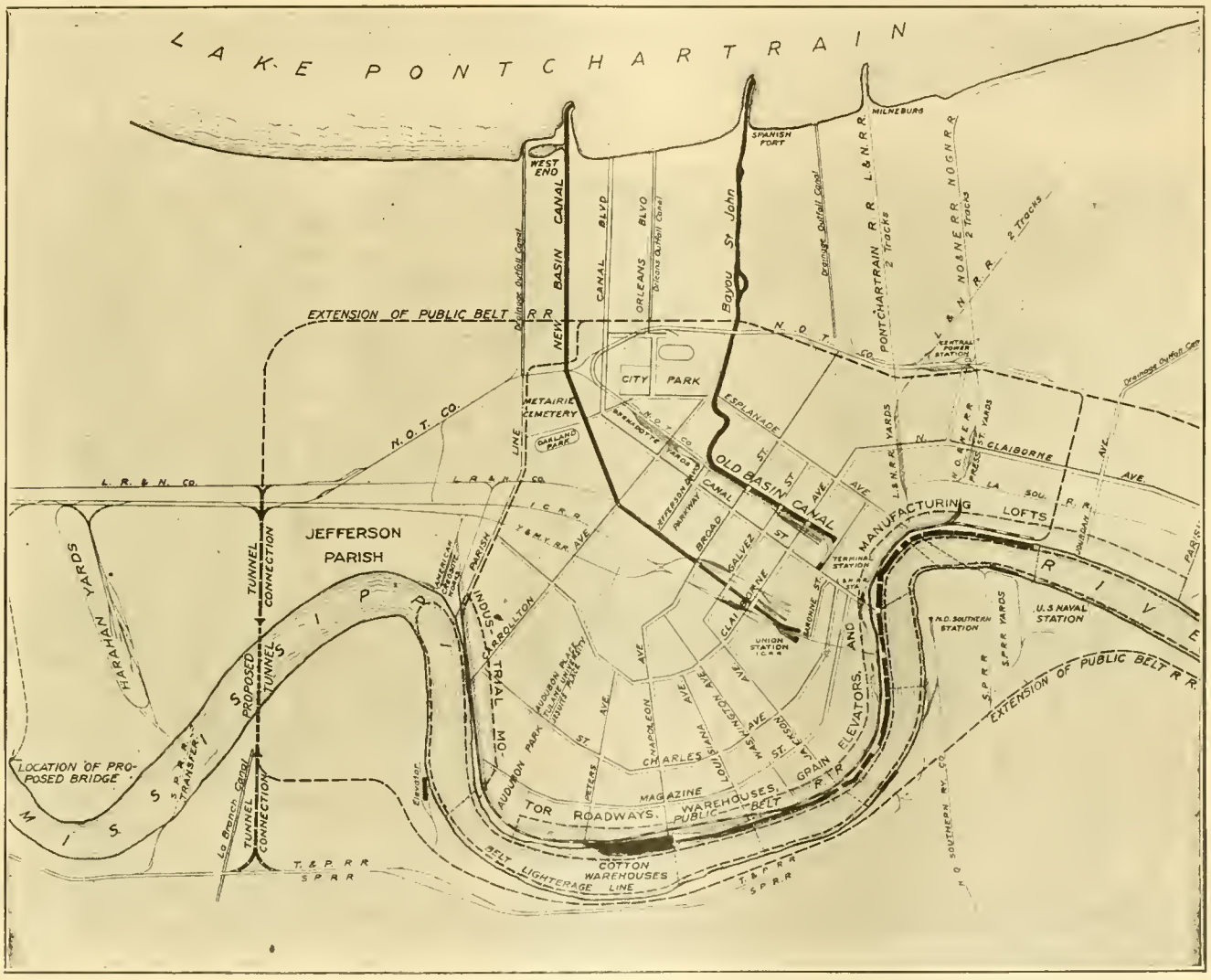

FIG. 1 PORT OF NEW ORLEANS, SHOWING COÖRDINATION OF RAIL AND WATER TRANSPORTATION

In volume of business, combining imports and exports, New Orleans is the second port of the United States, being exceeded only by New York. New Orleans is described as a two-way port, the import and export tonnage being practically equal, a condition obviously very favorable to the transportation interests. The value of the combined imports and exports averages about $1,000,000 per day.

provided by private interests through lease of the river frontage. The wharves were temporary structures; there were no sheds; there was no machinery, and charges assessed against vessels were considered excessive.

The Board of Commissioners of the Port of New Orleans was created by the Legislature in 1896 and in 1901 secured control of the river front.

The first Board which took charge of the facilities in 1901 was somewhat handicapped through having no other available funds than revenues produced by charges upon shipping.

Presented at the Spring Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New Orleans, La., April, 1916. Pamphlet copies without discussion may be obtained; price 15 cents to members, 30 cents to non-members.

FIG. 2 BANANA UNLOADERS, PAULINE STREET WHARF

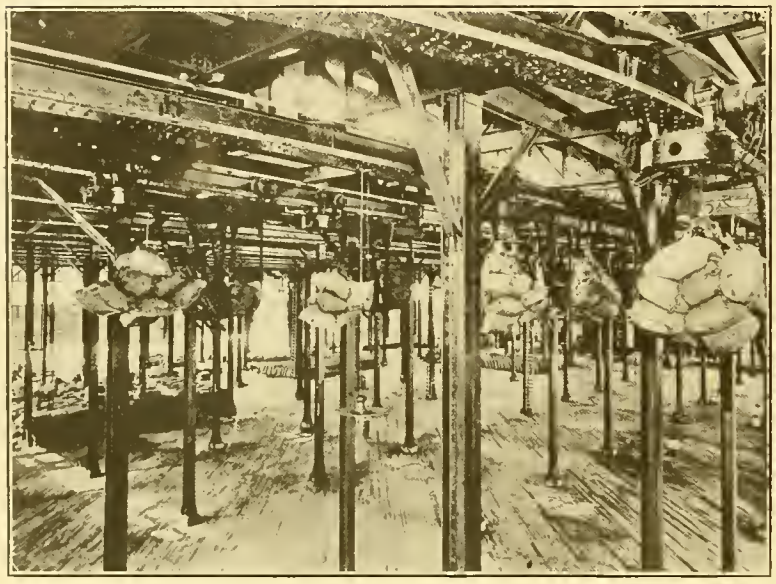

FIG. 3 TELPHERS IN CHALMETTE SUGAR REFINERY

FIG. 4 PORTABLE UNLOADER AND CONVEYOR

After a few years, however, the Legislature authorized the Board to issue bonds, and, with the proceeds of these bonds, wharves and sheds were constructed. In 1914 other bonds were issued for the construction of a Public Cotton Warehouse, and in 1915 for a Public Grain Elevator; and financial arrangements were made which will permit the prompt execution of further improvements, as adopted.

On account of this lack of funds in the early years, the facilities first constructed consisted solely of wharves for landings. The construction a few years later included closed sheds, and the more recent projects include, in addition, switch tracks generally on the wharf front, paved roadways along the rear of the wharves connecting with the city streets and mechanical devices suited to the purpose of the wharf. It is planned to rebuild promptly a large part of the existing wharf system, including in the rebuilding the additional facilities mentioned.

The river front of New Orleans is now administered by two State Boards: (1) The Board of Commissioners of the Orleans Levee District, which is empowered to acquire land and to build protective levees; (2) The Board of Commissioners of the Port of New Orleans, which has jurisdiction over the port and prescribes rules for operating vessels and controls the commercial use of the port facilities.

The wharves are served by the Public Belt Railroad, owned by the City of New Orleans and operated through the Public Belt Railroad Commission. The Belt Railroad connects with all railroads reaching the city and switches cars to and from the wharves and industries at a flat rate of two dollars per car. The Belt Railroad Commission was created in 1904 and began work in 1905, since which time construction has been carried on continuously.

The river is from one-half to three-quarters of a mile in width, and the depth within ten feet of the wharves ranges from 70 to 30 ft. Unloading can be done in midstream, but most of the vessels land broadside along the wharves, which extend out from 50 to 100 ft. from the bank. Easy access to this whole wharfage front is afforded by city streets and by railroad tracks in the rear of and upon the wharves. The levees for flood protection are very wide in the commercial district, and slope back so gradually as to be hardly noticeable. They serve the purpose of marginal streets along the water front, the wharves being built at the elevation of the levees and out beyond them.

While the developed river front is about 15 miles long there are 41.4 miles of river frontage under the control of the Port Commission. The developed harbor has a water area in excess of eleven square miles. A plan of the harbor, showing the coördination of rail and water transportation, is shown in Fig. 1.

The satisfactory design and construction of wharves and buildings on the banks of the river are made more difficult by the wide range of the water level, amounting to about 21 ft., and by the current and large amount of silt borne by the water.

The wide range of level, in particular, complicates

the design of machines for transferring cargo between wharves and vessels, involving special arrangements for adjusting the ends of conveyors and for adjusting overhead booms without fouling the rigging and wireless equipment of ships.

MECHANICAL EQUIPMENT

The mechanical equipment which has been developed in New Orleans is widely scattered through the harbor and includes several installations of special interest relating to the important industries of the port.

BANANA UNLOADERS

Banana importations at New Orleans exceed those at any other port, amounting for the year ended June 30, 1914, to 16,583,000 bunches, or equivalent to an average of 320,000 bunches per week.

The handling of this business by mechanical devices has been developed until practically all of the bananas are now unloaded by machines.

The design of this machine is complicated by the necessity for providing for a wide range of water level and for ships of various dimensions. The machine consists of a steel A-frame structure traveling lengthwise of the wharf on two rails about 21 ft. centers and carrying a structural steel main boom about 50 ft. in length, stepped about 20 ft. above the dock level.

On this boom, at a distance of about 30 ft. from the heel, is stepped an auxiliary boom twenty or more feet in length, from the end of which is swung the vertical leg of the conveyor. These two booms afford almost any desired combination of vertical and horizontal adjustment, while at the same time the main boom is sufficiently short to clear the stays and wireless rigging of the ships.

These booms and the framework carry the conveyor proper, consisting of two endless chains spaced about 5 ft. apart and running over pairs of sprockets at the foot and head of the conveyor frame, at the pivot points of auxiliary and main booms and at additional points at the discharge end of the unloader.

The distance between chains is maintained by pipe spreaders and through bolts spaced about 3 ft. centers, attached to which is a 4 ft. canvas belt, with sufficient slack between each pair of spreaders to hold a bunch of bananas when the chain is moving vertically.

Upon reaching the point of discharge the bunch is forced out of the pocket by a roller behind the belt and drops upon a short horizontal conveyor, from which the bunches are picked up by hand, inspected, sorted and loaded in cars, or disposed of locally.

The entire machine is driven through gearing and clutches by one 15-h.p. motor. The capacity of each machine is upward of 2,600 bunches per hour.

Three groups of these unloaders, consisting of 10 units, are owned by the Dock Board, the total investment being about $90,000. The most recent installa-

Fig. 5 Typical Coal Storage Plant

Fig. 6 Typical Floating Coal Elevator

Fig. 7 Car Ferry Incline

tion is at the Pauline Street wharf, and consists of four machines costing approximately $37,500. This installation is shown in Fig. 2. The section of the wharf on which the machines operate is of pile and timber construction, with steel shed, about 360 ft. by 260 ft. As the area is covered, rain does not interrupt the discharging of cargo. The wharf is served by eight transverse spur tracks accommodating five cars each; and as one ship may carry 40,000 to 45,000 bunches or about 120 carloads, the entire track capacity may be filled and moved three times in less than a day's time. The cost to the Dock Board of this wharf with its shed and tracks was about $1.40 per square foot. In the rear of the wharf the Public Belt Railroad has yard capacity for 200 additional cars.

The Board of Commissioners makes a charge for the use of the banana conveyors of ¼ cent per bunch, which considerably exceeds the cost of operation, maintenance and interest charges.

TELPHER SYSTEM CHALMETTE SUGAR REFINERY

New Orleans receives large quantities of raw sugar from Cuba, Porto Rico and local production districts. The American Sugar Refining Company alone receives over 300,000 tons per annum at its large Chalmette refinery, just below the city.

This plant has a well equipped telpher system for receiving, storing and delivering raw sugar. This system operates between a wharf about 80 ft. by 800 ft. paralleling the river, and a storeroom about 250 ft. by 260 ft. located inside of the levee at a distance of about 200 ft. in the clear from the wharf.

The wharf is a pile and timber structure below the floor level and of heavy steel construction above, the shed covering the inshore 60 ft., while the outer 20 ft. is open.

The storeroom is of heavy steel construction, with columns set on piles and double hardwood floor laid on packed sand bed. The column spacing on the wharf is approximately 20 ft. both ways, while in the storeroom the spacing is about 20 ft. by 25 ft. Both structures are enclosed with galvanized iron, and the two are connected by four elevated runways, for the telpher system, which are also entirely enclosed. The arrangement of the telphers in the storeroom is shown in Fig. 3.

The track system for the telphers is divided into two sections, each consisting of a loop on the wharf and four loops in the storeroom. The telphers can be operated selectively over any of the loops of a section by means of a transfer or switch which connects the tracks, as desired. The two track sections can be inter-connected by a special transfer or switch on the wharf. The long wharf loop is equipped with a transfer or switch cutting off a large part of the run when ships are unloading at suitable points.

The telpher equipment consists of 25 machines; each has a capacity of seven bags of sugar weighing about 330 lb. each, or about one long ton, and is equipped with two travel motors of 6 h.p. each, on a swivel truck, and one hoist motor of 5 h.p. The telphers travel 700 ft. per min., which enables the telpher to pick up its load, make a round trip to the storeroom, discharge therein and be on the wharf ready for another trip within five minutes.

The storeroom has a maximum capacity for storing sugar of about 370,000 bags or 52,500 tons, each panel between four columns containing approximately 2500 bags when tiered 28 bags high.

Sugar arriving by boat is practically all in bags. The bags are unloaded from barges or boats by three small electric derricks on the outer face of the wharf, and from ships by the ships' tackle, in both cases being deposited on the uncovered portion of the wharf. The bags are then placed on trucks in lots of two or three and trucked to a portion of the wharf which is in reach of the telphers, in the case of imported sugar, passing over the Government scales on the way. On this floor the bags are sampled and weighed for settlement with the seller, again made up in slings, and transported by the telpher to the storeroom and there tiered as already described.

When sugar is to be used, the same telphers remove the bags from the tiers and deposit them at the shore end of the storeroom, where they are sampled and weighed for controlling the manufacturing process. At this point the sugar is removed from the bags and is carried by bucket elevators to the refinery.

The estimated capacity of this telpherage system, as outlined, is 3000 tons per working day of ten hours.

An auxiliary storage system consists of two smaller sheds located at the lower side of the main storage shed and served by an electric industrial railway which crosses under the telpher runs, where the loads are received by the cars. The tiering in these sheds is done by portable stackers.

Eight spur tracks provide facilities for bringing in or reshipping sugar by rail.

CONVEYORS FOR UNLOADING STEAMBOATS

The very low freeboard of the river steamboats and the comparatively great height of the wharves have made it difficult to move cargo from the boats to the wharves by hand. Machines have been developed for this work and a number of such machines have been used.

At present machines are in use on the steamboat wharf located just below Canal Street, the commercial center of the City. This wharf is about 1400 ft. long and has the usual shed. The machines are placed at intervals of about 200 ft.

Fig. 8 Texas & Pacific Railroad Co.'s Elevators A and B

and consist of escalators about 50 ft. long by 3½ ft. wide, made up of a trussed timber frame fitted with a slat conveyor on which dogs for engaging the truck axles are spaced at about 5-ft. centers. The outer end of the conveyor is suspended by slings and counterbalance from a pile and timber head-frame. The conveyors were originally operated by small steam engines bolted to the framing, with boilers alongside, but these engines have now been replaced by 10 h.p. electric motors.

CONVEYORS FOR UNLOADING COASTWISE STEAMSHIPS

For loading and unloading cargo from the side ports of their steamers, the Southern Pacific Company or Morgan Line use hinged conveyor gangways. The most recent installation is at the St. Louis Street wharf and consists of three sets of gangways, each set consisting of one single and two double units about 15 ft. in width by 75 ft. in length. The double units permit of simultaneous handling from side ports and deck.

Each unit consists of a decked truss span supported by three steel trusses about 6 ft. deep, properly cross-braced. A width of about 5 ft. at one side of each unit is occupied by a slat conveyor set in flush with the decking and operated through gearing by a 15 h.p. motor, located under the gangway at the inner end.

At the outer end is a substantial structural steel frame resting on the edge of the wharf, and supporting the sheaves for counterbalance weights and hoisting gear. The gangway is raised and lowered by wire rope operating through double blocks and winding on a drum which is driven through spur and worm gearing by a motor.

In one set of these gangways 3-h.p. motors are used for hoisting, but the motion was found to be too slow and in the second and third sets installed later, and of heavier construction, 10-h.p. motors are used.

The wharf area served by these machines is about 204,000 sq. ft., with steel sheds over the full length of 1887 ft., assigned to this Company. In the year ended June 30, 1914, about 625,000 tons of miscellaneous freight crossed this wharf, or the equivalent of an average of 330 short tons per lineal foot per year.

PORTABLE UNLOADERS AND CONVEYORS

As a substitute for the conveyors just described for use on wharves not equipped with machines, there are several installations of portable sectional conveyors. These conveyors are also used to move cargo from the edge of the wharf to storage in the sheds and for stacking. One such unloader and conveyor, which has a maximum capacity of 1 ton per minute, is shown in Fig. 4.

The conveyor is made up of a number of sections, supported and connected by platforms, some of which carry the power units. The power is distributed over two, and in the case of the heavier machine, over three electric motors, instead of driving the entire equipment by one motor. With the assistance of a battery crane truck, one or two men can connect or disconnect all the sections and place them on the ground ready for moving in a few minutes, and when disconnected the whole equipment can then be drawn from place to place by motor trucks.

These conveyors have been in successful use, handling a variety of materials, particularly coffee, rice, sugar, cement, etc., in bags, coils of wire, boxes, miscellaneous packages and one of the larger machines has handled cotton bales.

COAL HANDLING EQUIPMENT

The coal companies, the transportation interests and some large consumers have established coal handling plants of some interest.

The Alabama & New Orleans Transportation Co. has a coal storage plant at Violet, just below the city on the Lake Borgne Canal near its junction with the river. The plant consists of three towers movable along tracks parallel to the canal. These towers span railroad tracks and with an extension boom reach barges in the canal and storage piles on shore.

In connection with this storage plant, the company operates barges for delivering coal in the harbor and a self-propelled steel bunkering barge of the hopper type, driven by a kerosene oil engine. The handling mechanism consists of a conveyor in the hull of the barge taking coal from the main hoppers and discharging it into the boot of a bucket elevator which in turn delivers the coal to a conveyor boom discharging on the vessel alongside.

The New Orleans Coal Company, which carries on a general bunkering business, has a shore plant for loading its barges which consists of tracks which cross a platform scale and a hopper. Below the mouth of the hopper is an electrically driven belt conveyor discharging into a barge; this barge, together with the bunkering elevator is taken by a tug to the ship which is to be coaled.

The elevator is mounted on a barge and consists of a skip raised in guides by a drum hoist, the skip receiving coal from a hopper fed by a revolving derrick equipped with a clam shell bucket. The skip hoists the coal and discharges into hinged spouts leading to the coaling hatches of the ships.

The Monongahela River Coal & Coke Company operates

Fig. 9 Illinois Central Railroad Co.'s Elevators D and E

floating coaling plants similar in general design to the elevator described above.

The Illinois Central Railroad has installed at Harahan, immediately above the city, a plant of 300 tons hourly capacity for transferring coal from cars to barges. Cars loaded with coal are placed in a double track gravity yard of about twenty cars capacity. The cars pass over and discharge the coal into a concrete hopper under the tracks. The hopper and tracks are covered by a frame shed. From the hopper the coal is carried by a 36-in. belt conveyor through a gallery for about 150 ft. to a 50-ft. adjustable boom which is suspended from a gallows frame and extends over the barges. The plant is driven by electricity, separate motors operating the belt, the boom hoist and a winch for shifting the barges. The feed to the belt is regulated by an oscillating plate feeding device. The coal is distributed across the barge by an adjustable discharge chute on the end of the boom. Two men operate the plant, one handling the cars and one the conveyor.

The New Orleans Railway & Light Company has installed on the wharf at the foot of Race Street, opposite their central station, a plant of 200 tons hourly capacity, for unloading coal from barges and delivering it across the shed and roadway to the storage pile.

The wharf end consists of a heavy steel tower resting on four spread columns and supporting a mast and boom with bucket and a hopper. The boom swings in a vertical plane only and slopes down and toward the river. Traveling on the boom is a two-yard clam shell bucket delivering coal into the hopper. This hopper discharges into small cars which are then weighed and hauled by cable over an elevated runway and dumped on the storage pile. The inshore end has not been completed as yet.

The U. S. Naval Station, on the west bank of the river, includes a coaling plant which is designed to take coal from barges or colliers and store it, delivering it again as desired into ships' bunkers.

This plant consists of a steel and concrete storage house with elevated bins and steel wharf structure which is also provided with bins and surmounted by a moving tower carrying a clam shell bucket. The two structures are connected across the levee by a covered conveyor gallery.

In storing, coal is transferred from the vessel by a 2-ton clam shell bucket to the center hopper on wharf. The coal is then spouted to the main conveyor which carries it along the conveyor monitor of the storage house and, by means of adjustable trips, distributes it in the bins.

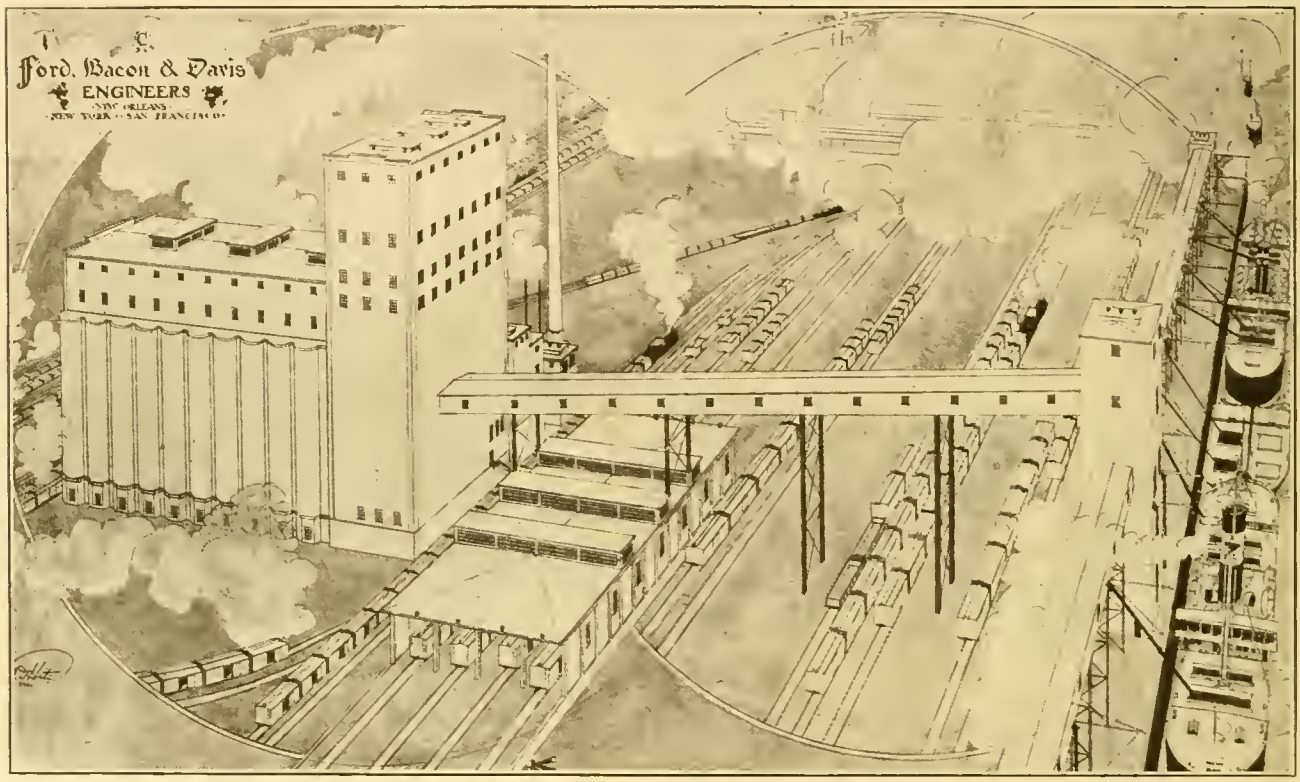

Fig. 10 Design of the Public Grain Elevator

For bunkering a ship, the coal is either spouted from these bins direct into a filler at the rear of the storage house or into small cars running under the bins and delivering to the filler. The filler discharges on the main conveyor which carries the coal to the wharf and dumps it on a smaller conveyor running lengthwise of the wharf and discharging into the wharf bins or hoppers from which the ship is bunkered direct by means of chutes.

All conveyors are of the suspended bucket type and are provided with automatic weighing devices.

The wharf hoppers are fitted with small auxiliary hoppers near the tops, to which the chutes may be attached and used for bunkering in high water periods.

The storage capacity of this plant is 3000 tons. The capacity of the wharf bins is 750 tons. The hoist motor is 125 h.p.; the conveyor monitor motor 75 h.p.; the main conveyor 40 h.p.; the breaker motor 30 h.p., and the trolley motor 15 h.p.

The American Sugar Refining Company is now installing at the Chalmette refinery a small coal plant of about 70 tons hourly capacity for receiving coal from barges and delivering it into the track hoppers of the present boiler house.

The plant consists of a wharf 36 ft. by 204 ft. paralleling

the river, and on the wharf runs an electric locomotive crane fitted with a two-yard clam shell bucket and operated by an alternating current motor of about 100 h.p.

This crane lifts the coal from the open barge and deposits it in an elevated dock-storage hopper of 170 tons capacity. This hopper automatically delivers the coal to a conveyor belt by means of beaded flight feeders, actuated by a 3-h.p. motor. This conveyor, operated by a 10-h.p. motor, leads over the levee and across the road to a transfer bin of 130 tons capacity. From the transfer bin the coal is dumped into special 50-ton steel cars with hopper bottoms standing on a platform scale. Two cars at opposite points on an endless cable are hauled on a track with automatic turnout between the scale and the boiler house track hoppers.

Fig. 5 shows a typical coal storage plant, and Fig. 6 a floating coal elevator. The total capacity of the storage plant illustrated is 750 tons per hour; the hoisting engine is 35 h.p. and the trolley engine 20 h.p. The clam shell is 2-ton size.

Fig. 11 Traveling Electric Crane in Public Cotton Warehouses

CAR FERRY INCLINES

On account of the variation in the river level, car inclines with adjustable tracks are required for delivering cars to the lighters or ferries. The West Side roads have four sets of inclines, the most recent installations being for the Texas & Pacific R. R., near the trans-Mississippi Terminal, and for the Southern Pacific Company at Harahan. Such an incline is shown in Fig. 7.

GRAIN ELEVATORS

There are in service seven grain elevators of standard frame construction, all owned by railroad companies, except one small elevator privately owned. The large elevators include:

Texas & Pacific:

Elevator A	350,000 bu. capacity storage
Elevator B	1,000,000 bu. capacity storage

Illinois Central:

Elevator C	350,000 bu. capacity storage
Elevator D	1,000,000 bu. capacity storage
Elevator E	1,500,000 bu. capacity storage

N. O. Terminal Co.:

Chalmette Elevator	500,000 bu. capacity storage

These elevators, except the Illinois Central Railroad local elevator C, which is assigned to local use, are all of the usual frame type, receiving grain from cars, storing it and delivering it through dock galleries on board vessels at the wharves.

The Texas & Pacific Railroad Co.'s elevators A and B are shown in Fig. 8, and the Illinois Central R. R. elevators D and E in Fig. 9.

In addition to these elevators, there are at present under construction, a reinforced concrete elevator of 200,000 bu. storage capacity, privately owned, and the Public Grain Elevator.

The Public Grain Elevator is being constructed by the Board of Commissioners of the Port of New Orleans, and is of modern type of reinforced concrete. This elevator will have a storage capacity of 1,000,000 bushels and will include some unusual features, being specially designed for rapid handling, conditioning and blending of grain. The design of this elevator is shown in Fig. 10.

It will be noted that the design provides unusual facility in the receiving of grain secured by the three distributing belts and their equipment of Mayo spouts over tank storage. The additional height required for this special equipment has been taken advantage of in providing also flexibility in distribution spouting in the workhouse, which materially increases the speed of operation.

Fig. 12 Automatic Grapple Above Cotton Bale

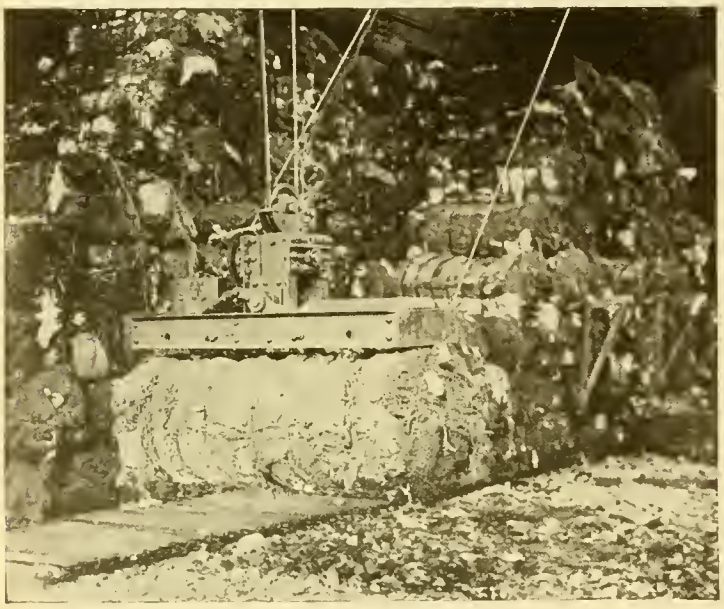

Fig. 13 Automatic Grapple Holding Bale

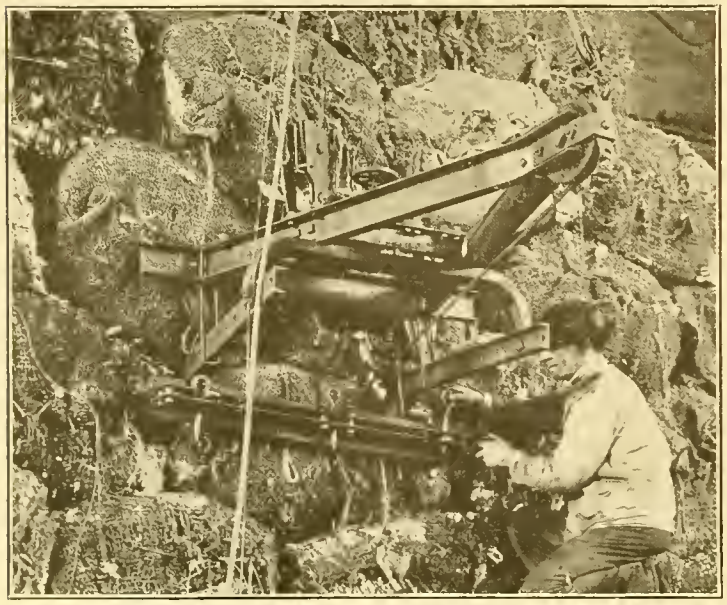

Fig. 14 Cotton Bale Puller in Position

The height of the basement permits an unusual amount of the tank storage reaching each of the four shipping belts greatly facilitating the blending or mixing of grain. In addition the work house includes the necessary equipment of cross-conveyor belts, etc.

The drying plant is a distinct feature: besides having 2000 bu. drying capacity per hour, the building provides deposit space above the drier for a full day's run, which can be filled from three different parts of the storage in less than half an hour. The building also provides deposit for a half day's run below the drier.

Special attention has been given to the rapid loading of vessels, the plant as designed having four 46-in. belt shipping conveyors, with total capacity of 100,000 bu. per hour, all of which can be used to load one to four vessels at the same time.

On account of the large amount of grain accessible to the Mississippi River, the plant is being equipped with a marine tower and machinery to unload ships or barges. To more readily accommodate the great variation in water level and the varying dimensions of the vessels, a pneumatic unloader has been adopted.

In addition to these special features, the plant is provided with safety devices of latest type, including a complete dust collection system, signal systems, strand indicators, journal alarms, etc. On account of the fire proof construction and protection apparatus, it is expected that the minimum insurance rate will apply.

PUBLIC COTTON WAREHOUSES

The Cotton Warehouses and Terminal plant of the Board of Port Commissioners is of particular interest because of the cotton handling machinery with which it is equipped, and because of the consequent unique design of the buildings. The plant has an annual warehousing capacity of 2,000,000 bales and is composed of four large warehouses, a compress building and a two-story wharf house, all of the latest type of reinforced concrete construction. All of the buildings are connected by two-story runways or bridges upon which cotton is transported from one part of the plant to another.

Cotton is handled in the warehouses by high speed electric traveling cranes which are operated by one man who rides in a cab attached to the trolley. One of these cranes is shown in Fig. 11. The span is 28 ft. 6 in. The hoisting motor is 20 h.p. and speed of hoisting 150 ft. per min. The trolley speed 150 ft. per min. The travel motor is 10 h.p. and travel speed 500 ft. per min. The capacity is 2 tons.

By the use of an automatic grapple, this same operator can pick up cotton from the platforms or from trucks, and place it at any desired point in the warehouse, or can load it on a truck or trailer for transportation to the wharf. Fig. 12 shows one of these grapples above the bale, and Fig. 13 the grapple holding the bale.

Ordinary hooks are also used to some extent instead of the grapples, but require an additional man to place them on the bales. Where it is desired to remove a bale of cotton from the pile, a specially designed bale puller, Figs. 14 and 15, is used in connection with the crane. This requires the help of only one man in addition to the crane operator, but will remove any desired bale

from a tier any number of bales high in less than three minutes. The cost is 25 cents for each bale actually pulled.

The cranes can be transferred from one warehouse compartment to another on transfer tables, Fig. 16, thus avoiding the necessity of supplying a separate crane for each. The traverse motor is 6 h.p., and the traverse speed 100 ft. per min.

The cranes are of the three-motor type and are rated at two tons capacity, operating on 220-volt direct current. The hoisting motor is rated at 20 h.p. and raises the load at the rate of 150 ft. per min. The bridge is moved at a speed of 500 ft. per min. by a 10-h.p. motor and the trolley 150 ft. per min. by a 2-h.p. motor.

A compress building contains three steam presses of the usual Morse type, one having a 90-in. cylinder, one an 86-in., and one an 84-in., and a hydraulic press of 450 tons capacity has been contracted for.

Hand trucks are used to some extent in the immediate vicinity of the compresses, but, for the most part, the cotton is handled from place to place in the plant on small self-propelled storage battery trucks, Fig. 18. The speed of these trucks is 6 to 8 miles per hour, and the capacity 2 tons. The batteries have 24 cells, U. S. Lighting, 9 plates per cell. The motors are 2 to 3 h.p.

It is also proposed to employ electric tractors with trailer trains for the transportation of cotton from one warehouse to another and from the warehouses to the wharf. Each tractor will draw three trailers holding ten bales of cotton each. These trains are to be operated on the overhead runways and will travel at a speed of 6 to 8 miles per hour. A number of gasoline motor trucks with special bodies to carry 17 bales of cotton, have been provided for the transportation of cotton about the city. Two of these trucks are shown in Fig. 19. The economical speed is 12 miles per hour The capacity is 4 tons and the rated horsepower 32.4.

The wharf is to be provided with single leg gantry cranes for loading and unloading the ships. These are to be two-ton cranes of the three-motor type with a luffing or derricking boom giving a maximum radius of 50 ft. The cranes will serve the apron wharf with its two railroad tracks, as well as a second story platform of the wharf house and will take cotton from any of these places and lower it directly into the holds of the ships. They can, of course, also be used for unloading cotton from vessels and placing it on the wharf or platform, or in cars. It is possible that a continuous belt conveyor similar to the banana conveyors will be developed for the purpose of loading the vessels.

Table 1 shows the labor costs at the Public Cotton Warehouses.

LOCOMOTIVE CRANES

Several locomotive crane installations are of interest. In one plant bricks are placed in crates at the kilns, and the crates loaded on barges. On arrival the crates are removed from the barge by crane and loaded on teams or first placed in storage; the bricks remaining in the original crates from the kiln to the consumer.

Other locomotive cranes, both steam and electric driven, are used for handling sand, gravel and shells from barges to and from storage and to teams or cars.

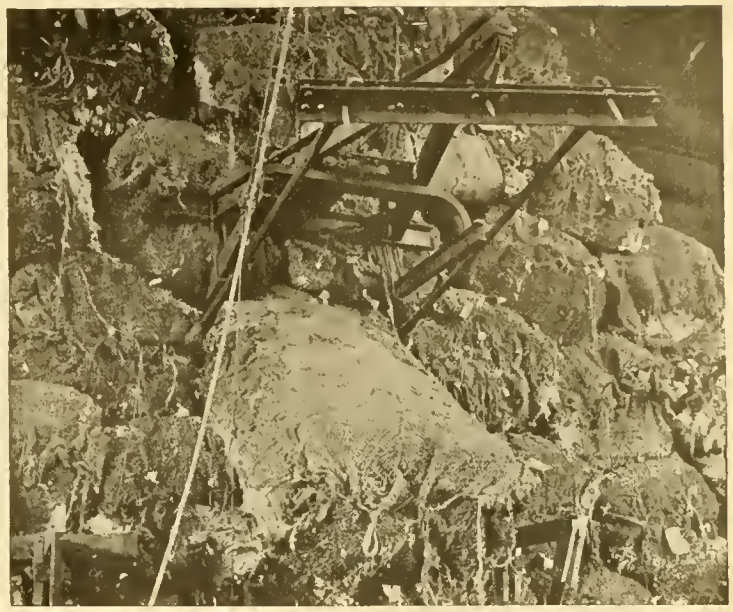

Fig. 15 Cotton Bale Removed by Puller

Fig. 16 Transfer for Cotton Warehouse Cranes

Fig. 17 Storage Battery Cotton Trucks and Trailers

Fig. 18 Storage Battery Cotton Trucks

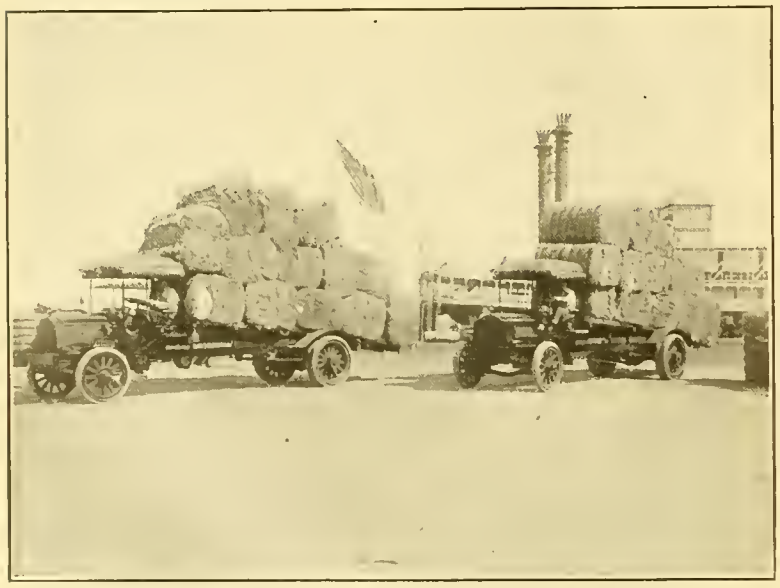

Fig. 19 Special Gasoline Trucks for Handling Cotton

TABLE 1 LABOR COSTS AT COTTON WAREHOUSES

Operation		Cost in Cents Per Bale	
		Min.	Avg.
Unloading		1.3	2.
Inspecting and Sampling		2.3	3.
Weighing		2.0	4.
Compressing		6.0	8.
Band Making		1.0	1.
Trucking	Hand Trucks	...	2
	Electric Trucks	...	1
Storing	By Hand	2.0	6.
	With Crane	1.5	2.25
Repiling	By Hand	...	4.00
	With Crane	...	1.75
Turning Out	By Hand	2.0	7.
	With Crane	2.0	7.
Pulling Machines	Hand	25.0	50.
	Crane	10.0	25
Ranging		...	1.5
Marking		...	0.5
Spotting (Part Output)		...	1.5
Shipping	By Trucks	...	2.5
	On Cars	...	3.0

Average Total Labor in Plant	26 cents	Laborers paid from 20 cents to 25 cents per hour
Compressing	8 "	
Total	34 "	

Fig. 20 shows a locomotive crane handling sand from barges, Fig. 21 an electric locomotive crane handling shells from a pile and Fig. 22 a locomotive crane handling bricks in crates.

The barge shown in Fig. 20 is of 300 yd. capacity. The 2-yd. clam shell handles 250 yd. per hour.

FLOATING DERRICKS

Privately owned by individuals, the steamship companies and contractors are many floating steam derricks, Fig. 23, of various capacities, there being one each of 100, 50, 40 and 35 tons and a considerable number of smaller machines.

SAND AND GRAVEL HANDLING

Special elevators are used for unloading sand, gravel and shells from barges and delivering to storage piles. The unloader shown in Fig. 28 consists of a barge carrying a revolving crane with clam shell bucket which delivers the material to a hopper on the barge. From the hopper the material is spouted to a belt conveyor on an adjustable boom which delivers it to stock piles on shore. The clam shell is of 1½ yd. capacity and the unloader handles 150 yd. per hour.

MISCELLANEOUS EQUIPMENT

In addition to the larger equipment already mentioned, many smaller devices are in general use. Included in this class are the electric and hand operated portable cranes, electric trucks frequently with trailers, gasoline trucks, timber jacks, tiering machines, etc.

Fig. 24 shows a portable elevator, icing refrigerator cars. Fig. 25 shows a small storage battery crane truck. Fig. 26 illustrates a portable crane handling mahogany logs. Fig. 27 shows a timber jack.

DISCUSSION

W. C. Brinton. Engineers have done comparatively little thus far in regard to freight handling machinery on harbor work. Compared with the large volume of miscellaneous freight handled, the amount of machinery in use is very small. The difficulties connected with handling freight are mostly not due to engineering. In many cases we find that customs requirements make it necessary for as many as five different organizations to handle goods between the ship and warehouse or street and freight car.

At one large terminal in New York, a large amount of freight was recently being handled five times in taking it from the ship to the freight car. First it would be unloaded from the ship to the pier. Then the weighing gang would come along and weigh it, laying it down on the pier again. Then the warehouse gang would come along with an entirely different operation, take it up and put it into the warehouse. Coming out of the warehouse there might be another weighing on account of the merchant wanting a public weighmaster, requiring a distinctly different handling of the goods from what was done by the warehouse gang. Then, if it was loaded on the freight cars, the railroad had in many cases to go through a final set of operations.

In such handling, difficulties are magnified, because it is almost impossible to put in machinery to work economically if one gang has to depend upon another. You can get a gang of men to take the material out of the warehouse, but if the weighmasters are not there the work of the weighing gang is held up.

I understand that in New Orleans there are difficulties in applying machinery because of the disagreements between the stevedores, labor unions and steamship companies. But if machinery was applied, the ultimate gain would go to the laborers in many cases. It will take considerable study and hammering on the part of engineers to get these types of machinery used so as to get the ultimate benefit possible. There is no doubt in my mind, however, that we are still in advance of European conditions in this country in handling freight.

Concerning the use of telphers, tractors and trailers and machines which will carry a load on their own backs, a very nice point to determine is which is the best type of equipment. There is no doubt that telphers will do work cheaper where you have one type of package in large quantities. If you have a long haul, with a large turning radius, tractors and trailers are desirable. If, however, you have crowded pier conditions and constantly changing kinds of commodities to haul, with fairly short hauls, a machine which will carry a load on its own back will do it more cheaply than tractors and trail-

Fig. 20 Locomotive Crane Handling Sand from Barges

Fig. 21 Electric Locomotive Crane

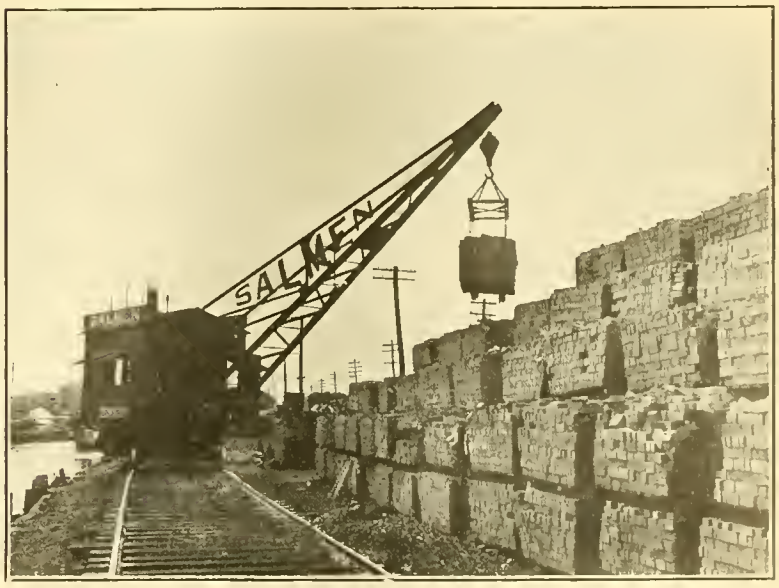

Fig. 22 Locomotive Crane Handling Bricks in Crates

Fig. 23 Floating Derricks

Fig. 24 Portable Elevator Icing Refrigerator Cars

Fig. 25 Storage Battery Crane Truck

ers. That must be qualified, however, by taking into account all the work, that is the labor of loading and unloading. The turning radius of the train of tractors and trailers is so great, it is almost impossible to get the trailers delivered immediately alongside of the pile.

Sometimes the problem is to keep a short turning radius, combined with a platform large enough to accommodate the bulky material used in steamship work. It is easy to make a storage battery tractor which will carry two tons, but it is not so easy to make one which will carry two tons of the kind of commodities we have in steamship terminal work without piling the material too high. If you use a bob truck, 6 or 7 ft., then in order to get on two tons of the average steamship freight, you have to pile it higher than it is economical to do with labor. If you have a platform truck, with a platform 11 or 12 ft. long—about the length that they are using on their largest trucks at the New Orleans cotton warehouses, combined with the ability to raise separate plank platforms by a power raising mechanism, you can get the combined advantages of tractors and trailers and a machine which will carry a load on its own back. That must be done with a machine of a uniform turning radius, because there is allowed a fairly large turning radius for all the places where they are using tractors and trailers and the tractors and trailers can be left outside of the buildings and the goods picked up with a crane for removal to the different compartments. However, on many classes of hauls it would be cheaper to do the work with separate plank platforms and pick up the platforms. The machine will then not be delayed while loading and unloading the platforms.

On miscellaneous steamship freight such as we have along the river front in New Orleans and in New York, there is no doubt that the separate plank platform with a machine which will pick up the plank platforms, will do the work cheaper than the tractors and trailers, due to the fact that you have no difficulty in getting the loading done immediately alongside the pier.

Frank B. Gilbreth. In this matter of devices for handling materials at docks, I want to call attention to the use of gravitation for this purpose. I have been advocating such use for many years, and my successful experience with gravitation as a transporting force will perhaps make my findings on this subject of some value.

Many years ago we utilized this force by inventing a gravity concrete mixer, the principle of which is now being widely applied. We were also the first to transport concrete long distances by gravitation from a large sheet metal pipe, the lower end of which could be swung over a large area. This was the first use of the invention of "spouting," or conveying the concrete long distances by gravitation. It was ahead of its time. To-day practically all large jobs of concrete are "spouted."

The efficiency of gravity as a transporter and of handling materials in different parts of a building

by simply hoisting them and having them descend by gravitation on roller conveyors has been demonstrated time and again. The cost of this method is low. Yet in spite of these facts not over one tenth of one per cent of all buildings under construction use roller conveyors for transportation purposes. In the public cotton warehouse described horizontal transportation is being done by trucks. This is inefficient and is wasteful of both time and money. The vertical transportation of material at docks costs very little comparatively, for the reason that it can easily be systematized, standardized and controlled. Handling materials at this public cotton warehouse by hoisting vertically by power and distributing horizontally by gravitation would reduce the cost to a point that would be surprising.

A further reduction of costs could be secured by standardizing the handling devices, but the first step is an appreciation of the unusual force, of the availability, and of the efficiency of gravitation as a transporting force, and of the advantageous by-products, as well as products, of its utilization.

John R. Fordyce did not wish to discuss any feature of the port equipment described except the cotton handling warehouse. He said that no doubt the warehouse met all the conditions which had to be contended with, but he would like to give the results of some of his own experience in cotton handling.

Cotton Storage and Piling.—The compartments are designed so that four rows of bales are arranged with two open aisles, to enable access to the ends of each bale, so that any bale can be pulled out of the piles, and also that water from the sprinkler above can reach the origin of any fire. The height of the compartments are I believe approximately 35 ft. from the floor and the compartments near the wharf are to be 40 ft. The two piles of bales that lean against the wall can doubtless be carried up to twelve bales high, or about 20 ft., without fear of toppling over, but the two piles in the center which lean on each other cannot safely be carried up more than eight bales high or about 14 ft. (I assume the thickness of a compressed bale as 20 in.) Even at this height it will be hard to get a bale out of the lower tiers of the side or wall piles because of the great weight above and the rough and uneven character of the bales. The pull of the ropes of the bale-puller will throw the pile over against the wall and the pile will of course not fall down, but if this same operation were tried on the middle piles there would be danger of the whole pile being thrown over. In case many bales had to be taken out, the piles would no doubt have to be repiled, as the holes, unless filled, would cause the collapse of the pile. A system of jackscrews working from the floor could raise the weight of the bales above and enable the lower bales to be pulled out just as easily and cheaply as the plan described.

The overhead electric crane, while ideal for machine shops and other places where the packages have to be carefully handled and placed, does not seem to me to be the best thing for cotton handling.

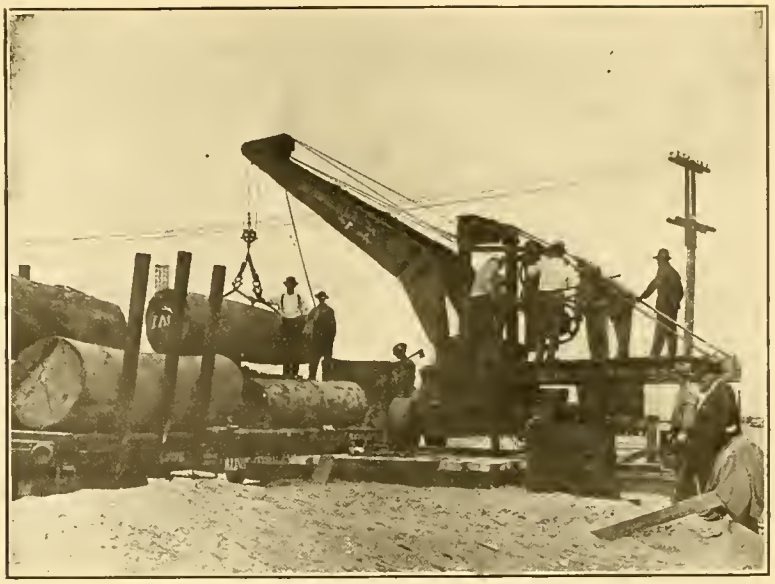

Fig. 26 Portable Crane Handling Mahogany Logs

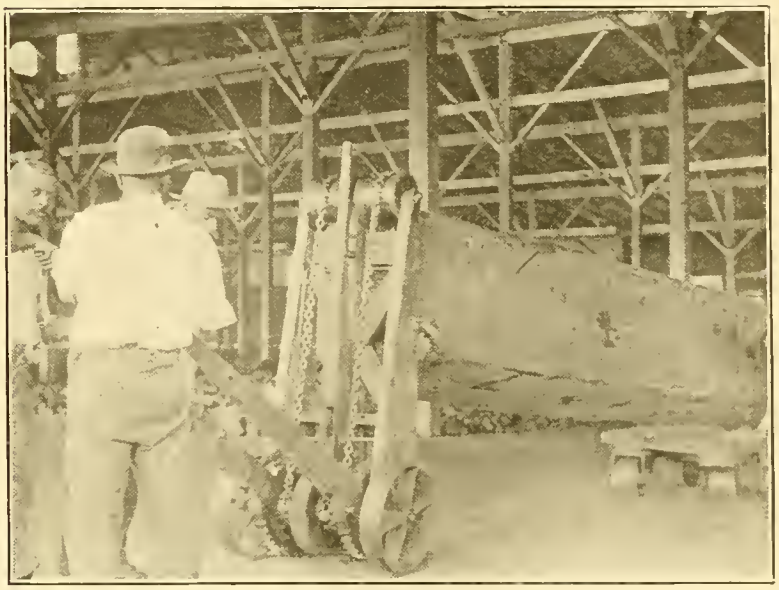

Fig. 27 Timber Jack

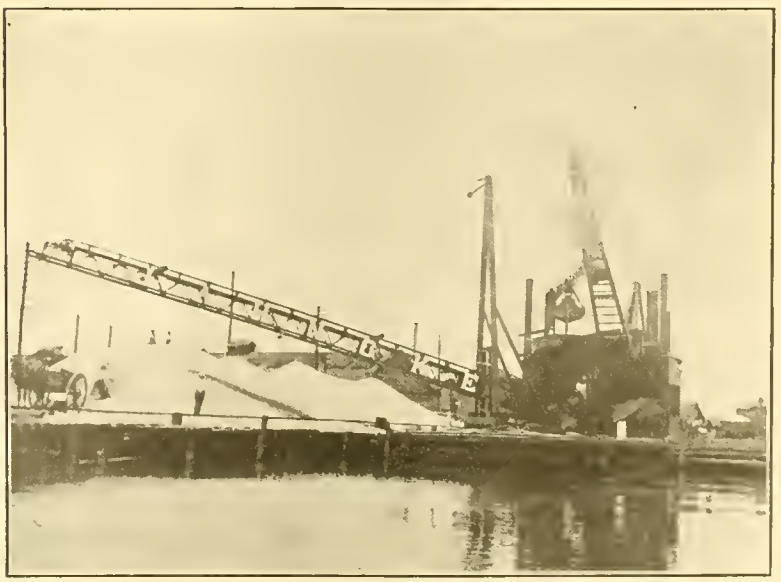

Fig. 28 Floating Elevator Unloading and Piling Shells

However, I realize that if this warehouse system is likely to be used for other commodities, then the cranes and the high warehouses will probably be ideal. For cotton, however, you have wasted at least one third of the height of your buildings, expense of preparing your craneways, power plant, crane transfer structure and maintenance of the cranes. The cost of these is out of proportion to the benefits gained, in handling a slow moving, non-damageable package such as a bale of cotton.

Assuming that 20 ft. is the practical height of a pile of cotton. A building 25 ft. high would give ample room and clearance for the automatic sprinkler, and an elevator working from the floor of the aisle would hoist bales equally as well as overhead cranes, and at the same time could be arranged to lift off the weight of the bales above the one which was wanted. Thus the additional cost of building the runways and all the attending apparatus would be saved and a cheap elevator used which could be dragged in and out of a compartment much quicker than a crane could be. Another and far more serious objection to the overhead electric crane is the danger from fire. I tried an overhead monorail hoist over cotton in 1901 in Little Rock, Ark., and had to abandon its use because it set fire to the bales below. I understand that several fires have already occurred in these New Orleans warehouses, and have before me a pamphlet issued by the Louisiana Fire Preventive Bureau which attributes the cause to defective mechanism in the cranes, which no one of course foresaw. Even if these are corrected others may develop and I believe the only safe way to do it, is not to try to use electricity in overhead apparatus. Overhead apparatus operated by cables similar to aerial trams can be applied and the winding engines kept on the outside of the compartments. I have devised one for the warehouse in Galveston, where the sheave runs on a rope so that the entire strain is taken off the roof, which is too light for any increased weight. This rope can be shifted from side to side in the bays and thus come over any pile of cotton. The bale of cotton can be dragged back and up over a pile of bales when no aisles are left, which sometimes occurs in congested times. This whole apparatus is cheap and can be carried out of one compartment and erected in another in a short time and at little cost. The necessary rings and hooks which have to remain in a compartment holding one thousand bales cost less than $50.00, so that the amount of money locked up when the compartment is full or idle and not being worked is a minimum.

Transportation of Bales.—Mr. Brinton stated that the carrying of bales by trailer pulled by electric storage battery tractors is not as practical or economical as if the load was carried by the truck itself. Mr. Gilbreth has said that a slight grade should be given the roadways from the warehouse to the wharfs, as the loads were always to be in the same direction. Here again the designing engineers had no doubt to provide for goods from ships moving in as well as cotton from warehouses moving out. I have had quite a lot of experience in handling cotton by trolley systems, and have found that a slight fall of 6 in. per 100 ft. in the direction of the movement of the cotton is a great help. In Memphis, Tenn., in the plant of the Memphis Terminal Corporation, there is a trolley track with that fall on which one mule can push one hundred bales of cotton in one string of trolleys. His work in one day at that rate would be the delivering of 4000 bales in ten hours over an average distance of half a mile. A system similar to that could be applied very easily in the New Orleans plant for you already have all the headroom needed. The bales hoisted out of the compartments on to the upper runways by the overhead cranes could be dropped on a roller platform which could be easily moved along opposite the opening of each compartment. The trolley track running along the outside of the posts could have the required grade and the bales hung on to the trolleys as they were rolled past this roller platform. They could then be gathered into strings, and pushed over to the wharves by tractors. The same tractor which could pull four trailers loaded with six bales each or twenty-four bales in all, could push one hundred bales if they were hung from trolleys. The empty trolleys could be returned to the warehouses along the outer runways and hoisted to the upper levels by inclined moving chain elevators such as are used in packing house practise. This system could be easily designed to carry other commodities than cotton and to work both in and out with loads.

In submitting these ideas I realize fully that it is much easier to criticize than to originate and that not knowing all of the conditions which had to be considered by the designing engineers I may have of course arrived at a different conclusion from theirs.

The taking advantage of the pull of gravity wherever possible for moving materials is, however, a subject worthy of careful study. It has worked wonders in other places and should be considered here.

GARDNER T. VOORHEES. One of the biggest things that I have seen at this meeting was the warehouse receipt of the public cotton warehouse, and I think this has an immense value as a negotiable matter. I am confident that a similar receipt on the very valuable goods that have to go into cold storage would have an equally great value, although, of course, the goods that go into cold storage, more particularly in the North, the butter and eggs, form the big things on which money is loaned by the banks. But in the future a warehouse receipt, having the city and the state both back of it, the same as the cotton warehouse receipt inaugurated in this port, would, I believe, be of great value to the users and producers of any material passing through cold storage.

GEORGE H. DAVIS, who presented the paper in the absence of the author, emphasized the point that the handling machinery of a port is not an engineering problem entirely. It is possibly 25 per cent engineering; possibly 25 per cent business, 25 per cent policy in running—as to whether this will be acceptable or that will be acceptable—and 25 per cent miscellaneous. While the machines themselves are simple, and such that a casual observer would think ought to be used everywhere, as a matter of fact, it is rather difficult to establish machinery handling through a port of this kind. The matter is one of slow development, and the slowness does not come from the engineering side, but from other sources.

Experiments have for some months been under way for the production of a high-speed tool steel which will equal any at present on the market, but which can be easily made without the use of alloys dependent upon components of limited supply, such as tungsten and molybdenum. Such an alloy has been produced. The melting is done in an ordinary crucible furnace capable of high temperatures, and the steel is then cast to the desired form in either metal or sand moulds. When cold, the tools, without any forging or heat treatment, are ground on an emery wheel (dry) and finished on a wet grindstone. As the tools possess the correct hardness, various skilled operations are eliminated.—*Engineering,* May 26, 1916.

A NOVEL METHOD OF HANDLING BOILERS TO PREVENT CORROSION AND SCALE

BY ALLEN H. BABCOCK,[1] SAN FRANCISCO, CAL.

Non-Member

THERE will be described in detail a radical departure from the conventional methods of handling boiler troubles due to corrosion. At present the method considered most highly scientific is to send samples of water to a chemist in order that a proper corrective may be prescribed. The composition of the corrective is usually a trade secret, jealously guarded, which the purchaser uses blindfold. On the other hand, the method to be described applies one corrective to all waters. A different composition of feed water demands not so much a different composition of corrective as a different quantity thereof. A simple chemical test, made by the engineer of the plant, or his clerk, gives the condition of the water *in the boiler, under steaming conditions,* and determines the quantity of chemicals to be applied. The purchaser now works with his eyes open.

It seems from all that can be ascertained at the present time, that at least there is a method of handling boilers, with a compound applicable to any water under any conditions of steaming, without a material change in the formula. The only requirement is that the boilers must be treated individually; it is not enough to treat a battery, or to treat the feedwater going into the boilers in general.

The first application by the author of this method was made at the Fruitvale power station of the Southern Pacific Company, the boiler equipment of which consists of twelve water tube boilers, each of 645 boiler h.p. It has since been used by the Southern Pacific Company in stationary plants in the oil fields and on locomotives in the same district.

[1]Consulting Electrical Engineer, Southern Pacific Company.

The method is in no respect original with the author. It has been his good fortune to be able to apply the work of another who was similarly situated, but who solved the problem for himself. The results have been such that it seems worth while putting them on record, particularly since a description of the method has lain in the technical literature of this country unnoticed for about three years. Apparently it has attracted almost no attention outside of a very limited circle.

The first inspection of the boilers of the Fruitvale plant after it was put in operation showed that serious corrosion began a very short time after the plant was started, although the boilers were not on regular load. The ordinary remedial measures produced no results at all. Bearing in mind that the plant was put in service to haul trains in the fall of 1911, it is significant that by June, 1912, the feed elements of the boilers were all in serious condition. With a total of 3360 tubes in all boilers, 252 tubes were requisitioned for replacement during practically the first eight months of operation. By the end of July, 1912, the trouble was extending to the second row of tubes, and 250 more tubes were requisitioned to take care of the trouble. In September, inspection showed that the drums were being attacked. In October, boilers Nos. 1 and 3, after having been equipped with new tubes and placed in service in August, and worked entirely with water treated by the lime process, were found to be pitted worse than ever, and this was after the first serious effort to treat the water had been put into effect. In November, 1912, the piping was modified according to a plan sent by the manufacturers of the boiler, but in December of that year the inspection showed the pitting

SYNOPSIS OF PAPER

This paper gives an account of experiences with a method of preventing corrosion and scale formation in steam boilers, which differs from the commonly accepted theory of boiler water treatment in that a high alkalinity is carried in the boiler. It has been commonly considered that a boiler water high in alkalinity has a decided tendency to prime, and this is probably true if no anti-priming substance is added. Under the high alkalinity treatment described, boilers have been run with no corrosion for more than a year, and the normal alkalinity has frequently reached 10 per cent without any tendency to prime.

The treatment was first applied by the author to twelve 645-h.p. water tube boilers at the Fruitvale power house of the Southern Pacific Company, California, which presented one of the most pronounced cases of localized corrosion on record. At the time the treatment was commenced, all other known methods of treatment, including observation for electrolysis, had failed to stop the corrosion, which became so serious that eighteen months after the boilers were put in service one-third of the tubes had been replaced.

The treatment consists in adding to the hot-well water a compound known as the Navy Standard Boiler Compound, originally developed by Lieut.-Com. Frank Lyon, U. S. N., as the result of numerous investigations and experiments on the corrosion of boilers and piping. The ingredients of the compound are sodium carbonate, trisodium phosphate, dextrine or starch, and a tannin compound, such as cutch. The sodium carbonate is the main ingredient and is used to take care of any chemical reactions and render the solution non-corrosive. The tannic acid and starch throw down the scale-forming compounds present in ordinary feed water. The trisodium phosphate prevents the rise in surface tension of the solution and consequent priming which would be caused by the original impurities in the water and by the application of the other ingredients in the compound. In using the compound to prevent corrosion a sufficient quantity must be added to the water of each individual boiler to render the alkaline strength of the solution 3 per cent normal or above.

The use of the compound at Fruitvale resulted in almost complete cessation of troubles from corrosion. Two months after the first boiler at the station was placed under treatment, the tube replacements were reduced from 171 per month to zero, and the labor and material costs were correspondingly reduced from over ten thousand dollars a year to twelve hundred. There is no scale in the boilers; they are absolutely clean. Below the water line they show clean black iron; above a thin coating like whitewash.

The results were so satisfactory that the method was extended to locomotives in service in one of the worst locomotive water districts on the Southern Pacific Lines, and to other power plants of the company's system, all with favorable results. In one particular case, the water carried 230 grains per gallon of solid matter and nearly every known variety of boiler trouble had been experienced, but the compound eliminated corrosion and precipitated the solids in a soft, slushy form easily washed out.

The Associated Pipe Line is using the compound successfully in twenty-six stations in the San Joaquin Valley, chiefly for the prevention of scale. Most of the stations have three 250-h.p. water tube boilers and use water containing solid matter varying in amount from 5 to 231 grains per gallon. In places where the solid content is so very high it has been necessary to increase the quantity of anti-foaming chemicals above that ordinarily contained in the compound. This has been done, not by changing the composition of the compound, but by adding separately a quantity of the non-foaming ingredient, trisodium phosphate.

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to be very severe, and in January, 1913, 300 more tubes were requisitioned. This made a total of 1050 tubes in a year and a half, not counting about ninety which were put in by the manufacturers.

About this time began the use of a compound furnished by one of the best known companies in the business. The result was apparently to transfer some of the trouble from the tubes to another part of the boiler where there had been no trouble before. A sediment of black mud formed a scale which caused blisters and tube failures at those points. In June, inspection showed bad corrosion and pitting in all parts of the boiler, and 960 tubes were requisitioned. By October, 1913, the total work orders for boiler repairs on that plant amounted to $16,000, or nearly 12 per cent of the first cost of the boiler plant. Three different special formulae for compounds submitted by the same chemical company had been used, but as things were going from bad to worse, the use of the special compounds was discontinued.

In the fall of 1913, with a fine steam plant in a very critical condition, 1160 tubes out of 3360 had been replaced and there was no end in sight. A new expert was called in, who began by suggesting the conventional methods of zincs and paints, and that perhaps electrolysis was to blame, although everything had been kept carefully insulated. The result was no better than before.

THE NAVY STANDARD BOILER COMPOUND

About that time the author was handed the August 1912 number of the Journal of The American Society of Naval Engineers, which gave an account, by Frank Lyon, Lieutenant-Commander U. S. Navy, of what seemed to be a highly significant development in boiler trouble treatment.[1] In the course of his article, Commander Lyon said: "The writer has no hesitancy in saying that any boiler, using any water, can be kept from corrosion for any length of time." Having been brought up to understand that whatever a Naval officer says is so, without qualification, the salvation of the Fruitvale boiler plant appeared to be within reach.

The result of Commander Lyon's investigations was the development of the Navy Standard Boiler Compound. This compound is composed of sodium carbonate, trisodium phosphate, starch and tannic acid. The sodium carbonate takes care of any chemical reactions and renders the solution non-corrosive. The tannic acid and starch are added to prevent the formation of scale, the action being to hold the impurities in suspension in a colloidal state. The trisodium phosphate prevents the rise of the surface tension of the solution and consequent priming caused by the impurities in the water and by the application of the other ingredients in the compound. In using this compound to prevent corrosion a sufficient quantity must be added to each boiler to render the alkaline strength of the water in the boiler 3 per cent of normal or above, and the alkaline strength must be maintained in *each* boiler.

The compound may be purchased from the Government Contractor[2] for about one-half the cost of the ordinary compounds. Various proprietary companies also supply essentially the same material under their own trade names, but at about ten times the price of the real article.

[1] Navy Department, Washington, D. C. $1.30 postpaid. Reprints of the article are also available.

[2] Through the courtesy of Commander Lyon, the Society is informed that the compound has been made up by Bird, Archer & Co., 209 Washington St., New York, and Lord & Company, Philadelphia.

USE OF THE NAVY COMPOUND IN THE BOILERS OF THE FRUITVALE STATION

On the 4th of March, 1914, the first boiler was placed under treatment with the Navy Standard Compound. By the 26th of March it was in use in all of the boilers. As illustrating the results, the record of tube replacements month by month is most significant. In 1912, 690 tubes were replaced; 858 in 1913. In January and February of 1914 there were 229 tubes replaced in the two months, or at the rate of 1374 a year. The treatment, as stated above, was begun on the 4th of March, and was in all the boilers on the 26th. Thence the record stands: In February, 171 tubes replaced; March, 24; April, 15; May, 2; and from May 1914 to June 1915 (date of writing), not one has been replaced for failures. There have been 13 tubes replaced since May 1914, but they have all been replaced because they had to be taken out to get at something else, or by reason of obvious defects.

As to the money saved by the introduction of this method: In 1912 it cost in labor and material $5790; in 1913, $10,256; in the first six months of 1914 it was $1579, and since then the expense will hardly come to a hundred dollars a month for everything considered, that is, the ordinary wear and tear of the plant, washing of boilers, etc. In addition to this, extra labor in the plant (made necessary by the failing tubes), to the extent of $181 a month, has been discharged. The treatment as practised there costs about $80 a month, depending upon the amount of compound used. There is no scale in these boilers; they are absolutely clean. Below the water line they show clean black iron; above, a thin coating like whitewash.

USE OF THE NAVY COMPOUND IN LOCOMOTIVE BOILERS

The first two months' operation at the Fruitvale power station with the Navy compound in use showed such very satisfactory results that the management ordered a trial of the method on probably one of the worst locomotive water districts in the company's service, namely, that part of the San Joaquin Division between Bakersfield and Mojave, known generally as the Tehachapi Pass. Mr. R. S. Twogood, assistant engineer in the office of the consulting electrical engineer, was detailed on this work and for nearly a year he has given practically his entire time to this demonstration. The following is an abstract of his contribution to the discussion at the December (1914) Meeting of the San Francisco Section of the Society, when this subject came up for a general discussion.

On July 21, 1915, a compound test was started on freight Mallet locomotive No. 4031, operating over the Tehachapi Pass. The locomotive was just out of shop. It had a new set of flues, was free from scale, with the exception of a thin deposit on the crown sheet and crown and stay bolts that were not removed during back shopping. The engine was left in chain-gang service.

At first an effort was made to carry the alkalinity at 3 per cent, but so far the best results have been from 0.5 per cent to 0.7 per cent normal alkalinity. Several things in the design of the locomotive, especially the Mallet, contribute to this result: for example, a very small steam space and steam dome; no perforated dry pipe to collect steam from all parts of the boiler; constant surging of the water due to the motion of the locomotive; sudden opening of the throttle and consequent great demand for steam, which reduces the pressure on the surface of the water under the throttle and causes it to rise and pass over into the steam pipes. Also, the water used for loco-

motive purposes in this district contains a large amount of solid matter which would tend to cause priming.

One point constantly in mind was to find some treatment in which one man could be made responsible, without having to depend on the engineers and firemen. This means that the boiler must be treated at engine turning points.

At first the chemicals (enough for the entire trip) were put into the tender tank, thence to pass with the feed water through the injector, feed-water heater and into the boiler. By this method the desired percent of normal alkalinity in the boiler was not reached until one tank of water (10,000 gal.) had been used. Also, considering the fact that the tank capacity is much greater than the boiler capacity, the tank alkalinity was very low. This low alkalinity, though strong enough to bring out some solid matter, did not furnish sufficient tannic acid and starch with the standard proportion of chemicals to prevent this solid matter from forming scale. In the injector, where the cold water came in contact with the steam, and later where the warm feed water came in contact with the hot boiler water, some scale was formed. After this was noticed no more compound was added to the tank, but was pumped, in a concentrated solution, through the injector. This gave at once the desired percent of normal alkalinity in the boiler. There has been no further trouble with scale.

The water from Bakersfield to Mojave averages about 3 lb. of scale-forming matter per thousand gallons. A Mallet locomotive in a helper trip from Bakersfield to the Summit and return will use from 30,000 to 35,000 gal. of water, which means about 100 lb. of scale per helper trip. With the present method of treating, 20 lb. of compound are pumped into the boiler before leaving Bakersfield yards. This gives an alkalinity of about 0.6 per cent, and as this percentage remains approximately constant between engine turning points, it is possible to treat the boiler for an entire trip before it leaves the roundhouse.

If too little compound is used the precipitate is fine and does not settle readily; but when the amount is sufficient the precipitate is large and flaky and settles very rapidly. This makes it easy to clear the boiler of some of the solid matter by blowing down after the engine has been standing on the siding a few minutes awaiting passing trains.

Present practice is to wash the boiler every second trip. A large percentage of the solid matter runs out with the water while draining the boiler and the rest is easily washed out. The solid matter has no tendency to cake, but will remain indefinitely in the form of a soft brown mud. It must be borne in mind that the frequency of washing is a function of the amount of solid matter in the water and the amount of water used.

Prevention of corrosion and scale formation was the main endeavor and yet another result was obtained, just as important. Absolutely no boiler troubles were encountered during the first four months of the test, and then the record was broken only by a minor leak, a record that gives some idea of the importance of keeping the boiler free from scale and thus prevent the high and uneven temperatures in the steel which cause the opening up of joints.

It is standard practice to carry from 1000 to 1500 lb. of sand on a Mallet locomotive to cut the soot from the inside of the flues. Why is it not just as important, for good steaming, to use some method to keep the outside of the flues free from scale?

The ingredients of the Navy compound originally were proportioned for use in stationary and marine boilers, and at an alkaline strength of 3 per cent normal. The 10 per cent of trisodium phosphate was added to prevent light water. The locomotive type of boiler, in general, shows a greater tendency to foam than other types of boilers and should, therefore, have a stronger non-foaming reagent. In cutting down the alkalinity from 3 per cent of normal to less than 1 per cent, the amount of trisodium phosphate has been greatly decreased with good results. The amount required seems to vary so much with different runs and conditions that as yet no decision can be made as to a definite amount for general use.

A new water was obtained at Bakersfield in January that is a great deal better than the old, as far as content of incrustating matter is concerned, but it is very light. Foaming and priming became so bad in one of the passenger locomotives that the water in the glass rose as much as 8 in. when the throttle was open. No compound of any kind had been used in this boiler. Six pounds of trisodium phosphate (no compound) was then put in the boiler through the injector just before the engine left the roundhouse for each trip. There has been no foaming on this locomotive since.

During the early part of the test on Mallet No. 4031 some light water and foaming were experienced. It was feared at that time that water, passing over, would loosen superheater units and high-pressure steam piping, and would cut cylinder bushings and packing, but these fears proved to be ungrounded. The engine has made more miles between shoppings for boiler repairs than any other Mallet operating out of Bakersfield.

On this division, where the water is poor, practically all of the locomotives are back-shopped on account of the boiler and not the machinery. The present indications are that the use of this compound will make the life of the boiler longer than that of the machinery.

During the last month the use of this compound has been extended to all freight Mallets (seven) operating out of Bakersfield. Some of these had been in service for several months and large quantities of scale had formed. The cutting of this scale made very dirty boilers, causing frequent blowing and boiler washing. After two or three weeks, scale from 1/8 in. to 3/8 in. thick came off in large quantities, which proves that the compound will cut the old scale, but this action causes such dirty boilers that such procedure cannot be recommended. By the practice outlined above, a clean boiler can be kept clean and operated with success, using water classed by boiler people as very poor.

USE OF THE NAVY COMPOUND IN STATIONS OF THE ASSOCIATED PIPE LINE COMPANY

The results in the Fruitvale power station boilers caused prompt steps to be taken to extend the use of the compound to other stations either operated or controlled by the Southern Pacific Company.

The Associated Pipe Line Company operates an oil pipe line from the oil fields in the southern end of the San Joaquin Valley to tidewater near San Francisco. On this pipe line are 30 steam pumping stations equipped, some with three and some with four 250-h.p. water-tube boilers. The feed water is of practically every known grade from good to very poor, and nearly every known type of boiler compound has been used from time to time in the worst of these stations. Mr. E. B. Partridge, Jr., superintendent of the pumping plants in the fields, came to Fruitvale power station for a study of the method. He began his investigation in the most

skeptical frame of mind and he introduced the compound first into a station where, as he said, it could do the least harm. Eight months later, at the December meeting of the San Francisco Section of the Society, where the subject was discussed, he gave an account of his experience which is here briefly summarized: In the thirty different pumping stations there were thirty different kinds of water, with a solid content running from 6 to 230 gr. per gallon. In the first station, a three months' trial of the compound showed that a turbine tube cleaner was no longer necessary, because the boiler was readily washed out and cleaning would not be required oftener than every three months.

These results were confirmed at the next station where the compound was tried. It was then introduced in a station which most of the feed-water experts in the State had turned down as impossible. The water carries 230 grains to the gallon. In these boilers 2½-in. extra-heavy boiler blow-off nipples corroded away in from three to four months and 3-in. extra heavy feed-water lines pitted through in the same length of time. Nearly every known variety of boiler trouble had been experienced at this plant, but the Navy compound eliminated corrosion and precipitated the solids in a soft slushy form easily washed out. Owing to the unusually large quantity of solid matter in the water, however, it was necessary to blow the boilers every hour and to clean every ten days.

At another station where corrosion very similar to that in the Fruitvale boilers had been experienced from the start and all kinds of compounds had failed to relieve the trouble, the Navy compound was introduced. Up to that time they had used No. 9 gage seamless tubes in the bottom boiler rows, and No. 10 gage special spellerized tubes in the upper rows, but none of them lasted more than three months. Feed lines, blow-off pipe lines, boiler drums and headers, together with the tubes, were all affected by corrosion; but the Navy compound straightened out all their trouble in this station precisely as in all the others. In order to have further verification, pieces of new tubes were hung in these boilers and after three months they showed not the slightest signs of corrosion.

In general, Mr. Partridge found that when he commenced to use the compound there were a great number of tubes which had been badly pitted and that these failed gradually, but they held up surprisingly well, considering their condition. Only a very few of these old tubes have been lost and none that were put in just prior to the introduction of the Navy compound treatment. He found that to get results it is necessary to work intelligently and not at all in the old haphazard fashion. He detailed an inspector on the work who travels from station to station, not only to see that the compound is being properly used and in sufficient quantity, but also to instruct engineers and to quiz them as to the results they obtain.

At every pumping plant a printed form is filled out and mailed to the general office every morning. From these Mr. Partridge keeps a close supervision over all of the plants. The reports show how much compound is used; what percentage of alkalinity is carried; how often the boilers are blown, that is, a bottom or a surface blow; when any particular boiler is cut in or cut out, and why; and the condition of the boiler when it is opened for cleaning. The importance of these results is best understood by engineers who know the operating conditions of an oil pipe line, where all the pumping plants are in series from one end of the line to the other, and a delay or a stoppage at any one station affects the output of the entire line, and consequently the earning capacity of the whole property.

USE OF THE NAVY COMPOUND IN SOME VESSELS OF THE U. S. NAVY

The use of the Navy Standard Boiler Compound was discussed in a preliminary way at a meeting of the San Francisco Section, after which it was suggested to the author that it would be well to go slow in using Navy compound, for the reason that some vessels had experienced such serious damage to their boilers from it as to cast discredit upon this method of boiler treatment. The substance of the statement was that for some years evidence has accumulated to show that under certain circumstances the use of sodium carbonate or sodium hydrate in boilers makes the steel brittle and causes failure of the joints by cracks; that at present it is impossible to state how or why the action occurs, but it is possible to name the circumstances under which it is likely to occur, the characteristics of the cracking when it does occur, and the principal cases that have come under direct notice.

Briefly, the theory advanced to the author as to the trouble is as follows: That sodium carbonate is always partially converted into sodium hydrate when in solution under boiler temperature, so that it makes no difference whether the carbonate is used in the beginning, or caustic soda, or both, as sodium hydrate will always be present sooner or later. When either of these substances is used for the treatment of scale, no trouble from the cracking of the steel is likely to occur, because they react with the scale and there is little or no excess hydrate. Where cracking has occurred it has always been true that free hydrate has been present in the boilers in the absence of sulphate; so that the statement is warranted that whenever sodium carbonate or sodium hydrate is introduced into a boiler in the absence of substances reacting with them, brittleness will result sooner or later. Cases have been known in which the brittleness approaches that of neat cement of the same thickness as the plate. It occurs only in the seam of the boiler, either due to the fact that the joints are at higher stresses here than in the rest of the plate, or that the joints are the only place in which this solution can concentrate, and it is known that unconcentrated solution does not attack steel at all. The cracks that result are distinguished from ordinary forms of cracking by the following characteristics:

They are more fully developed at the surfaces of the contact of the joints than they are at other surfaces, so that a crack at a rivet hole will often measure ¾ in. on the contact surface of a ½-in. plate without showing at all on the other surface; in other words, the surface of the crack itself is usually triangular, with the base of the triangle on the contact surface. They usually originate at the rivet holes and show scarcely any tendency to follow the lines of stress. Running from adjacent rivet holes, two cracks will often pass each other and after passing, join, leaving an island in the plate; that is, the cracks show no strong tendency to join each other. They change their direction sharply and often, to an extent of 90 deg.; they are always unaccompanied by any elongation of the plate; and finally, they are always, of course, below the water line.

The statement made to the author gave also a number of cases of such defective plates. Among others were named the boilers of the U. S. Torpedo Boat Destroyer *Aylwin*, wherein occurred a fracture of one drum, and cracking of one or more drums of three boilers out of four; also the U. S. Coast Guard Cutter *Unalga*, where a cracking of one drum out of two in a period of operation of about fourteen months was noted. The statement concluded by a note to the effect

that in the case of the Coast Guard Service, an order had been issued discontinuing the use of the Navy compound.

Because the treatment, at least in this form, originated in the Navy Department, because the *Aylwin's* boilers were cited among others as having failed from this cause, and because the Navy boilers are operated in general with water that is practically free from sulphates, the statements with reference to Navy experience were investigated as fully as possible, and the following facts were developed:

The use of Navy compound has not been discontinued in the Navy, but the compound is used ordinarily only in sufficient quantity to maintain the water in the boiler at a low alkaline strength, and not above ½ of 1 per cent normal, the point at which corrosion changes in character from general corrosion to local corrosion or pitting. In a steaming boiler no difficulty is experienced in maintaining the alkaline strength of the water at or above 3 per cent normal; but naval boilers are idle during a large part of the time, and owing to the fact that the compound does not remain in solution in idle boilers, but settles to the bottom, the alkaline strength of the water in the upper part of the boiler frequently falls between the limits of 1 per cent and 2.5 per cent of normal. As is well known, the effect of this alkaline strength is to promote corrosion in its most dangerous form—local corrosion or pitting.

The early experiments with the boiler compound determined the facts that good steel will corrode almost evenly over its entire wetted surface when placed in distilled water, and that as boiler compound is added to give the water a low alkaline strength, the rate of corrosion is somewhat decreased, but the character of the corrosion remains the same. Therefore, low alkalinity inhibits all but a light general corrosion, which is so small in amount that its effect may be disregarded for practical purposes.

Further, since the Navy uses distilled water to a large extent, only small quantities of scale-forming substances are ever present in the boilers, and hence large amounts of boiler compound are not required to prevent the formation of scale.

In the case of the *Aylwin's* boilers the Naval Engineering Experiment Station conducted an extensive investigation of the rupture of the drum, and authority was granted for a representative of the manufacturer to be present during the tests. The conclusions of this investigation were that no experimental or other evidence indicated that the failure of the *Aylwin's* boiler was due to the use of boiler compound containing sodium carbonate or sodium hydrate.

It is needless to say that any condition of design or construction that causes leaky seams which can be made tight only by excessive caulking might possibly produce brittleness in the metal of the plate.

The White-Forster boiler installed in the *Aylwin* class has D-shaped water drums, similar to the Yarrow type. In practice, it was found impossible to keep the seams of the White-Forster boiler tight, owing to the tendency of the drum to assume a circular shape under pressure. The manufacturers of this boiler have since corrected this by placing struts in these drums across the long diameter. It is also understood that similar trouble has not been experienced with Yarrow boilers.

With reference to the *Unalga* as another vessel having had trouble of a similar nature, not enough is known at the present time upon which to venture a statement as to the cause of failure. It is known, however, that the cracks in the steam drum plates of these boilers are similar to those observed in the *Aylwin's* lower drum plates; that the manufacturer of the boiler has conducted tests of the material, and that at the suggestion of the company the Naval Engineering Experiment Station will soon begin an independent examination and investigation of the material with a view to determining the cause of the peculiar conditions existing. It has also been learned that boiler compound in considerable quantity was used in this boiler, and that another vessel with a duplicate boiler, but in which only small quantities of the compound were used, has not had trouble.

APPENDIX

SYNOPSIS OF INVESTIGATIONS BY FRANK LYON, LIEUTENANT-COMMANDER U. S. NAVY[1]

From July, 1896, to August, 1899, Commander Lyon was Assistant Engineer, *U. S. S. Oregon*, and for the greater part of the time was in direct charge of her boilers. The feed water was kept in practically an open tank and was kept so strongly alkaline as to render it unfit for ordinary purposes. In this vessel corrosion of boilers was almost unknown.

From May, 1906, to May, 1909, Mr. Lyon was Senior Engineer Officer of the *U. S. S. New Jersey*. Troubles from corrosion were experienced throughout the three years. The corrosion was most noticeable in the piping in which the water was heated more or less between its entrance to and exit from the system.

The *Oregon* had fire tubular boilers and the *New Jersey* Babcock and Wilcox boilers. The water in the latter was kept slightly alkaline, but owing to fear of priming in these small drum boilers, it was never kept as alkaline as that in the *Oregon's* boilers. It was felt that every effort to prevent corrosion and to keep the boilers clean had been made, yet destructive local corrosion was going on and increasing in effect in spite of the zincs, non-acidity of the water, cleaning and other efforts to stop it. The Navy regulations had been followed, and experiments made, yet Mr. Lyon had failed in every particular to stop corrosion of metals having their surfaces in contact with water, and he was detached from that duty and left, knowing that there was something woefully wrong in the methods he had pursued and with the general methods of treating corrosion on shipboard.

With this excellent grounding in a knowledge of the effects of corrosion, he began at the Naval Engineering Experiment Station an experimental investigation of the problem of preventing corrosion. Tests were made in distilled, sea and brackish waters, in diluted sea and brackish waters with jars open and closed; in steel pots, glass jars and in a boiler. Very soon after starting this investigation it was seen that in the untreated distilled or in fresh waters the specimens of steel corroded all over; that as the concentrations[2] increased, the rate of corrosion at first decreased slightly and then began to increase. In the concentration where the rate showed an increase there were always evidences of local corrosion or pitting, and as the concentrations increased the rate of loss increased to a maximum, then fell rapidly to zero and remained there, the areas of local corrosion becoming smaller and more pronounced until they disappeared altogether in the concentration in which the loss was zero.

The concentration whose strength is just below the one in which local corrosion or pitting first appears, he called the lower-limit concentration; the one in which the rate of corrosion is a maximum, the critical; and the one just above the one in which the last signs of corrosion appear the upper-limit one for the metal tested.

In general the fundamental fact was established that if the

[1] The Journal of the American Society of Naval Engineers, August, 1912. Navy Department, Washington, D. C. Price $1.30 postpaid. Reprints of this article are also available. Many of the paragraphs above which refer to Mr. Lyon's work are abstracted liberally from his article.

[2] In this discussion, the concentrations mentioned are the alkaline salts in the water expressed in percentages of "normal solution." Equal volumes of normal solutions will just satisfy a chemical reaction completely without any surplus of reagents remaining on either side of the equation.

solution is kept sufficiently concentrated with sodium carbonate, corrosion is inhibited. That is the sum and substance of it.

Also, that the order of magnitude in which corrosion occurs in distilled-water solutions in the normal concentration of sodium nitrate, chloride and sulphate was in about the order of the strength of the acid radicals.

The upper and lower limit concentrations in those solutions in which they are found, vary with the metals immersed, and with the conditions of the surface of the metal in contact with the solution, both with regard to impurities in it and to the physical treatment it has received.

The last two points are very important to remember as accounting for local corrosions; and also this vital point:

That the rate of loss in the critical concentration is greater than that in the untreated water. In other words, it is better not to treat the water at all than to treat it near the critical values, and this can be done very readily by pouring compound into a boiler without paying attention to what the concentration is in the boiler, a fact that demonstrates the necessity for the individual testing of the water in the individual boiler under steaming conditions.

The limit and critical concentrations of the following solutions for one grade of steel were determined very carefully. Expressed in percentages of normal strength in distilled water, they are:

Solution	Upper limit	Critical	Lower limit
Sodium carbonate (calcined)	2.6	0.8	0.16
Caustic soda	2.6	0.8	0.16
Lime	2.6	0.6	0.15

These are the three salts used extensively in boiler treatment. They have practically the same characteristics as regards solution pressure, which is the measure of the tendency to corrosion.

Further work along these lines with open jars showed that the concentration of lime solutions weakened very rapidly, while those in caustic soda, sodium carbonate, disodium phosphate and the chromates maintained or increased their concentration as the water evaporated. Solutions of lime water exposed to the air may be non-corrosive to steel one day and corrosive the next, due to the absorption of carbonic acid from the air, while if the upper-limit concentration of sodium carbonate is made, steel thrown in it will not corrode until the concentration is brought below the upper limit by some external means.

The English of that is, use sodium carbonate if possible; do not use lime unless forced to, and when lime is used be careful not to work near the critical value.

Commander Lyon found that steel connected to copper by a good metallic conductor does not corrode in an upper-limit concentration of sodium carbonate, lime, caustic soda or disodium phosphate. In similar concentrations air, oxygen, carbonic acid gas, graphite, zinc oxide, mill scale, and other supposed exciters of corrosion have no effect upon steel or iron until the concentration is reduced below the upper limit for that steel. Steel was suspended in a glass basin in, and above, the limit concentration of sodium carbonate, and pure oxygen was blown under it in such a way that sixty bubbles a minute impinged on the steel and passed up along its sides; this continued for eight days, and no signs of corrosion were evident, and there were no losses of weight. This was continued for fifteen days longer, using air instead of oxygen, with the same result.

Zinc, being of higher potential than iron, will corrode in an upper-limit concentration for iron or steel.

It was found that the upper-limit concentrations for all irons and steels was about 2.6 per cent normal alkaline strength of sodium carbonate and of caustic soda solutions, in distilled and in sea-water. The highest concentration of any of these chemicals in which corrosion was found is 2.5 per cent of normal.

With pure feed water, sodium carbonate and trisodium phosphate, properly proportioned, will stop corrosion and priming if enough of the mixture is used. If impure water is used, then sodium carbonate, trisodium phosphate and cutch (containing tannic acid), when used in the right amounts, will stop corrosion, prevent priming, and also prevent scale from forming unless the saturation of sludge gets too high. Such a mixture is the Navy Standard Boiler Compound; and if by the use of this compound, the water in the boiler is always kept at a concentration of or above 3 per cent normal alkaline strength, no corrosion will take place, no scale will form and the water will be no more likely to prime than it would be if it were untreated.

The ingredients of the Navy compound are intimately united by thorough digestion, dried, finely powdered, and well mixed. They are readily soluble in water. The compound must show on analysis at least 76 per cent of anhydrous sodium carbonate (Na_2CO_3), 10 per cent of trisodium phosphate (Na_3PO_4, $12H_2O$), 1 per cent of dextrine or starch, and sufficient cutch to yield at least 2 per cent of tannic acid, the remainder to consist of water and only such impurities as are common to the ingredients.

These investigations demonstrated why the boilers of the *Oregon* showed no signs of corrosion in three years, and why those of the *New Jersey* were considerably corroded in the same time. In the one the corrosion had been prevented by keeping the water strictly alkaline; in the other it had been materially aided by an insufficient degree of alkalinity. Mr. Lyon's conclusions are tersely expressed as follows:

"The writer has no hesitancy in saying that any boiler using any water can be kept free from corroding for any length of time if treated with soda, and if its concentration is maintained at or above 3 per cent normal alkaline strength. If the water is not to be kept sufficiently alkaline, it had better be kept neutral."—A statement that is absolutely borne out by the results of his treatment as applied at the Fruitvale power plant according to his method.

DISCUSSION

WALTER M. MCFARLAND. It is unpleasant to have to say that a number of the statements in this paper (as relating to marine boilers) are entirely inaccurate.

It is stated that the White-Forster boilers were of such design that it was impossible to keep the joints tight ordinarily. That statement is incorrect. The company with which I am connected has built all the White-Forster boilers constructed in this country, and I know of a large number used in the British Navy; and the boilers have given satisfaction generally.

A great deal might be said about this whole soda question, which is a very complicated one. I do not propose to go into it at length now, but some facts should be brought out. The *Unalga* was mentioned as having had boiler troubles, and it was said it was not known whether the trouble was due to soda or not, although it was mentioned there was some difference between the conditions on this vessel and a similar vessel.

The facts are that two vessels, the *Unalga* and the *Miami*, were built. They were sister ships, with identical boilers, and everything else,—and were put into commission at the same time. After the boilers of the *Unalga* gave trouble, the details of which I will not go into now, the suggestion was made to look into this soda question. It was found that in the preceding period of about eighteen months, since the boat had been commissioned, the *Unalga* had used 3,300 lb. of soda in her boilers, and the *Miami* had used only 300 lb. and had never had any trouble. The officials of the Coast Guard decided that it was undoubtedly soda which caused the trouble. They rescinded at once the order requiring soda to be used so that the strength of the solution should not be less than 3 per cent of a normal alkaline solution; and they ordered the present practice, which makes the water slightly alkaline, so that it is only a little more than neutral,—one-half of 1 per cent. of a normal solution.

The drum plates of the *Unalga* were badly cracked and the drums were condemned by the Coast Guard officials, removed,

and replaced by new ones. Very shortly after that, this matter was called to the attention of the Navy Department; and after the Navy officials looked into the story of the *Unalga* and what had happened, they also rescinded the order that not less than a 3 per cent of normal solution should be used. Since then they have been using one-half of 1 per cent solution.

There is another point in the paper to which I object. (I understand, of course, that the author and his associates got their information as best they could, but it is unfortunate that these erroneous statements should be made.) The statement is made, in the case of the *Aylwin*, that an investigation was made by the Naval Experiment Station at Annapolis, at which the manufacturer was permitted to have a representative present; and it was settled that the trouble with her boiler was not in any way due to soda.

As a matter of fact, there was a preliminary report from the physicist of the Experiment Station, but the matter is still under investigation at the Experiment Station and has not yet been settled. There is a great deal to be said about the matter; it is very complicated, and requires the most careful study and investigation. The reason for this is not because there is any doubt in the minds of those who have studied the subject, but the deleterious action of soda comes as such a surprise to those who encounter it for the first time that they want to investigate it carefully before endorsing this explanation of the phenomena.

I am authorized to say that later on, at the proper time, men who have made a very exhaustive study of this whole effect of soda solutions on boiler seams will prepare a paper, probably for this Society, which will give the latest possible information on the subject.

Geo. H. Gibson said that he believed that the return to treating feed water inside the boiler, as advocated in this paper, is a step backwards, at least for stationary plants. That corrosion will not occur in a solution of proper alkalinity was originally demonstrated, he believed, by the German investigators Heyn and Bauer. Where water is treated externally to boilers, a greater or smaller excess of reagent is employed, which accumulates in the boilers, and the concentration of alkalinity can be controlled by periodic blowing down. If the water is treated cold, however, a considerable amount of scale and sludge forming solids fail to be eliminated in the softening system, as pointed out in the paper. On the other hand, if the water is treated above 170 or 180 deg. fahr., the reactions are practically instantaneous and the precipitate formed is coarse and settles rapidly. It is certainly better to remove these solids before the water enters the boilers, as practised in modern hot process softening systems, wherein the water is first heated and de-aerated by spraying through a steam bath before the chemical reagents are added. The proportions of the chemical should be based on an analysis of the water, and lime, as well as soda, is necessary for the correct treatment of many waters. In this way practically all of the scale or sludge-forming substances can be eliminated, as will be seen from the following analyses of water before and after treatment, as obtained in large steam plants.

	Grains per U. S. Gallon	
	Before Softening	After Softening
Total dissolved solids	21.49	18.25
Total incrusting solids	18.28	1.35
Total dissolved solids	19.44	21.01
Total incrusting solids	9.04	0.32

The first analysis quoted shows that the water before treatment contained over eighteen grains per gallon of incrusting solids. After treatment it contained 1.35 grains and the excess of reagent used is 0.88 grain of sodium carbonate and 1.22 grains of sodium hydrate. The second sample was a water which not only deposited scale but caused corrosion, the corrosion being due to the presence of free sulphuric acid. Before treatment, this water contained 9 grains of incrusting solids and after treatment 0.32 grain. The excess of treating reagent used was 3.18 grains of sodium carbonate and 0.33 grain of sodium hydrate. He could give further examples, but these illustrate the point at issue.

This elimination of scale and sludge forming solids is found more important in preventing foaming and priming than is the keeping down of alkalinity in the boiler, as pointed out in the paper. As a matter of fact, boilers can be operated successfully at heavy overloads with high alkalinity, but not with high alkalinity combined with a large amount of sludge in the water.

A good example is presented by analyses obtained at one of the boiler plants of the U. S. Navy Department. Before the water softening system was installed at this plant, a great deal of trouble was experienced, but whether the Navy compound was tried or not he did not know. The total incrusting solids in this water were 23.29 grains. It was impossible to operate the boilers up to rating; there was severe priming, and it was found necessary to shut down part of the plant and turn off a number of lights and use less steam in order to carry the balance of the plant. It was the practice to wash the boilers out every 24 hours. After the water softening system was put in, treating the water hot, the incrusting solids were reduced to 1.75 grains, and the boilers operated successfully, although there was present in the water 67.63 grains of soluble salts.

The elimination of sludge is also desirable, because of the fact that sludge is carried over by even slight priming, and its accumulation may cause burning of superheating surface, lubrication troubles, and filling up of turbine blades. Such removal is doubtful where the precipitation of solids is brought about in the boiler itself, as advocated in this paper.

M. F. Newman (written). The author's comparison of the difference in operating conditions between the use of hard, corroding feed water, and when subjecting the feed water to treatment with compound within the boilers is merely an illustration of changing the lime and magnesia salts into precipitates of such a form that they do not adhere to the surfaces within the boiler and the effect of introducing an alkali to combine with acid radicals that, under ordinary circumstances, would be free to attack the boiler metal.

The action of boiler compounds for the precipitation of lime and magnesia and the neutralizing of harmful acids has long been thoroughly understood, and it is well known that the addition of starch and tannin to a compound consisting principally of sodium salts tends to prevent the adherence of the precipitated lime and magnesia.

While the method described by the author may be considered novel, it is by no means rational, since to impurities already present in the boiler feed there is being added more impurities, so that the final effect is to increase the impurities in the water in the boiler without any compensation in the way of removing or freeing the water from suspended matter.

The application of precipitants to water within the boiler is irrational and at the best is a mere makeshift. In the process of generating steam nothing but pure water is evapor-

ated so that there is a constant building up of impurities in the water remaining in the boiler. This applies to the soluble salts as well as the suspended matter.

When the reactions for the precipitation of lime and magnesia are carried on within the boiler, the result is to befoul the water with suspended matter and increase its density with soluble salts, so that more fuel is required for the generation of steam and a more frequent changing of the water to eliminate the soluble solids, as well as the suspended matter collected.

The logical method of overcoming scale and corrosion in steam boilers is to properly soften and purify the water by removing all permanent hardness, eliminating or neutralizing all acids, and reducing the remaining scale-forming substances to less than 3 grains per U. S. gallon, maintaining the alkalinity in the purified water between 3 and 4 deg. (1 deg. equivalent to 1 gr. calcium carbonate per U. S. gal.) with the effluent clear and free from suspended matter. Such a softened and purified water constantly supplied to boilers will not form scale or cause corrosion.

As an illustration of the results accomplished by this rational method with a properly designed apparatus, the following analyses of raw and softened water are submitted to show water from widely differing sources in close agreement as to alkalinity and softness.

ANALYSES OF RAW AND SOFTENED WATER

	A	B	C	D
	Grains per U. S. Gallon			
Volatile and Organic Matter	1.45	1.35	.75	.65
Silica	.65	.45	.35	.45
Iron and Alumina Oxides	trace	trace	trace	trace
Calcium Carbonate	17.75	1.75	10.50	1.50
Calcium Sulphate	3.06	....	....	....
Magnesium Carbonate	....	....	3.99	....
Magnesium Sulphate	12.42	....	5.07	....
Magnesium Chloride	....	....	.96	....
Magnesium Nitrate	....	....	.21	....
Magnesium Hydrate	....	.23	....	.52
Sodium Sulphate	25.77	43.59	....	6.18
Sodium Chloride	16.15	17.63	.13	1.32
Sodium Carbonate	....	.80	....	1.06
Sodium Hydrate	....	.68	....	.08
Sodium Nitrate	....	....	.21	.24
Total Solids	77.25	66.48	21.96	12.00
Suspended Matter	.15	trace	.15	trace
Free Carbonic Acid	.44	none	.44	none
Alkalinity	17.75	3.75	15.25	3.50
Incrusting Solids	33.88	2.43	21.08	2.47
Non-Incrusting Solids	41.92	62.70	.13	8.88

Analysis A Water from Shallow Creek Bank Well, Enderlin, N. D.
Analysis B Same water as A after softening.
Analysis C Spring water from Clarkdale, Ariz.
Analysis D Same water as C after softening.

Howard Stillman (written).—Concerning the use of the 3 per cent normal alkalinity and the Navy compound on locomotive boilers in main line service, I quite differ from Mr. Babcock as to results obtained on the locomotive boilers he has experimented with. In the first place Commander Lyon states distinctly that very rapid local pitting and corrosion occurs with alkaline solution under 2.6 per cent, placing the concentration of 3 per cent as the upper limit at which corrosion will positively stop. This concentration is equivalent to 92.7 gr. sodium carbonate per gallon, or 12.2 lb. per 1,000 gal., an amount of soluble matter locomotive boilers cannot carry without excessive foaming and priming. With the use of the Navy compound on locomotives Mr. Babcock is maintaining less than 1 per cent normal alkalinity, and there seems to be no reason to expect a decrease in corrosion under these circumstances, inasmuch as the potential of the liquid is considerably less than that of the metal with which it is in contact. The evidence brought out by Commander Lyon's paper indicated that corrosion would not stop until the potential of the liquid was in excess of the metal, and that 2.6 per cent normal alkalinity was required to produce this.

On many occasions I have inspected locomotive boilers using the Navy compound and as yet do not find any evidence of decrease in pitting and corrosion in bad water districts.

The Mallet Consolidation engine 4031 to which Mr. Babcock refers, was first placed in service with new firebox on Dec. 20, 1912. The Navy compound was first used in July, 1914, and maintained until June, 1915, when the engine was withdrawn from service and condemned for new firebox. During the interval the engine ran 19,790 miles. I made a thorough inspection of the firebox in the boiler shop after it had been removed, and found the crown sheet badly pitted and corroded on the water side. The Navy compound was used for a period covering but 43 per cent of the engine's mileage, but the extent of the pitting and corrosion appeared to exceed that shown by the firebox of an engine of the same class in like service on the same district, that had used Navy compound only 4 per cent of its mileage, practically none. The evidence from engine 4031 does not appear to bear out Mr. Babcock's statement regarding the effect of the compound in lengthening the life of the boiler. This engine was shopped, not for machinery, but for boiler repairs, with a firebox mileage of but 45,501.

Mr. Babcock states that the new water at Bakersfield is very light. The engineers in this district state that it appears to be light only when used with Navy compound. On engines not using Navy compound no trouble is experienced with "lightness" of this water.

Nothing new is here brought out regarding the specific action of carbonates or phosphates of soda, of which the Navy compound is composed chiefly, on such solids as produce permanent hardness. The compound is effective in breaking up and decreasing scale formation, throwing out such matter within the boiler as insoluble carbonates or phosphates in definite proportion.

The tendency for boiler water to foam and prime is a direct function of the rate of evaporation demanded. The evaporation of the Fruitvale boilers was shown by official test to be approximately 3.7 lb. equivalent per sq. ft. of heating surface per hour. My test records of the Mallet locomotive boilers show the corresponding equivalent to be at the rate of 7.937 lb., or an increase over the stationary practice of 114 per cent. There is a great deal of complaint from our mechanical department on the district over which the Navy compound has been used from foaming and priming.

Mr. Babcock makes reference to the use of trisodium phosphate as a specific against foaming. The evidence in operation of our power does not show this to be true. He states that trisodium phosphate prevents the rise of the surface tension of the solution and consequent priming. I do not find any verification of this statement in principle.

The Navy compound is being applied by Mr. Babcock most generally to superheater locomotives. Superheaters are placed in boilers at considerable expense, and if, owing to circumstances, their superheating surface is converted to evaporating surface, as with priming, their efficiency is impaired in direct proportion.

In order to determine the loss of superheat efficiency from this cause, tests were made with Mikado engine 3239 in passenger service between Los Angeles and San Luis Obispo, a run of 223 miles. This engine is one of our latest type Mikados, 26x28 in. cylinders, 210,400 lb. on drivers, and 63 in. wheel. It has used the Navy compound and trisodium phosphate since July, 1915. Full details of these tests are on file, and a summary of them is here given.

TABLE 1 EFFECT OF NAVY COMPOUND IN LOCOMOTIVE OPERATION

	Out Trip—L. A. to S. L. O.		In Trip—S. L. O. to L. A.		Totals and Averages	
Date	9-23-15	9-28-15	9-24-15	9-29-15		
Navy Comp. & Tri-Sod. Phos.	with	without	with	without	with	without
Gal. fuel oil per 1000 ton-miles	17.59	16.32	11.26	10.78	13.55	12.74
Aversge superheat, deg. fahr...	191	265	242	249	221	254
Per cent more fuel per 1000 tou-miles	7.78	....	4.45	....	6.35	....
Per cent less superheat	27.92	....	2.81	....	12.99	....

The excesses shown for the outward trip are due to the treatment with 5 lb. Navy compound and 9 lb. trisodium phosphate, given at Los Angeles. With no treatment at San Luis Obispo on return trip the losses were less.

Regarding the instructions that engineers operating engines which are being treated with this compound should, as often as necessary, avail themselves of the opportunity to use the blow-off cock, heat losses from blowing off are directly proportional to the volume of water wasted and heat units therein at 200 lb. pressure.

F. F. Vater contributed a written discussion, in which he stated that the water used at Fruitvale is not a bad water; as far as the analysis shows, the only corrosive elements are nitrate of lime and chloride of magnesium. In any properly operated treating plant, these two substances would have been changed to sodium chloride and sodium nitrate, both of which are inert. The analysis says nothing of the dissolved oxygen, which may or may not have been present; if present, it would have a material bearing on the trouble.

If there were no dissolved oxygen in the water after passing through the softening plant, absolutely nothing of a corrosive nature remained in the water after treatment. This being true beyond argument, he suggested that the cause of the pitting and corrosion lay entirely outside the quality of the water, and that an intelligent search would have developed the cause.

J. H. Andrew has definitely shown that a saturated solution of caustic soda will embrittle iron and steel plates by occlusion of hydrogen. At boiler temperatures it is well known that soda ash yields up its carbonic acid, changing to caustic soda. We have, therefore, in the boiler caustic soda in a dilute solution, knowing that caustic soda in saturated solution crystalizes steel and iron.

A score of plants use in their boilers well water containing sodium carbonate, and have had trouble with cracked plates, tears, ruptures and boiler explosions. It cannot be proven that soda ash was the cause, because a wide gap exists between a saturated solution, such as used by Mr. Andrew, and a dilute solution, which is all that could exist in the boiler. We know that in saturated solution the crystallization of the metal takes place in short periods of time, numbered by days. We know further that several years' time elapsed between the introduction of the water containing sodium carbonate and the culmination of the trouble.

It stands to reason that a dilute solution will bring about the same effect, given sufficient time, that a saturated solution will bring about in a short time. In none of the cases where trouble came, due to crystallized plates, did the alkalinity of the water entering the boiler equal 1/200 part normal. What then will occur in time to a boiler in which 3 per cent normal alkalinity is maintained?

He did not like the density of the water where Navy compound is used. Neglecting the starch, trisodium phosphate or tannic acid at Fruitvale, we have a saturation of 998.667 grains per gallon, corresponding to a density of 1.017. Sea water has densities ranging from 1.026 to 1.03. He had seen tube after tube burned out in cases where the water had a density of 1.0032. Rather than take any chances beyond 1.0032, he would use barium hydrate to precipitate the sulphate, and get rid of the sodium sulphate end product.

Mr. Babcock speaks of loss of tubes since the adoption of the Navy compound, from other causes than pitting and corrosion. To him, the cause is excessive density of the water evaporated, and the wonder is that the tube loss from density is not greater than the tube loss from pitting and corrosion.

The whole tendency of the times in boiler practice is to obtain pure waters. With pure water high evaporative capacities can be obtained without trouble, and this cannot be done by using Navy compound. With boilers constructed of pure metal, waters treated hot, and low excess of soda ash, much more economical boiler performance will be obtained, and no pitting or corrosion due to auto-electrolysis or anything else will occur.

L. M. Booth[1] (written). It is surprising that Mr. Babcock should have been content to follow, without modification, the error of Mr. Lyon of feeding to boilers a substance like carbonate of soda which contains over 41 per cent carbon dioxide, —itself a fruitful cause of corrosion. It is safe to assume that, by the use of such a large quantity of soda ash in boilers, he has transferred some of his corrosion troubles to steam lines and other surfaces beyond the boilers.

The record of the reduction of corrosion is important, although the author would have had greater success by a judicious use of caustic soda instead of sodium carbonate. It is a fact that sodium carbonate changes to caustic soda in the boiler, so why add the corrosive carbon dioxide which must necessarily be promptly expelled with the steam to get in its corrosive work elsewhere? Besides, the water in question is one which requires a caustic treatment instead of a carbonate treatment.

All of the chemical information available on boiler water treatment is none too much to command when tackling a corrosion problem, so it seems that the author's "one corrective to all waters" is an endeavor to make the task more easy and simple than it really is. In the first place, let it be understood that by the elimination of the lime process—assuming that it was efficiently carried out—there was fed to the boilers of this power plant, every day of service on the rating basis, 668 lb. of sludge which might just as well have been diverted to the sewer. The presence of this suspended matter, 1 lb. per 1000 gal. of water evaporated, increases the tendency of foaming and necessitates more blowing off than if Mr. Babcock had used the lime process on the feed water as preliminary to the excess soda method in the boilers.

While no data are given to show the quality of the water delivered by the water treatment plant which was abandoned for the Navy compound process, it is to be assumed that the water was not properly treated, since in Mr. Geibel's supplement are recorded unfavorable results in transformer cooling coils, etc., and also that there was hard scale in the boilers.

I wish to endorse the general plan of testing the boiler blow-off water, although I recommend tests be made to determine the amount of suspended matter, in addition to the alka-

[1] President, L. M. Booth Co., Hudson and Morris Sts., Jersey City, N. J.

linity tests described. The additional information is valuable and it is but slight trouble to obtain it, the process being much quicker and simpler than the alkalinity test.

William Kent said it seems the author has established his point in regard to the particular water dealt with, but the paper contains no reference to water treatment in general.

He thought several terms in the paper should be made clearer, for instance, "3 per cent normal," "back shopping," "engine left in chain gang," "light water," etc.

Regarding the composition of the Navy compound, he thought the expression "sufficient cutch to yield at least 2 per cent tannic acid" should be translated so that engineers could go to the chemical manufacturer and buy the materials for making the compound.

E. N. Trump thought the paper implies that the cracking is due to excess of caustic soda, whereas it has not been proven that caustic soda is the cause of the cracking of steel. It may be the cause of cracking of some kinds of steel, but not enough is known about the subject to make exact determinations. He had undertaken many investigations and performed various kinds of experiments to find out the cause of the cracking of steel in contact with caustic soda, but so far without result.

He thought the statements made in the paper in this connection are not based on adequate scientific investigation. From his experience there certainly existed no cracking because of carbonate of soda. An excess of caustic soda appears in some instances to give trouble, but only in the case of certain kinds of steel.

Frederick E. Geibel said, in reply to a question by E. P. Bates, it was found in experiments that corrosion was most rapid with a temperature of 190 deg. fahr., and results with the boilers in service checked with experimental figures.

J. F. Walsh explained the shop terms questioned by Professor Kent. He said "back shopping" refers to putting a locomotive in what is termed the "back shop" after it is practically worn out. In this shop the flues are ordinarily removed, and the entire engine, boiler and parts thoroughly overhauled.

The term "chain gang" is used in the practice of running engines with other than regularly assigned crews, where the crews vary from trip to trip. A chain gang is such a crew.

"Light water" is water which foams easily. Such water is likely to be carried over into the cylinders and cause much trouble.

The Author. In answer to those advocating pre-treating of the boiler water, I might say that any method of purifying the water before it enters the boiler is certainly preferable, all things considered. The hot treatment is believed to be more effective than the cold, but is necessarily not applicable to water for locomotives. The cold treatment has been used very extensively, but unless water is given ample time to settle, the desired results are not obtained. Recent experience with lime-treated water by the cold process bears out the statement made by Commander Lyon—that lime water under certain conditions is highly corrosive.

Mr. McFarland promises some further data on the destructive action on boilers carrying water at high alkalinities. Since our experience has failed to develop a single case of trouble from this source, his paper will be received with much interest. It is to be hoped that he will be sufficiently explicit, and that his statements will be sufficiently supported by unbiased evidence to justify his charges that many of my statements are inaccurate.

It is quite evident that Mr. Stillman has not followed personally the tests on locomotive boilers using Navy compound. No attempt has been made to carry a 3 per cent solution in locomotive boilers, but only a sufficient quantity to prevent scale and corrosion. The mileage on Engine 4031 given by Mr. Stillman may not be considered as a very good record, but it is 59 per cent greater than the previous record of this same engine not using the compound. His statements in regard to the effect of the compound on the superheat are based only on one round trip. Fuel records on eleven superheat engines over a period of twenty months show a 5 per cent decrease in gallons of fuel per 1000 ton-miles in favor of the engines treated with Navy compound. And he persists in a total lack of appreciation of the well-known fact that a boiler can better be blown off by a series of quick, short blasts than by opening the cock wide for several minutes. Furthermore, he fails apparently to comprehend the meaning of the upper and the lower limits fixed by Lyon's investigation, beyond which *in both directions* corrosion does not occur. The zones between neutrality and the lower limit, and between the upper limit and any higher degree of alkalinity yet observed, are those of no corrosion. (See "Effect of varying degree of concentration of alkaline solutions," in paper by Lieut.-Com. Frank Lyon.[1])

The remainder of Mr. Stillman's discussion is founded on evidence derived from sources we have long since found to be unreliable.

In a paper before the American Waterworks Association at its Urbana meeting in 1915, W. A. Pownall covered the subject of soda ash treatment of water for locomotive use in a comprehensive manner. The paper stated:

"The prevention of scale formation may be accomplished by using water softeners which remove practically all of the hardness and suspended solids, or by treating each supply of water with enough soda ash to neutralize the sulphate hardness and provide a slight excess (of soda ash), all of the scale forming solids being converted into a soft sludge which can be readily blown out through a properly located blow-off cock. Soda ash or sodium carbonate is found in some waters, and unless it is so high as to cause foaming trouble, waters of this type are desirable for boiler purposes in that they will not form scale and require no treatment. The Wabash Railroad has sodium carbonate waters at Mansfield, Bement, Sidney and Stonington, Ill., and would like to find more supplies like them, but unfortunately most waters contain sulphate hardness and must be treated.

The soda ash is changed to sodium sulphate in the boiler, and locomotive boilers worked to full capacity and using surface waters will usually be in a foaming condition when this sodium sulphate (and other sodium salts) in water from the boiler are over 2000 parts per million. Where only clear well waters are used, this limit will be 2500, or even higher, and in stationary boilers, with their lower rate of evaporation and greater steam space, the foaming point may be 5000 to 6000 parts per million. The mud and carbonates precipitated in the boiler may cause trouble in three ways:

1 The foaming tendency of the water in the boiler increases.
2 Heavier scale will form at times when treatment is light.
3 There is danger in mud-burning.

It is essential, therefore, that engines using soda ash treated water be equipped with suitable blow-off arrangements for removing the sludge from the boiler."

[1] Jour Am. Soc. Nav. Engrs., August, 1912.

CAPACITY AND ECONOMY OF MULTIPLE EVAPORATORS

BY E. W. KERR, BATON ROUGE, LA.

Member of the Society

DURING the last few years, the author has carried on a large number of investigations of both the capacity and economy of multiple evaporators and vacuum pans. This work has been done in the laboratory on a small apparatus, and in sugar factories on apparatus of commercial size and under regular operating conditions. The results of much of the laboratory work were given in a former paper before this Society,[1] and the object of the present paper is to give results of experiments made since the first paper was written, together with certain general observations.

The process of evaporating in sugar factory work consists of two distinct parts: *First*, the juice with a density of 12 deg. to 18 deg. Brix[2] is concentrated by evaporating off part of its water to approximately 55 deg. Brix in a multiple evaporator. *Second*, the syrup produced is then taken to a vacuum pan working single-effect, and where further water is removed by

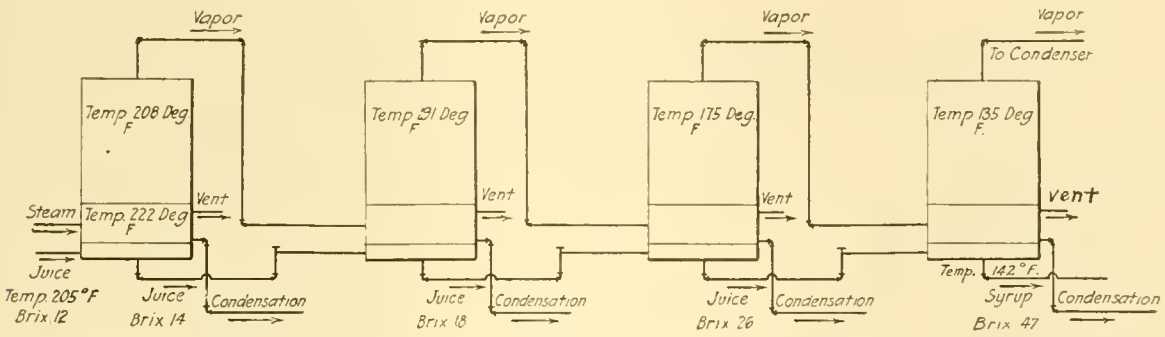

FIG. 1 QUADRUPLE EFFECT FOR SUGAR JUICES. TEMPERATURES AND DENSITIES OBTAINED FROM TEST

[1] Tests upon the Transmission of Heat in Vacuum Evaporators, Trans. Am.Soc.M.E., vol. 35, p. 731.

[2] The Brix saccharometer or hydrometer indicates directly the percentage of sugar dissolved.

SYNOPSIS OF PAPER

This paper discusses the capacity and economy of multiple evaporators used in the process of manufacture of cane sugar. The paper is the second paper presented to the Society by the author on this subject, the first given two years ago dealing with laboratory apparatus of the same type. The complete results of the author's tests on multiple effect evaporators under regular operating conditions, as embodied in the second paper, are given herewith, together with an adequate summary of the balance of this paper.

In the tests of capacity and economy recorded, a typical log included observations of the pressure of vacuum in the steam or vapor space of each body; temperature and density of juice entering and leaving; weight of juice entering or leaving; weight of condensed steam from the first body, etc. The evaporators tested included double, triple and quadruple effects of the vertical submerged tube, the horizontal steam tube, the horizontal film, and the vertical film types, also the first of these with special steam distribution and running under vacuum, and again with atmospheric pressure in the last body, and lastly vertical steam tube evaporators with special means for venting each tube. Various methods of removing condensation and of venting the incondensable gases were employed, and the tests were made under several conditions of heating surface.

The types of evaporators tested were: A, vertical submerged tube (so-called standard); B, horizontal steam tube; C, horizontal film; D, vertical film; E, standard type with special baffle and under vacuum; F, same as E but no vacuum; and G, vertical steam tubes with special means for venting each tube.

All the types tested are illustrated in the paper, and results of all tests are given in tables and curves. Table 1 summarizes the principal data from the tests, and Table 5 gives all the data relative to economy.

The tests showed a great variation in the coefficient of heat transmission, not only for different types, but in different evaporators of a given type. This variation was due to difference of design and operation, including steam velocity and density, method of venting, cleanliness of heating surface on both steam and juice sides, velocity of liquor circulation, density and purity of liquor and height of boiling.

The coefficients of heat transmission in the factory evaporators were, as a rule, lower than those obtained with the laboratory apparatus, previously recorded, and higher than is usually obtained with surface condensers. The average coefficients obtained in the tests of different types were as follows, the coefficient for type A being taken as 100:

A	100
B	108
C	199
D	135
E	126
F	255
G	149

These, however, cannot be taken as an absolute measure of the heat transmitting capacity per unit of heating surface in the different types, because conditions were not equally favorable in all cases.

In thirteen of the tests, the steam condensed in the first body was determined, and from this and other data, the thermal efficiency was calculated. The thermal efficiency varied from 85 to 97.5 per cent, the variation being due to difference in the radiation losses and vent losses. The radiation loss varied with the capacity of the evaporators, the number of bodies, the proportion of external surfaces covered and the difference between the temperature of the steam inside and the atmosphere outside.

The discussion which follows the paper gives considerable information on sugar evaporation, with special reference to heat transmission in multiple evaporators. In one discussion the author's results are compared with those by other investigators. Other subjects of discussion are loss of sugar due to entrainment, effect of juice scale and viscosity, etc. To all the points raised the author replies in his closure.

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evaporation under conditions suitable for crystallizing the sugar, the final density being in the neighborhood of 95 deg. Brix.

This paper will consider the first part of the process, namely, the evaporation in multiple effect. Fig. 1 shows diagrammatically the general arrangement of a quadruple effect. Steam is admitted to the first body and is condensed, and the latent heat is transmitted in succession through the heating surface of the four bodies, the boiling temperature in each body being lower than in the preceding body.

The thin juice enters the first body, where a portion of the water is removed. The juice then passes in succession to the

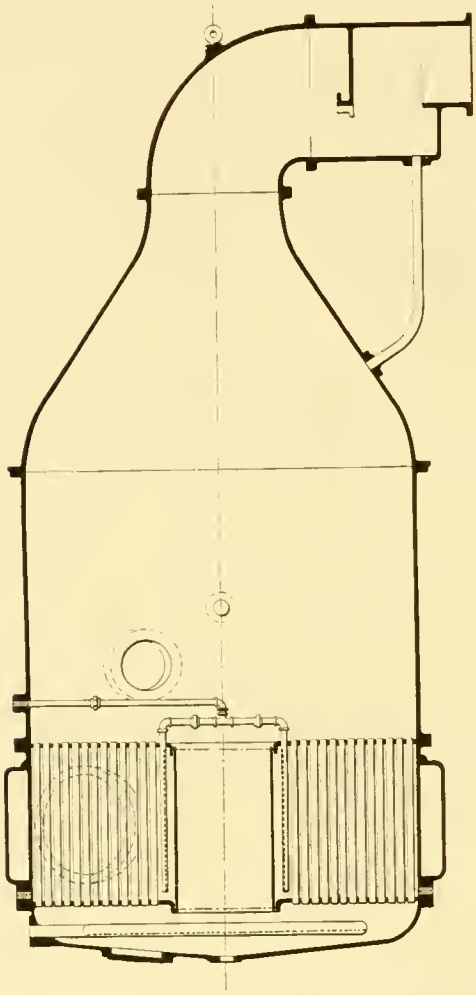

Fig. 2 One Body of Vertical Submerged Tube Evaporator with Belt Steam Distribution. (Type A)

other bodies, in each of which a portion of the water is evaporated, and leaves the last body at a density which is hand-regulated by means of valves in the liquor lines entering the different bodies. The juice entering each body, except the first, is hotter than the boiling temperature in that body, consequently some heat is delivered by the liquid as well as the steam. Whether heat enters the first body in the liquid or not depends upon the temperature of the entering juice.

CAPACITY

The capacity of evaporators depends on two general factors: *coefficient of heat transmission* and *temperature fall*.

The factors affecting the coefficient of heat transmission discussed in the first paper,[1] may be enumerated as

1 *a* Steam distribution; *b* Steam velocity
2 Density of heating steam
3 Quality of heating steam (whether superheated or not)

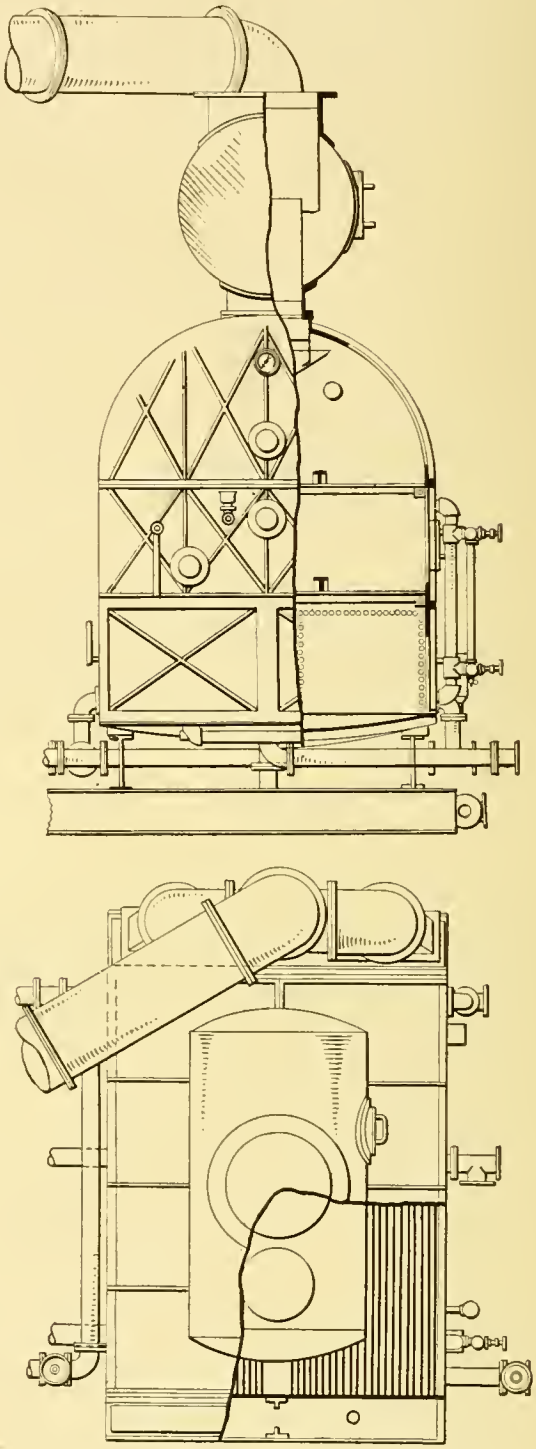

Fig. 3 Horizontal Evaporator (Type B)

4 Presence of air or other incondensable gases in the steam, which may be expressed mathematically by the ratio $P_s \div P_t$
5 Presence of condensation on the heating surface

[1] Tests upon the Transmission of Heat in Vacuum Evaporators, Trans. Am.Soc.M.E., vol. 35, p. 731.

6 Cleanliness of heating surface (steam side)
7 Material, thickness and molecular structure of tubes
8 Cleanliness of heating surface (liquid side)
9 Velocity of liquor circulation

The temperature fall depends on the following factors:

10 Pressure of steam supplied to first body
11 Vacuum in last body
12 Hydrostatic head (height of boiling)
13 Presence of air or other incondensable gases in the steam (see item 4 above)
14 Density of liquid being boiled
15 Purity of liquid being boiled.

The heat transmitted from steam through a metal wall to a liquid being boiled takes place in three steps: *a* From the steam to the initial surface of the metal; *b* From the initial surface through the metal wall to the cooler surface; *c* From the cooler surface to the liquid being boiled. Items 1 to 6 affect *a*; item 7 affects *b*; items 8 and 9 affect *c*, and items 10 to 15 affect temperature fall.

The paper here considers the effect of design in the various types of evaporators upon these several factors.

TESTS OF EVAPORATORS IN SUGAR FACTORIES

The object of these tests was to gather data regarding the capacity and economy of different types under regular operating conditions. Observations were made of practically all

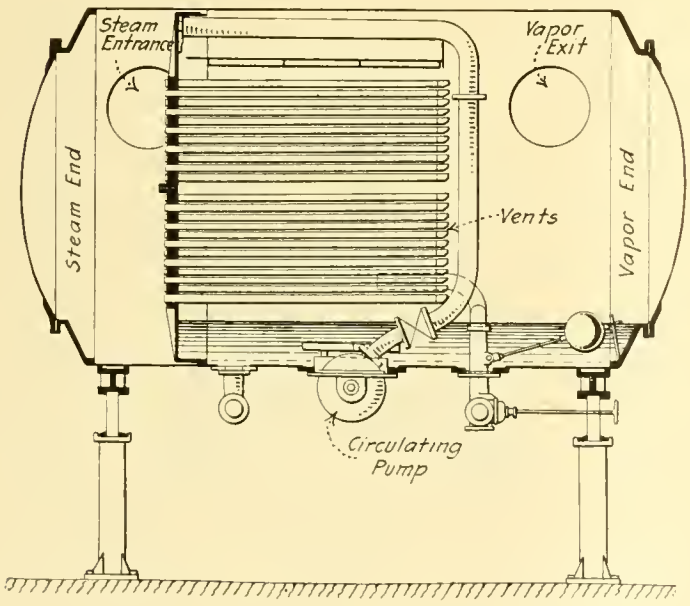

Fig. 4 One Body of Type C Evaporator

factors which might affect the results. A typical log included observations of the pressure or vacuum in the steam or vapor space of each body; temperature and density of juice entering and leaving; weight of juice entering or leaving; weight of condensed steam from the first body, etc. This form of log was used in tests where data regarding both capacity and economy were sought. It was not possible to weigh the condensed steam from the first body in all cases, so that only capacity data were obtained in many of the tests. In the logs for such tests the weight of the condensed steam from the first body was omitted.

The weight of juice was determined by measuring the volume in factory tanks and then calculating the weight from the densities. The condensation from the first body (steam supplied) was determined by weighing or by a venturi meter, the former in most of the tests.

The instruments for measuring pressures, vacuums, temperatures, etc., were calibrated.

EVAPORATORS TESTED

The evaporators tested included double, triple and quadruple effects, also the following types:

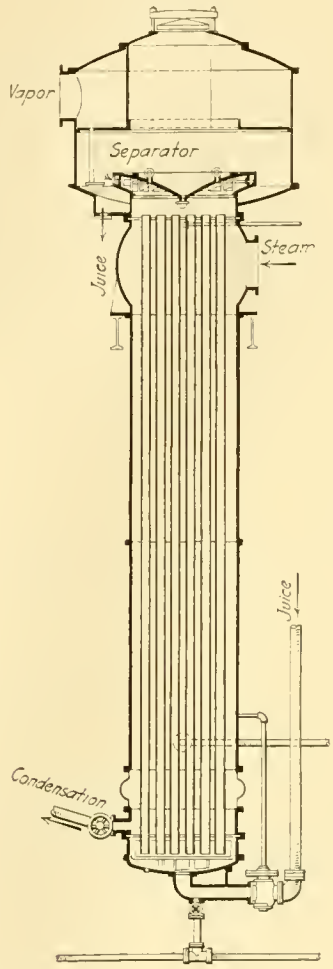

Fig. 5 One Body of Type D Evaporator

A Vertical submerged tube (so-called Standard, Fig. 2).
B Horizontal steam tube (Fig. 3).
C Horizonal film (Fig. 4).
D Vertical film (Fig. 5).
E Standard type with special baffle steam distribution, running under vacuum (Fig. 6).
F Same as E but with atmospheric pressure in last body, no vacuum apparatus being used.
G Vertical steam tubes with special means for venting each tube (Double Tube, Fig. 7).

Types A and B are so familiar that it is not necessary to describe them. It may be well to state, however, that the majority of the sugar house evaporators used in practice belong to one or the other of these two general types.

In type C the horizontal tubes are expanded at one end

into a thick tube plate, and at the other are closed except for a small vent which releases the incondensable gases into the vapor space. The water of condensation leaves the tube at the end where the steam enters. Juice is supplied by centrifugal pumps to a distributor above the tubes and falls in a film from one tube to another. The piping is such that the juice may be recirculated over the tubes until the desired concentration in each body is obtained.

In the vertical film type D, the juice level is near the bottom of the tubes, the latter being approximately 20 ft. long. A rapid current of steam rising through the tubes sweeps juice

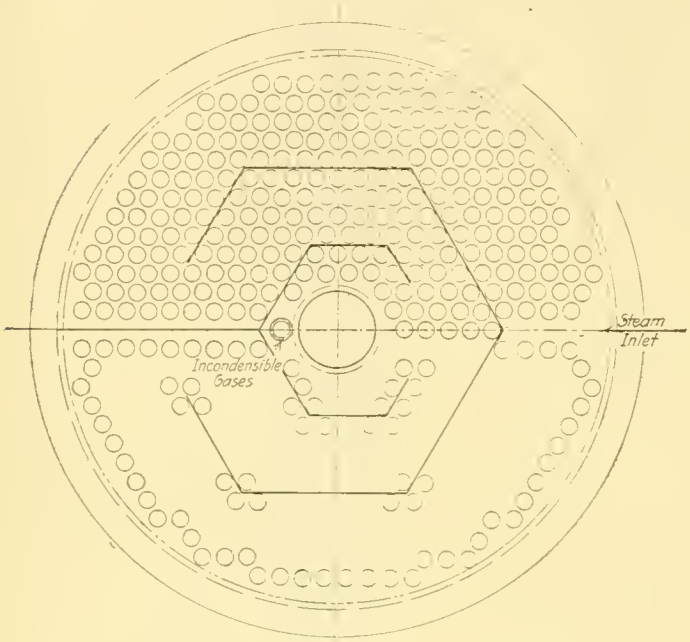

Fig. 6 Steam Distribution (Types E and F Evaporators)

along with it. The pressure of the steam on the interior of the tube keeps this juice as a film (often referred to as *climbing film*) on the tube surface. The juice thus projected upward, on issuing from the tops of the tubes, enters a special separator which separates it from the vapor. The juice and vapor then pass from body to body in the usual manner.

CONDITIONS OF OPERATION

In order to interpret the results of the tests, it is important to note some of the details of conditions of operation. The most important of these are:

1 Method of removing condensation
2 Method of venting the incondensable gases
3 Condition of the heating surface.

Referring to Fig. 1, the removal of condensation from the steam compartments may be effected by:

a Pumps from each body
b Siphoning the condensation from body to body, a pump being used to remove it from the last body
c Barometric leg pipe; this method can be used only in case the evaporator is high enough to give a column of water sufficient to balance the vacuum in the space being drained.

The venting of incondensable gases may be effected by:

a Small pipes tapped through the shell just under the top tube sheet
b Small pipes tapped into the top tube sheet and located near the downtake. Usually two or four of these tubes are used, which are connected together inside of the vapor space with a single pipe brought through the shell and a valve placed on the outside for control
c In horizontal evaporators, the steam chest opposite the steam entrance is vented
d Special methods depending on the type of evaporator.

In all of the above, the vented gases may be taken direct to the condenser or to the next body, though so far as heat transmission is concerned, it is doubtless better to vent direct to the condenser. Usually valves are placed in vent lines in order that control may be exercised. In some cases, the venting is continuous and in other cases intermittent, depending upon the ideas of the operator. In types C and G special means of

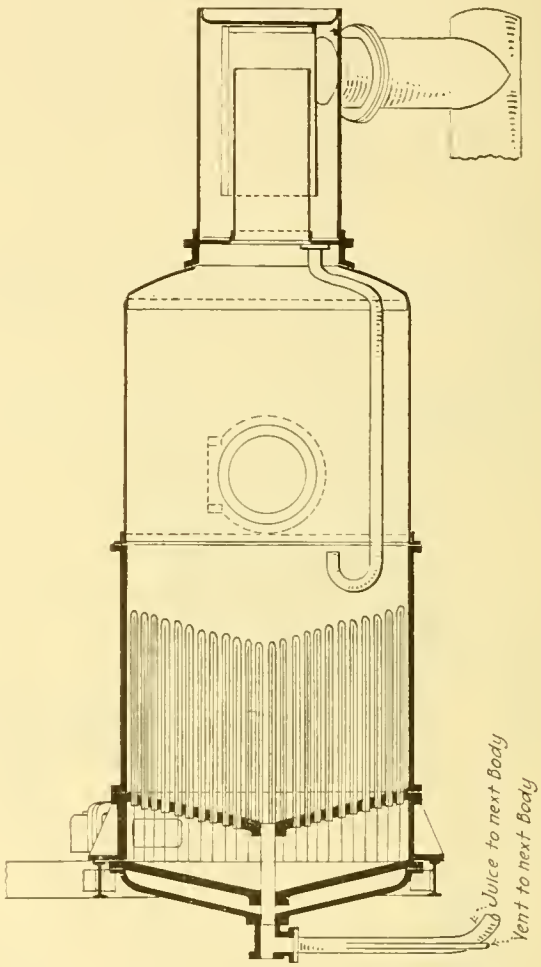

Fig. 7 Double Tube Evaporator (Type G)

See also Fig. 6, Tests upon the Transmission of Heat in Vacuum Evaporators, Trans. Am.Soc.M.E., vol. 35, p. 731.

venting are used which have been explained above. Data regarding the methods of venting are given in the tables:

RESULTS OF TESTS

Table 1 gives the more important data from the tests on multiple evaporators. Fig. 8 is a graphical log of a typical test.

The percentage evaporation by weight was calculated by means of the formula $X = \frac{(B-b)}{B} \times 100$, in which B is the Brix of the juice leaving, b, the Brix of the juice entering, X

the per cent water evaporated in terms of the weight of the juice. In determining the percentage evaporation by volume, the formula $X = 100 - 100\ (gb/GB)$ was used, g being the specific gravity of the juice entering, and G the specific gravity of the juice leaving. In most cases, the volume of the juice leaving was measured in factory tanks, the weight of juice entering and the weight of water evaporated being calculated by the use of the first formula above.

It is customary to make evaporator guarantees on a basis of 75 per cent evaporation by volume. As the initial and final densities of the juice are seldom such as to give exactly 75 per cent evaporation, it is necessary to determine the "equivalent volume of juice in gallons per 24 hr." by calculation. There seems to be no standard unit for rating evaporators. Sometimes an evaporator is guaranteed to handle a stated number of gallons of juice per 24 hr. with 75 per cent evaporation, nothing being stated as to the temperature of the juice; in other cases the temperature of the juice is specified. Probably the best standard rating would be "equivalent gallons of juice handled per 24 hr. with 75 per cent evaporation." Primarily a multiple evaporator is supposed to evaporate and not heat; actually, however, the juice may enter the first body at a temperature lower or higher than that of boiling.

The following example shows the method used in calcu-

TABLE 1 PRINCIPAL DATA FROM TESTS ON SUGAR HOUSE EVAPORATORS

No.	Duration, Hr.	Type	Number of Bodies	Rated Capacity, Gal. per 24 Hr., 75 Per Cent Evaporation	Length of Tubes, Ft.	Diam. of Tubes, In.	Heating Surface, Each Body, Sq. Ft.	Steam Pressure 1st Body, Lb. Abs.	Steam Pressure Last Body, In. Abs.	Temperature, Deg. Fahr.		Density Degrees Brix at 17.5° C.		Method of Removing Condensation*	Method of Venting*	Number of Days Since Cleaned	Per Cent Evaporation		Juice Treated per 24 Hr. Equiv. to 75 Per Cent Evap., Per Cent of Rated	Water Evaporated, Lb.	Water Evaporated per Lb. of Steam Supplied, Lb.	Water Evaporated per Sq. Ft. Heating Surface per Hr., Lb.	Thermal Efficiency, Per Cent
										Juice Entering	Juice Leaving	Juice Entering	Juice Leaving				By Weight	By Volume					
1	7.13	A	4	290,000	4.5	2	4504.8	16.3	1.8	183.5	101	13.7	50.2	*f*	*bc*	6	72.7	76.6	137	587,914	...	5.44	....
2	6.00	A	3	270,000	4	2	3740	14.6	3.6	185.9	134.2	15.2	55.5	....	.....	3	72.6	77	.....	350,584	....	5.19	....
3	6.66	A	3	290,000	4	2	3983	15.3	3.2	188.6	....	13.2	52.2	*e*	none	3	74.7	78.6	102	505,304	....	6.35	....
4	12.0	A	3	185,000	4	2	2579	15.6	3.4	198.4	....	15.4	61.1	*e*	*bd*	0	74.7	79.4	138	933,684	....	10.38	....
5	5.75	A	3	280,000	4	2	....	16.7	4.9	183.8	....	13.6	51	*e*	note 1	0	73.4	77.4	83	327,466	....	4.96	....
6	4.33	A	3	210,000	4	2	2855	14.7	3.5	194	124.5	13.3	58.2	*e*	none	7	77.2	81.3	87	195,763	....	5.27	....
7	4.92	A	2	125,000	4	2	1901	14.9	5.2	206.7	128.9	15.9	56	*e*	*ad*	....	71.6	76.1	145	104,775	2.09	5.67	....
8	3.5	A	2	120,000	4	2	1808	13.6	5.1	172.7	137.1	16.9	42.4	*e*	*ac*	12	60.3	64.4	86	88,255	....	6.95	....
9	6.0	A	2	130,000	4	2	2137.6	14.4	4.1	176.8	123.2	13.6	52.4	*e*	none	0	74.1	78.1	63	124,474	....	4.85	....
10	4.5	A	2	130,000	4	2	2137.6	14.5	3.8	174.3	123.1	13.2	51.3	*e*	none	6	74.3	78.2	42	54,504	....	3.19	....
11	6.0	A	2	100,000	4	2	1585.6	14.9	6.2	185.2	143.4	15	48.3	*e*	*bd*	3	68.9	73.01	64	95,857	....	5.04	....
12	6.16	A	2	100,000	4	2	1585.5	14.7	6.9	188.0	144	14.1	49.4	*e*	*bc*	0	71.5	75.5	90	141,888	....	7.26	....
13	5.0	A	2	125,000	4	2	2042	14.7	5.0	188.6	140	13.3	54.2	*e*	*bd*	3	75.4	79.4	151	239,478	....	11.72	....
14	4.0	B	4	145,000	9½	¾	2000	22.9	3.1	200	119.8	18.1	55.9	note 2	*d*	6	67.6	72.5	109	155,198	3.52	4.85	85.06
15	4.0	B	4	145,000	9½	¾	2000	21.4	3.8	199.7	129.2	17.5	62.9	uote 2	*d*	3½	72.2	77.2	174	248,701	3.7	7.77	89.05
16	6.0	B	4	145,000	9½	¾	2000	23.4	4.0	200.5	127.3	16.0	47.2	note 2	*d*	7	66.1	70.3	107	225,586	....	4.69	....
17	6.0	B	4	250,000	13	⅞	3432	18.7	3.7	181.0	....	13.0	57.5	*c*	*c*	0	77.5	81.4	86	314,062	3.4	5.08	90.48
18	4.5	B	4	250,000	13	⅞	3432	17.4	5.0	196.5	140	13.0	59.3	*e*	*c*	0	78.1	82.1	116	319,833	....	5.18	....
19	6	B	3	125,000	11	¾	1560	15.5	7.5	186.2	135	13.2	54.3	*e*	*c*	....	75.7	79.7	62	113,716	2.86	4.05	100.4
20	5.33	B	3	200,000	13	1¼	2849	20.9	3.3	195	130	10.6	58.3	*e*	*c*	1	83.5	85.1	191	502,311	....	11.03	....
21	6.00	B	3	30,000	10	1¼	654.3	20.1	3.3	195	131	11.7	58.5	*e*	none	1	79.9	83.1	290	130,669	....	11.09	....
22	5.00	B	2	100,000	13	1¼	1633.6	15.5	4.6	172.7	137.1	16.2	53.7	*e*	none	10	69.8	74.3	97.9	116,729	....	7.1	....
23	6.00	C	4	400,000	7¼	4½	2570	19.1	5.9	194	141	12.7	53.2	*g*	spec.	0	76.1	79.9	94	556,923	3.71	9.02	96.9
24	6.00	C	4	400,000	7¼	4½	2570	17.7	6.5	191.8	144	13.1	58.7	*g*	spec.	0	77.7	81.7	94	553,877	3.95	8.98	97.5
25	6.06	C	4	400,000	7¼	4½	2410	17.9	4.6	188.8	131	12.7	65.4	*g*	spec.	0	80.6	84.6	76	450,293	3.69	7.71	97.5
26	6	C	4	275,000	7⅔	3	1940	9.4	4.0	199.3	132	14.9	52.3	*f*	spec.	0	71.6	75.8	62	264,780	....	5.68	....
27	7.13	D	4	400,000	....	....	4000	17.9	5.2	205.0	141.8	11.6	47.3	*f*	note 3	3	75.5	78.9	138	837,836	4.21	7.34	97.2
28	6.03	D	4	400,000	....	....	4000	17.9	4.9	207.7	136.9	12.6	46.2	*f*	note 3	2	72.7	76.7	124	748,958	4.24	7.76	94.8
29	6	D	4	400,000	....	....	4000	18.1	5.2	208.8	132.6	12.8	45.4	*f*	note 3	0	71.8	75.5	131	790,172	4.28	8.23	93.3
30	4	D	3	200,000	23	....	2112	14.8	2.3	212.2	125	16.5	46.2	*f*	none	...	64.3	68.5	93	191,585	2.91	7.77	86.5
31	5	D	3	200,000	23	....	2112	13.6	2.3	213	123.1	15.2	50.1	*f*	none	...	69.7	73.9	95	247,400	3.09	7.81	90.6
32	5.87	D	3	145,000	26	2	....	18	3.6	175.4	124.5	16.5	54.3	*f*	none	1	69.7	74.3	85	173,133	....	6.26	.
33	6	E	3	220,000	4	2	3054	14.6	4.6	171	136	14.9	58	*f*	Fig. 6	1	75.4	78.8	105	338,859	2.49	6.27	97.4
34	5.39	E	3	.....	4	2	2683	11.06	5.0	184.6	129.2	15	51	*f*	note 4	2	70.6	74.8	...	190,517	..	4.4	.
35	4	E	3	.....	4	2	2683	6.07	3.2	179	....	14.7	50.8	*f*	note 4	7	73	75.2	....	156,176	....	5.3	
36	6	F	2	.....	4	2	1003.1	24	30.0	204.4	....	15.2	45.3	*e*	*a*	0	66.5	70.5	.....	73,502	..	6.11	
37	6	F	2	.....	4	2	1007.0	24	30.0	192.6	...	15.9	46.2	*e*	*a*	1.5	65.6	69.8	.....	77,161		6.43	
38	5.69	G	4	290,000	4	2	1529	15.4	5.8	188.1	147.4	15	64.2	*e*	Fig. 7	3	76.7	81.2	51	206,917	.	5.95	

* *a* — through shell at side; *b* — through top tube sheet; *c* — direct to condenser; *d* — body to body; *e* — pumps, each body; *f* — siphon, body to body, *g* — barometric leg pipe.

Note 1 — vented through 12 1/16-in. holes direct to vapor space

Note 2 — centrifugal pumps, each body.

Note 3 — 2-in. vents at side, bottom and top, body to body.

Note 4 — see Fig. 6.

lating "equivalent juice treated with 75 per cent evaporation" (see Table 1).

Boiling temperature, first body, deg. fahr.	194.07
Temperature juice entering first body	172.71
Temperature rise	21.36
Specific heat juice entering	0.889
B.t.u. per hour, first body, for heating 41,832 × 21.36 × 0.889	794,349
Latent heat at 194.07 deg.	981.35
Equivalent evaporation, lb., $\frac{794,349}{981.35} =$	809.4
Total per 24 hr., lb.	19,425.6
Actually evaporated per 24 hr., lb.	605,174.4
Equivalent, had all heat been expended in evaporating, lb.	624,600.0
Equivalent gallons at 194 deg.	73,456.3
Equivalent juice at 75 per cent evaporation, 73,456 ÷ 0.75 =	97,941.0
Rated capacity, gallons per 24 hr.	100,000
Per cent rated capacity actually developed	97.9

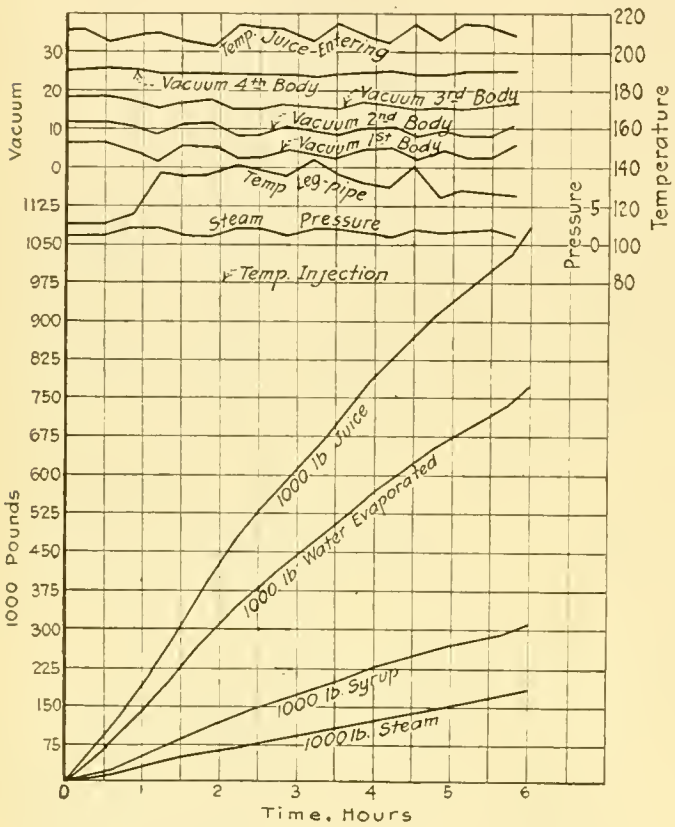

FIG. 8 GRAPHICAL LOG OF TYPICAL EVAPORATOR TEST

The term *thermal efficiency* (Table 1, last column) is used to indicate the heat efficiency of the evaporator as a whole. It may be determined by dividing the actual weight of water evaporated per pound of steam supplied by the theoretical weight of water that would be evaporated per pound of steam supplied were there no heat losses.

In order to illustrate the method used in calculating efficiency, the following example is worked out for a double effect. The general data used in working out the heat balance on which the efficiency determination is based are:

Total juice fed, lb.	94,706.9
Total steam condensed, lb.	36,302.0
Brix of juice entering	12.2
Specific heat[1]	0.919
Temperature juice entering	186.06
Calandria, first body	
Steam pressure, lb. abs.	15.46
Steam temperature	214.56
Total heat above 32 deg.	1,151.33
Juice side, first body	
Vapor pressure, in. merc. abs.	25.65
Vapor temperature	204
Total heat above 32 deg.	1,147.3
Latent heat above 32 deg.	975.18
Juice side, second body	
Vapor pressure, in. merc. abs.	7.94
Latent heat above 32 deg.	1,006.2

[1] The values for specific heat of sugar solutions with varying density were taken from Kopp's tables.

The heat balance was calculated as follows:

First Body

B.t.u. entering in steam, 36,302 × 1,151.33 =	41,795,581.6
B.t.u. entering in juice, 94,706.9 × 154.06 × 0.919 =	408,710.8
Total	55,204,292.4
B.t.u. leaving in condensation, 36,302 × 182.56 =	6,627,293.1
B.t.u. in juice in body, 94,706.9 × 0.919 × 172.32 =	14,997,981.6
Sum	21,675,274.7
B.t.u. leaving in vapors (55,204,292.4 — 21,625,274.7) =	33,579,017.7
Vapor leaving, lb., 33,579,017 ÷ 975.18 =	34,433.7
Juice to second body, lb., 94,706.9 — 34,433.7 =	60,273.2
Brix of juice entering second body, $\frac{94,706.9 \times 12.2}{60,273.2} =$	19.17
Specific heat at 19.17 Brix	0.874

Second Body

B.t.u. entering in vapors, 34,433.7 × 1,147.4 =	39,510,260.4
B.t.u. entering in juice, 60,273.2 × 172.32 × 0.874 =	9,077,606.8
Total	48,587,867.2
B.t.u. leaving in condensation, 34,433.7 × 172.32 =	5,933,615.2
B.t.u. in juice in body, 60,273.2 × 120 × 0.874 =	6,321,453.2
B.t.u. leaving in vapors	36,332,798.8
Vapors leaving, lb., 36,332,798.8 ÷ 1006.2 =	36,108.9
Juice leaving second body, lb.	24,164.3
Brix leaving second body, $\frac{60,273.2 \times 19.17}{24,164.3} =$	47.8
Total water evaporated, lb., theoretical, 34,433.8 + 36,108.9 =	70,542.7
Per cent of total evaporation, in first body	48.8
Per cent of total evaporation, in second body	51.2
Total water evaporated (theoretical) per lb. of steam 70,542.6 ÷ 36,302 =	1.9432
Total water evaporated (actual) per lb. of steam	1.9108
Thermal efficiency $\frac{1.9108}{1.9432} 100 =$	98.33

HEAT BALANCE OF DOUBLE EFFECT

Heat entering in steam, B.t.u.	41,795,581.6
Heat entering in juice	13,408,710.8
Total	55,204,292.4
Heat leaving in condensation, first body	6,627,293.1
Heat leaving in condensation, second body	5,933,615.2
Heat leaving in vapors, second body	36,332,798.8
Heat leaving in syrup, second body	6,321,453.2
Total	55,215,164.3

The coefficient of heat transmission, the B.t.u. transmitted per square foot of heating surface per hour per degree difference in temperature, is obtained for each body by dividing the heat in B.t.u. transmitted during the test by the number of hours, by the number of square feet of heating surface and by the apparent temperature fall in that body. The coefficients of heat transmission obtained in the tests are given in the paper for each body, also the average for all bodies. As the apparent temperature fall was used, the coefficients are termed *apparent*.

The coefficients for all tests are plotted against pressure of steam in Fig. 9. The variation is shown to be very wide, the principal value of this plot being to fix limits. Similarly Fig. 10 gives the results of the laboratory tests given in the former paper. It will be noted that the coefficients for the laboratory tests are higher than those from the full size factory evaporators. This is doubtless due to the fact that the heating surface in the laboratory apparatus was always clean, and that there was a better distribution of steam with the smaller calandria. Some of the tests were made with the apparatus operating under conditions so poor that to consider the data from them in comparing types would be unfair. In nearly all cases

the tests were made without special preparation, the time since cleaning, etc., varying considerably. It is interesting to note that the coefficients obtained are higher than with ordinary surface condensers and equally as high as with modern types of high vacuum surface condensers.

Table 2 gives the coefficients for each body for quadruples of the different types. Table 3 gives the average, maximum and minimum coefficients for each type taken from the same tests. It will be noted that the highest actual coefficients were

TABLE 2 COEFFICIENT OF HEAT TRANSMISSION

(Actual)

Type	1st Body	2d Body	3d Body	4th Body
A	410	340	265	145
B	400	330	240	135
C	680	630	525	220
D	430	395	320	180
F	685	400	...	...
G	682	571	365	138

obtained from type F (atmospheric double effect). These high coefficients were doubtless due to the high steam pressure and the corresponding high density of the steam. As *apparent* temperature fall was used in determining the coefficients, they not only indicate the relative heat transmitting ability of the heating surface in the different types, but include also the effect of peculiarities due to type, such as hydrostatic head, method of removing condensation, method of venting, etc. It will be noted that the film evaporators (types C and D) gave coefficients considerably higher than did the submerged tube types.

Comparing types A and B it will be noted that the latter has some advantage, the average actual coefficient for type B being some 8 per cent greater than the average for type A. The tests of type E show an average coefficient of 248, which is some 25 per cent greater than the average for type A. Comparing types C and D, the average coefficient for the former is 392 which is some 47 per cent greater than that of the latter. Type C requires centrifugal circulating pumps for handling the juice, something not required by other types. Tests of motors driving these pumps showed 0.1 h.p. per 1000 gal. of juice treated per 24 hr. This should be kept in mind in comparing this type with others. Only one test was made upon type G and this under conditions which could hardly be called favorable, the amount of juice supplied being far below its

TABLE 3 COEFFICIENT OF HEAT TRANSMISSION

(Actual)

Type	Average	Maximum	Minimum	No. of Tests Included in Average	Relative Coefficient (Actual) Standard = 100	Relative Coefficient (Corrected) Standard = 100
A	197	289	172	7	100	100
B	213	291	130	5	108	74
C	392	449	334	3	199	160
D	266	353	190	6	135	119
E	248	284	190	3	126	180
F	503	509	498	2	255	131
G	293	...	...	1	149	139

rated capacity and the juice head greater than would have been used had it been operated with an amount of juice nearer its normal capacity.

With type A only four evaporators out of a total of eleven gave coefficients above 200. In these four the conditions of operation were fair as regards cleanliness, drainage and venting. The number of days since cleaning is given in the paper for each test, though this can hardly be relied upon to give an accurate idea of the condition of the heating surface, for the reason that all of the evaporators had not been cleaned with equal thoroughness. In practice, the time consumed in boiling out, also the strength of the soda and acid, vary greatly. In some cases, the thoroughness of cleaning is not sufficient to

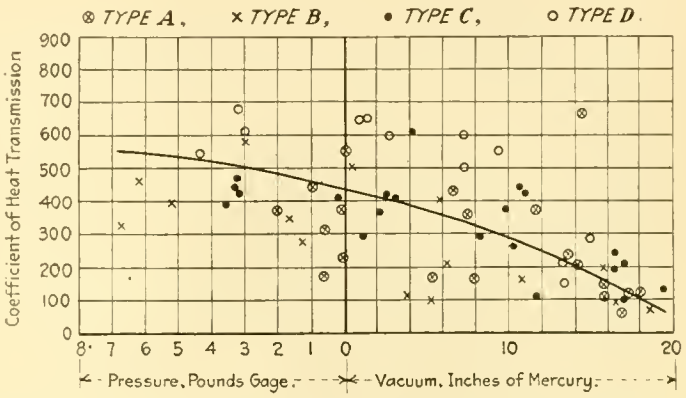

Fig. 9 Coefficients of Heat Transmission, All Tests on Sugar House Evaporators

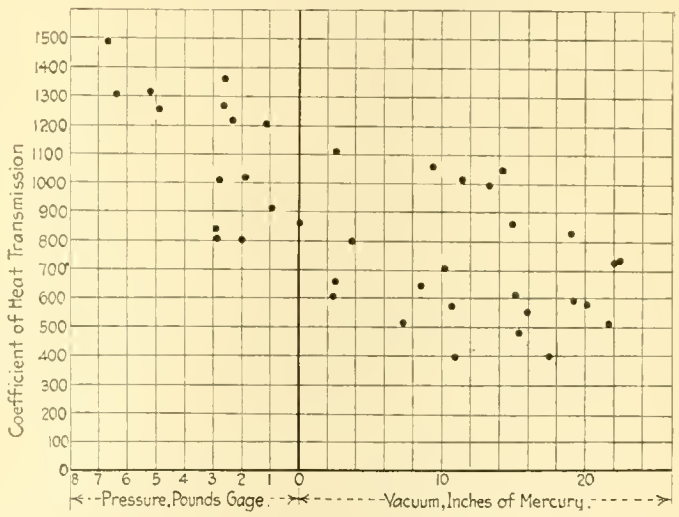

Fig. 10 Coefficients of Heat Transmission, Laboratory Tests

prevent a progressive fouling of the heating surface toward the end of the season.

It will be noted that practically all of the tests on type A were made with very low steam pressure in the first body, usually near atmospheric pressure, and in some cases, less than atmospheric pressure. With most of the other types, the pressure was higher, which puts type A at a disadvantage in making comparisons with the average coefficients given. According to laboratory tests, the coefficient of heat transmission varies according to the expression $U = 225 + 17{,}500\ D$, where D = density of heating steam in pounds per cubic

foot. This formula was used in calculating the *corrected* coefficients given in the last column of Table 3. These *corrected* coefficients may perhaps give a better means of comparing types than the actual coefficients, especially as regards types A and B. However, too much dependence should not be placed on these *corrected* coefficients, as the correction formula was determined from laboratory experiments.

Considering the four tests giving the highest coefficients for types A and B, the rating is:

(Actual)

Type A	100
Type B	106

(Corrected for difference in initial steam pressures)

Type A	100
Type B	96

The fairest comparison of types C and D will be obtained by using only tests 23 to 25 and 27 to 29, which were made on

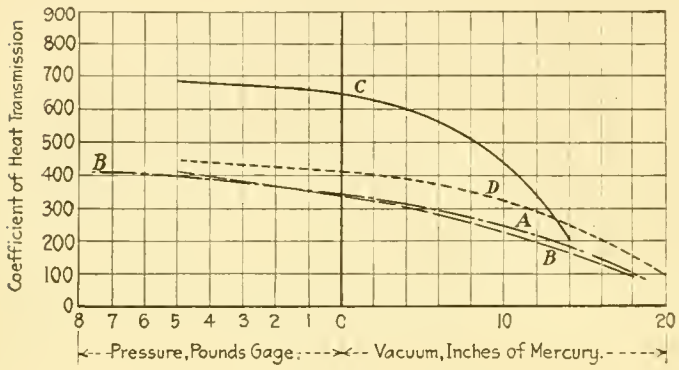

FIG. 11 COMPARISON OF HEAT TRANSMISSION COEFFICIENTS, TYPES A, B, C AND D EVAPORATORS

evaporators at the same factory and where the operating conditions were equally favorable.

(Actual)

Type C	117
Type D	100

The evaporators of type B were of two classes, namely, *a* with small tubes (¾ in. and ⅞ in.) and *b* with larger tubes (1¼ in.). Tests 15 and 16 with small tubes, and tests 20 and 21 with large tubes, were made under conditions that should afford a fair comparison. The ratings are:

(Actual)

Small tubes	100
Large tubes	142

(Corrected for difference in initial steam pressures)

Small tubes	100
Large tubes	111

RATE OF EVAPORATION PER SQUARE FOOT OF HEATING SURFACE PER HOUR

So far all comparisons have been made in terms of the coefficient of heat transmission. The unit "pounds of water evaporated per square foot of heating surface per hour" is convenient for rating evaporators, and is fairly satisfactory provided the steam pressure and the vacuum do not vary greatly. Table 4 gives averages of water evaporated per square foot of heating surface per hour for each type tested. The *actual* values do not furnish a fair comparison on account of the widely varying steam pressure and vacuum. An attempt has been made to determine the equivalent evaporation that would have resulted had all tests been made with a steam pressure of 5 lb. gage in the first body and a vacuum of 26 in. in the last body. This equivalent value is termed *corrected* water evaporated per square foot of heating surface per hour. The method of calculating the *corrected* value is as follows:

For example, in test 27, the total temperature fall for the conditions of the test was 87 deg. and for the *corrected* conditions 102.5 deg. were assumed. The actual average coefficient for the conditions of the test was 325, and for the *corrected* conditions 343. The *corrected* rate sought is

$$\frac{8.75 \times 102.5 \times 343}{87 \times 325} = 10.7$$

It is not claimed that these *corrected* values can be absolutely accurate, but rather an approximation to the results that would be obtained with the conditions assumed.

THERMAL EFFICIENCY

In thirteen of the evaporator tests recorded in Table 1, the condensed steam from the first body was weighed. Partial data regarding steam consumed for these tests are given in the same

TABLE 4 WATER EVAPORATED PER SQUARE FOOT OF HEATING SURFACE PER HOUR

FROM TESTS PLOTTED IN FIGURES IN THE PAPER

Type	Actual Equiv. to 75 Per Cent Evap.			Corrected 5-Lb. Gage and 26-in. Vac.		
	Maximum	Minimum	Average	Maximum	Minimum	Average
A Quadruple	.....	.....	5.55	.....	.....	6.18
A Triple	8.31	5.07	6.56	10.8	8.15	9.2
A Double	11.64	7.20	9.42	19.4	13.6	16.7
B Quadruple	7.89	4.82	5.89	5.61	3.87	4.55
B Triple	11.18	11.18	11.18	12.61	10.68	11.49
C Quadruple	9.20	7.90	8.75	11.42	9.56	11.05
D Quadruple	8.75	7.75	8.21	10.87	9.45	10.05
D Triple	7.38	6.62	7.11	9.6	7.45	9.21
E Triple	6.33	4.85	5.46	10.63	27.65	16.93
F Double	6.74	5.43	6.085	17.8	17.0	17.4
G Quadruple	.....	.....	6.092	.....	.....	9.67

table. Table 5 gives more complete data relating to steam consumption in these tests.

The factors which affect the weight of steam required to evaporate a given weight of water are: *number of bodies; radiation losses; losses due to vents; method of handling condensation; temperature of juice entering.*

One pound of steam entering the first body of a multiple evaporator causes the evaporation of approximately 1 lb. of water in each body, that is, 1 lb. of steam evaporates approximately 2 lb., of water in a double effect; 3 lb. in a triple effect; and 4 lb. in a quadruple effect. This relation does not hold exactly, for reasons which will be discussed later.

The loss due to radiation varies directly as the difference between the temperatures inside the evaporator and the atmosphere outside. This temperature difference is of course greater with atmospheric evaporators than with vacuum evaporators. It is also greater in the first body of a vacuum evaporator than in succeeding bodies. The radiation loss also varies directly

as the ratio of radiating surface to water evaporated. This ratio will be less with large evaporators than with small ones, and is affected by type also. Reference to Table 5 will show something regarding the value of this ratio for the evaporators tested. Naturally the radiation loss is affected by the kind and amount of insulating covering used. The loss due to radiation in the first bodies of an evaporator is multiplied; for example, the loss from the first body of a quadruple is multiplied by 4; that from the second body is multiplied by 3, etc. In view of this, it is evident that the total radiation loss from a quadruple will be greater than that from a triple, etc., other conditions being the same. A theoretical calculation will show that this loss should be relatively small. A rough calculation based on an average coefficient of radiation of about 2.8 B.t.u. per square foot of radiating surface per hour per degree fahrenheit difference shows the following losses in percentage of the heat delivered in the steam to the first body:

	Uncovered	Fully Covered	Three-fourths Covered
Double	1.06	0.26	0.46
Triple	4.2	1.05	2.07
Quadruple	9.8	2.7	5.0

These figures are for a 10-ft. standard effect including the vapor pipes, with steam at 5 lb. gage and a vacuum of 27 in.

Primarily, vent pipes are for the purpose of removing incondensable gases only. If this were carried out, the vent losses would be small, in fact they are probably small in general practice, even though some steam is vented with the gases. This loss, like the radiation loss, is multiplied for all bodies except the last. The vents may be connected to the next body or to the condenser direct. The former is probably more economical, though the latter is better as far as heat transmission is concerned. This loss is apt to be greatest in the early bodies, especially if the vent openings are too large. In order to reduce losses due to venting, it is important to design evaporators so that effective separation of gases from steam may be brought about. Attention has already been called to the fact that this has been attempted in types C, E, F and G.

Of the three general methods of handling the condensed steam from exaporators, *b* (see footnote, Table 1) evidently should be most economical for the reason that all of the condensation leaves the last body at the lowest possible temperature, the saving due to this arrangement being multiplied in all except the last body. It is common practice to use the condensation from the first body for boiler feed, though theoretically it would pay to run this water from body to body along with that from later bodies.

Primarily, evaporators are designed to vaporize water, though, in fact, some heating is generally done in the first body because the temperature of the juice entering is lower than that of boiling. It is evident that the amount of heating done in this manner will affect the weight of water evaporated per pound of steam supplied to the first body. It should be remembered also that the steam supplied for heating in this manner does not work multiple as does that used for evaporation.

TABLE 5 DATA FROM TESTS RELATIVE TO ECONOMY

See foot notes, Table 1

Test No.	Type	No. of Bodies	Rated Capacity, Gal. per 24 hr.	Actual Capacity, Per Cent of Rated	Radiating Surface per 100,000 Gal. per 24 hr., Actually Evaporated, sq. ft.	Portion of Radiating Surface Covered, Per Cent of Total	Steam Temperature 1st Body, Deg. Fahr.	Method of Venting	Method of Removing Condensation	Steam * Supplied to 1st Body for Heating Per Cent of Total	Water Evaporated per Lb. of Steam, Lb.	Thermal Efficiency, Per Cent
7	A	2	125,000	145	.....	.....	212.5	*nd*	*e*	−6.13	2.09	94.5
14	B	4	145,000	109	1921	73.50	234.9	*d*	note 2	8.9	3.52	85.1
15	B	4	145,000	174	1207	73.50	232.8	*d*	note 2	5.89	3.7	89.1
17	B	4	250,000	86	1780	0	224.5	*c*	*e*	11.73	3.4	90.5
23	C	4	400,000	94	832	100	225.4	spec.	*g*	8.06	3.71	96.9
24	C	4	400,000	94	832	100	221.5	spec.	*g*	7.83	3.95	97.5
25	C	4	400,000	76	1026	100	222.0	spec.	*g*	9.67	3.69	97.5
27	D	4	400,000	138	694	95	222.0	note 3	*f*	1.19	4.21	97.2
28	D	4	400,000	124	774	95	222.1	note 3	*f*	−0.50	4.24	94.8
29	D	4	400,000	131	734	95	222.8	note 3	*f*	−2.37	4.28	93.3
30	D	3	200,000	93	946	0	212.4	none	*f*	−12.98	2.91	86.5
31	D	3	200,000	95	923	0	208.3	none	*f*	−9.85	3.09	90.6
33	E	3	220,000	105	990	40	211.9	Fig. 6	*f*	7.46	2.49	97.4

* Minus values are for initial juice temperatures higher than the boiling temperature.

Table 5 gives the results of the tests as regards economy. It also includes information regarding the main test conditions which affect economy. A unit commonly used for measuring economy is "pounds of water evaporated per pound of steam supplied to the first body." This unit does not furnish a fair means of comparing the economy of different evaporators, however, for the reason that it does not account for variation in conditions. Thermal efficiency is more accurate, and the method of calculating this item has already been given. It will be noted that it varies from a minimum of 85.06 to 98.3, the average being 94 per cent. The table shows that the efficiency of type C was higher than type D, although the water evaporated per pound of steam supplied was greater in the latter than in the former. This apparent contradiction is due to two things: (1) the temperature of the juice entering the first body in the tests on type D was higher than in those on type C, more steam being required for heating in type C; (2) the condensation in type D was taken from body to body, begin-

ning with the second, whereas it was drained away separately from each body of type C. The low efficiencies obtained in the tests on type B quadruple, tests 14 and 15, are probably due to the small size, whereas both the C and D quadruples were of large size. Attention is called to the data in Table 5 regarding the ratio of radiating surface to water evaporated in the different types.

Type 17 on a type B quadruple evaporator gave an efficiency of 90.48 per cent. This is relatively low for an evaporator of this size and is doubtless due to the fact that it was not insulated. The low efficiencies obtained in tests 30 and 31 on a type D triple is doubtless due also to the fact that it was not insulated. These tests were made soon after the apparatus had been installed and before the covering had been applied. An inspection of this table will show the effect of high rates of evaporation in increasing heat efficiency; in fact some of the irregularity in the results can only be explained in this way.

DISCUSSION

M. B. De Pass[1] (written). The process of sugar making is divided, we might say, into four parts:

1 Extracting, by crushing process, of juice from the cane
2 Clarification by defecation and sometimes filtration
3 Evaporation (the subject under consideration)
4 Granulation and drying.

The capacity and economy of any of the stages depends very materially on the efficiency of the preceding stage.

In some climates during the crushing stage, a larger volume of water must impregnate the crushed cane to dissolve the sugar that is not in solution. This reduces the density of the juice and increases the volume of water that must needs be evaporated from it.

One factor, the paper tells us, is the fouling of the heating surface in effects which is caused by foreign substance that has not been eliminated during the clarification stages—in fact some of it is injected during this stage; hence the amount of water added in crushing and the nature of the juice clarified entering into the effects largely determines the size and style that is to be adopted and should govern the manufacturer's guarantee.

There are two factors governing the capacity and economy of multiple effects which are not referred to in the paper. One of these is very important and that is the size of the vapor pipes and save-alls; these regulate the velocity and vapor tension and fix the boiling point in each effect. Faulty vapor pipes cause entrainment and loss in capacity.

As the efficiency of a multiple effect depends very largely on the vacuum in the last body, and this in turn on the completeness of the condensation, attention to the design of the condenser is important. Owing to the low boiling point in the last vessel, the velocity of the vapors is greater and therefore the greater the chance of entrainment. Any syrup thus carried off into the condenser is never reclaimed, as is not the case in the other vessels where the sweet water may be trapped and re-evaporated or used in the first stage of extraction for saturation. So not only is a good condenser required on the last pan but also a good save-all that will completely strain the syrup from the vapor before it enters into the condenser. The writer has seen a "save-all" that reclaimed from 200 to 300 gallons of syrup in twenty-four hours, which would have been lost if permitted to pass into the condenser with the vapors and out into the hot well.

The standard type of vertical tube submerged calandria is the most popular of all multiple evaporators, and by the aid of such papers and experiments as are being made by Professor Kerr and other prominent engineers, the manufacurers are learning how and where to overcome all defects. The vapor velocity is controlled, entrainment is prevented, perfect condensation is accomplished, air pockets are done away with and the condensed waters are properly drained from the calandrias.

In dealing with the problem of heat transmission, various means are advocated by different manufacturers. Some use baffle plates and different arrangements to control the direction of the steam, some leave out tubes, and others both. The trouble to overcome in large bodies is that some parts get more heat than others, causing unequal boiling and dead spaces in the calandrias.

In the earlier apparatus, steam was admitted around a circular steam jacket, on the outside of the calandria, and the drains were also on the outside directly under the steam entrance. The consequence was that all the ebullition or boiling took place on the periphery of the calandria where the heat remained and a dead space formed in the center. Mistaking the ebullition at the periphery, caused by the heat remaining at that point, for circulation, someone conceived the idea that if there was a central down-take to aid the circulation of the liquid to work from the center to the periphery, that would aid the evaporation; and on experiment it apparently proved a success and the liquid actually appeared to work down through the down-takes and up through the tubes from center to circumference, while the fact of the matter was that the down-take filled the void and dead space in the center of the calandria, and it was still found that there was air and gas pockets in the center of the calandria which retarded exaporation. Something had accordingly to be done to relieve this and make the vapor, or steam, find its way to the center, this brought about the use of baffle plates, or deflectors, arranged so as to admit the vapor at one side and deflect it around in two directions to the other side, and thence to the center, as shown in Fig. 6 of the paper.

This was tried years ago at the American Sugar Refining Co.'s Plant in the city of New Orleans, where one of its Standard Triple Evaporators was equipped with deflecting plates, exactly as shown in Fig. 6. The plates deflected when the steam was first turned on, but after the entire calandria is filled, the pressure becomes equal and the plates of no further use.

In connection with these plates, however, the drain, gas and air pipes are connected as near to the center of the calandria as possible, where a partial vacuum is formed causing the removal of the pocket, or dead space, and the steam to be drawn to the center; thus utilizing heating surface that heretofore was idle and now becomes effective. Large 16-ft. diameter effects, built last year in Cuba, without the plates, but with the drains to sweet-water pump, also gas and air pipes all connected in the center of the calandria, have proven by good results that plates are not necessary.

From 1834, when Norbert Rillieux invented and put into use in Louisiana the first multiple evaporator, which was of the horizontal type, to the present day, many changes have taken place in the design and style, economy and efficiency, all of which are fast coming to perfection through the efforts of learned and practical men, who give the results of their labors to the trade and craft.

Professor Kerr has given us tests taken on, most, if not all

[1] c/o The Payne & Joubert Mch. & Fdy Co., New Orleans.

of the various types of evaporators now on the market. It is hard to form a comparative conclusion as conditions alter and govern each test, which is proven by the fact that the same man on the same type of machine obtains different results at different centrals. The rating of any evaporator is computed by the number of pounds of water-evaporation per square foot of heating surface as a basis. A multiple of four, or a quadruple effect, is now conceded to be the most economical and is being adopted by most all large houses. The following list shows how even the test of different experts varies in a quadruple effect:

Hausbrand	5.2 lb. per square foot
Kerr	5.5 lb. per square foot
Jones & Scard....	6.0 lb. per square foot
Wallis & Taylor...	7.5 lb. per square foot
Hind	8.0 lb. per square foot
Deerr	9.0 lb. per square foot

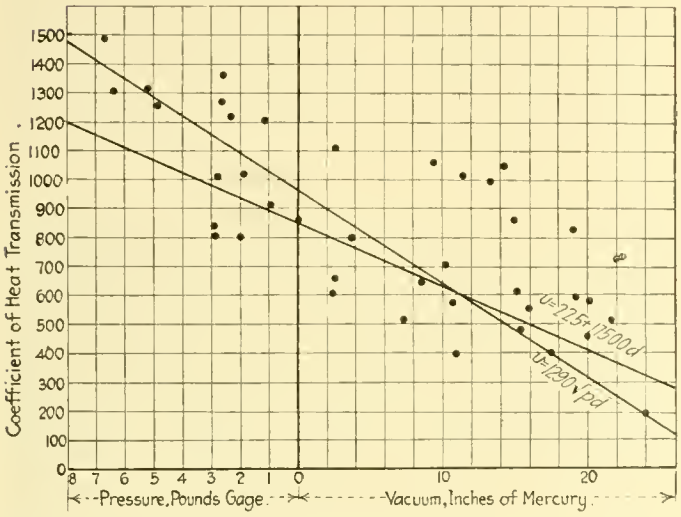

Fig. 12 Comparison of Author's and Parr's Formulae for Coefficient of Heat Transmission

We are indebted to our great Louisiana State University for the interest it is taking, through Professor Kerr, in carrying out such tests as are described in the paper, which are of so much value and interest to all concerned.

George A. Orrok (written). Professor Kerr has undertaken the investigation of one of the most complicated problems in the heat transmission field, and the results obtained show the difficulties which he has encountered. Theoretically, the case is that of the transfer of latent heat, introducing two changes of state, in consequence of which both upper and lower temperatures are constant and fixed by the pressures employed. The question is complicated by the presence of both air and water films on the gas side, with approximately similar conditions on the liquid side of the tube walls. Moreover, there is lack of control of film thickness because the circulation is negative or self induced, and an increase of certain film thickness (i.e. gas on the water side and water on the gas side) with an increase of circulation. When we added to this the scale and oil troubles on the gas side of the tube and the gumming of the surface from impure juice on the liquid side, it seems remarkable that so consistent results should have been obtained.

The author has plotted in Fig. 10 the results of all his laboratory tests given in his former paper. I have plotted (Fig. 12) across these points the line $U = 225 + 17500\ d$ which he has given as best representing them. I have also plotted a line $U = 1{,}290\ \sqrt{pd}$, Parr's[1] formula, in which the coefficient was obtained from the author's figures. These two lines cross at approximately 700 B.t.u. and 8 in. of vacuum. It would appear that variations as wide as 800 to 1370 B.t.u. at about 3 lb. per sq. in. pressure and 400 to 1070 B.t.u. at 10 in. of vacuum could hardly be expressed by either curve, and therefore the use of either as a correction formula would be inadmissable.

It is curious that all the performance curves in the paper inclusive cut the X-axis to the left of 22 in. of vacuum.

While the author has done some exceedingly good work in these tests of multiple effect evaporators which will enable the designer better to meet the demands upon this type of apparatus, the heat transmission problem for this particular case is likely to be troublesome for some time to come. It is highly probable that consistent results with multiple tube apparatus are only accidental and the simplest apparatus that will give the proper conditions will usually give the most consistent results.

Clark D. Libermuth.[2] The fouling of the heating surface by scaling is one of the most important of the practical considerations of the sugar apparatus.

Although it has been known that pressures above the atmosphere can be used in the first body of the evaporator, the high pressure has been brought into use only recently. At present in Cuba there are many evaporators in which steam under pressure is used in the first body. There being no sulphuration and little liming, no difficulty is met with. These higher pressures are now being used in Louisiana. More scale will be precipitated in the first body due to the higher temperature which may result in fouling the first body and cutting down the steam supply. The author is asked to investigate the effect of this condition in the first body with the Louisiana juices of high salt content.

Last year a rather peculiar situation presented itself over the State as a whole. The juices were of a higher purity than normal, yet the boiling took a longer time. There was general complaint. It was found, however, that the proportion of salts was much higher than usual, resulting in a high boiling point. The author is asked to investigate the relative effects of dissociable salts and organic compounds upon the elevation of the boiling point.

W. H. P. Creighton.[3] I agree with Mr. Orrok, that the question before us is extremely complicated. The theory of an engine condenser is simplicity itself when compared with that of the multiple effects used in the evaporation of sugar juices. The evaporation of sugar juices is an extremely important problem to us in Louisiana. Ten cubic feet of juice in the multiple effect will evaporate to two cubic feet, and in the vacuum pan will evaporate to one cubic foot. This cubic foot is an half and half mixture of molasses and sugar, and the apparatus must be designed to boil this mass. A 1,000-ton house will have about 1,000 tons of juice to get rid of, because maceration water and milk of lime will be added to the juice to be evaporated. To evaporate this water economically is a problem. There are temperature limitations; too high a temperature will spoil the sugar, while the low temperature is limited by the amount of vacuum obtainable. The *apparent* range is about 103 deg. But this is only ap-

[1] On the Theory of Multiple Evaporators, P. H. Parr, The Engineer, London, Feb. 18, 1916.

[2] Lauderdale P. O., Louisiana.

[3] 1445 Henry Clay ave., New Orleans, La.

parent. The difference in temperature in the first body, added to that in the second and in the third will not total 103 deg., because sugar solutions and water do not boil at the same temperature, under the same pressure. Then there is the loss due to hydrostatic head, the difference in juice height, which increases the pressure on the juice at the bottom of an effect. Hence, in the triple effect, 2 or 3 deg. may be lost in the first body, 4 or 6 in the second, and 10 or 12 deg. in the third. These added together reduce the apparent temperature range materially.

Table 1 may be correctly interpreted only by an expert in order to determine which of several causes were responsible for the variance in the amounts of water evaporated per sq. ft. of heating surface in evaporators of the same type. Different evaporators working under identical conditions will give different results. Personally, I am very much interested in the evaporator in Fig 6, as it was due to a suggestion of mine that Mr. Weber designed it. The entering steam was to sweep over tubes through a gradually diminishing area to maintain its velocity and keep the air moving with it to the very end where it is taken out by an air pump. In the ordinary standard evaporator, there is no way of telling if the air is being removed. There is violent evaporation in spots, indicating inefficiency, as the heat transfer is confined practically to such spots and they need high temperature differences to be effective. Whereas if the air is removed and the steam sweeps through a fixed channel, a less temperature difference will be necessary in the evaporator. This is illustrated in experiment 35, Table 1. Here the pressure in the first effect is only 6 lb. per sq. in. absolute, and in the last is 3 lb. per sq. in. absolute, a total pressure difference of only 3 lb. per sq. in This means that if the amount of steam admitted to the first effect had been large enough, the pressure would have been greater and hence there would have been a greater capacity. The author should say that capacity depends upon *three* factors: *quantity of heat supplied to the first effect*, coefficient of heat transmission and temperature fall. Scientific research in this field, considering each of the problems separately and as they affect the whole, is going to be of great value to the manufacturer and should result in the saving of an enormous amount of copper in the construction of evaporators.

E. H. ROUSSEAU.[1] I had the pleasure of making experiments on a small experimental evaporator with Mr. A. L. Weber. Heat transmission depends upon a difference in temperature. For an effective temperature drop from one side of the tube to the other, there must be a rapid replacement of the hot particles of juice by colder particles, so that the more rapidly cold juice can be brought to the heating surface, the more rapid will be evaporation. I refer you to evaporator D for the juice side of the evaporator and to evaporator E for the steam side. These I wish to combine in evaporator A which is our standard evaporator.

Viscosity increases with the concentration of a solution. As the viscosity increases, the size of bubbles formed in ebullition becomes greater in proportion to their weight and they are carried along more rapidly with the vapor currents formed. In the first body of a quadruple effect evaporator will be found conditions of high temperature and low density of juice. This is favorable for heat transmission. In the last body the conditions are low temperature and high density of juice. This is not favorable for heat transmission, but as the viscosity of the juice is high, the upward velocity of its bubbles is high and the temperature differences between the sides of the tubes are great, equalizing the rate of evaporation in the last with that of the first body.

In making these experiments, there was used an evaporator with a steam belt 2 ft. in diameter and 3 ft. high, with 2 in., No. 17 gage, standard copper tubes. Steam was under 10 lb. per sq. in. pressure and juice under atmospheric pressure. Steam distribution was as given in type E. With each new density, the level of the juice was varied from 0 to 36 in., and it was found that at 6 deg. Brix, the highest rate of evaporation was when the liquor was at $^1/_3$ the height of the tube. At 55 deg. Brix, the highest rate was with the liquor at $^1/_9$ the height of the tube, showing that with equal conditions of temperature, the density and viscosity of the juice increasing gave better results with a low height of liquor.

In these tests, steam was used. The air eliminator was closed; the heat transmission was 250 B.t.u. Opening the air eliminator and drawing out all of the air, the heat transmission was increased to 1000 B.t.u., an increase of 400 per cent. Uniform steam pressure can be maintained by high velocity of steam, by means of baffles, or by removing some of the tubes at the entrance, allowing the steam to enter the bulk of the heating surface, a pocket being provided from which to draw the air.

LEO LOEB (written). Another application of the multiple effect evaporators is the use for producing fresh water for drinking or boiler feed purposes from water containing a large amount of soluble salts. Compared with the sugar evaporators, the coil pressures in the first stages are generally higher, the heating surface is seldom, if ever, totally submerged, and the removal of the concentrated brine is governed by considerations of capacity and fouling of the heating surface and shell in contact with the brine.

The purity of the fresh water should be such that less than one grain of chlorine per gallon can be detected by the silver nitrate test. It is therefore necessary in some types of commercial evaporators to expose a portion of the heating surface, slightly heating the ascending vapors, and giving the particles of solid salt an opportunity to separate. However, if proper attention be given to baffle and separator design, it is possible to operate the evaporator with submerged heating surface at high rates of evaporation and obtain distillate of required purity.

The usual installation on shipboard consists of duplicate sets of three evaporators, so piped as to be operated in triple effect or single effect, depending upon the immediate demand for fresh water.

Of the various factors mentioned in the paper as affecting the capacity of evaporators, the most important in the design and operation of salt water evaporators are:

5 Presence of condensation on the heating surface,
8 Cleanliness of heating surface (liquor side),
14 Density of liquor being boiled.

Air and other incondensable gases have less effect in the salt water evaporator where higher steam pressures are used than in the sugar evaporators under vacuum, providing they are not permitted to blank off a portion of the heating surface.

The great loss in capacity due to condensation on the heating surface was clearly illustrated by recent tests on two horizontal tube evaporators. One consisted of 1½ in. brass tube heating surface arranged in eight horizontal rows and connected by return bends. Thus the condensate traveled the entire length of the eight tubes before being vented, with the result that the

[1] c/o Dibert, Bancroft and Ross Co., New Orleans, La.

coefficients of heat transmission were low, ranging from 115 to 323 B.t.u. per sq. ft. per hr. per degree difference in temperature between steam at entrance to coils and vapor in shell. When operating in single effect, the temperature of condensate at the vent was from 32 to 176 deg. below the temperature of saturation of steam entering the coils, and the evaporating capacity of the heating surface was from 7.7 to 19.9 lb. of vapor per sq. ft. with brine at 180 deg. fahr.

A modified design having nine rows was provided with a header so that the condensate from any tube could reach the vent by traveling through only one cooling coil. With the same steam and vapor pressures as in the first type, the coefficients of heat transmission were from 387 to 719 B.t.u. per sq. ft. per hr. per degree temperature difference between steam at entrance to coils and vapor in shell. The amount of subcooling of brine never exceeded 90 deg. and the evaporating capacity of the heating surface was from 17.2 to 81.4 lb. of vapor per sq. ft. with brine at 180 deg. fahr.

The reduction in capacity of the salt water evaporator when the concentration of the brine is increased from twice to three times that of normal sea water is about 10 per cent, amounting to fully 15 per cent if the concentration be further increased to four times that of sea water.

It would be interesting to know how Professor Kerr calculated temperature difference. In salt water evaporators, the temperature gradients on the two sides of the heating surface are complex. A portion of the surface in contact with the heating medium destroys the superheat which may result from throttling at the inlet valve, a great portion of the area is effective condensing surface and the final portion is water cooling surface. On the brine side, these states are reversed, a part of the surface acting as feed heating surface, the major portion as evaporating surface and a small portion at times as superheating surface. Under these circumstances it has been the practice to consider temperature difference as indicated above to be the difference between the saturation of steam to coils and saturation temperature of the vapor in the evaporator body.

The Author. I wish to call attention to the preliminary statement I made when this paper was presented—that it should be looked upon as a survey rather than as a research. The tests recorded were made on full-size sugar house evaporators operating under regular conditions, therefore there was little opportunity to control conditions as would be required for research work in the fullest sense. A former paper[1] by the author giving the results of a series of experiments on a laboratory evaporator is better entitled to consideration as research work, and I would respectfully direct the attention of Mr. Creighton, who mentioned in his discussion the need of research along these lines, to this paper. The tests recorded in the present paper give data only on the subject of rates of heat transmission, nothing having been said relative to the cost of heating surface, the cost of operation, maintenance, etc. The proper selection of an evaporator for a specific installation should of course include a consideration of all of these points.

Mr. De Pass calls attention to the loss of sugar due to entrainment. This bears on the present paper only indirectly because of the fact that, in order to separate the entrained juice, save-alls must be installed and the friction of the vapors passing through them may result in pressure losses which in turn reduce capacity by reducing temperature fall. In elaborate tests made by the author on a laboratory evaporator, data were obtained which seemed to show that entrainment is principally affected by the height of boiling and by the rate of boiling. In other words, the higher the boiling and the greater the rate of boiling, at least in the standard type, the greater the amount of entrainment. Practice seems to show that it is difficult to design save-alls that are efficient as separators that do not offer excessive friction.

Several references were made by those discussing the paper to type E, which makes use of a set of baffle plates in the calandrias to give a long and gradually narrowing steam path. This type was originally developed in Europe many years ago, but was recently introduced into this country by Mr. A. L. Weber.

It will be seen in the paper that the average coefficient of heat transmission for tests 33, 34 and 35 of type E was 248, whereas the average for the standard evaporator, type A, was 197, which seems to show that the higher steam velocity and possibly the better removal of incondensible gases due to the baffle plates have resulted beneficially. It may be well to state that this is only one of a considerable number of different arrangements of baffle plates that have been used or suggested for distributing steam in calandrias. The increase of steam velocity in such an arrangement will naturally result in pressure drop, which must be overcome by means of a pump. The power required to operate such a pump, however, is not so important in connection with an evaporator as in the case of a surface condenser for the reason that the exhaust steam from the evaporator pump can be utilized.

Mr. Orrok calls attention to the fact that all the performance curves in the paper cut the X-axis to the left of 22 in. of vacuum. I will call his attention to the fact that the coefficients plotted were *apparent*, that is, they were determined by dividing the heat transmitted by the apparent temperature fall. In other words, the temperature fall was obtained by subtracting the saturation temperature of the steam corresponding to the pressure in a body, from the saturation temperature corresponding to the pressure in the preceding body. Due to the effect of hydrostatic head, viscosity of juice, the presence of air in steam, etc., the actual temperature fall is less than the apparent fall. As is well known, also, the difference between *actual* and *apparent* fall is greater in the last bodies. Consequently a curve representing actual temperature falls would be nearer horizontal than those given in the paper. The above will answer Mr. Loeb's question, regarding the method of determining temperature fall.

The effect of juice scale, as Mr. Libermuth points out, also the effect of juice viscosity discussed by Mr. Rousseau, are important, and while some work has been done along these lines by the author, we hope to make experiments in the future that will enable us to form more definite conclusions regarding these points than we now have.

The principle upon which the Diesel engine operates has not to date been successfully adopted for use with the commercial motor truck. It is more than probable that such a development will occur, and should it do so it will provide a very useful alternative as an offset to gasoline, the cost of which for trade vehicles is a considerable item in the running expenses. There is no doubt that a vehicle propelled by an engine of the Diesel type, using heavy oil as fuel, would be a boon to users of that class of machine.

Suggested modifications of the present Diesel engine for the end in question are described and illustrated.—*The Commercial Motor*, XXIII-578, April 6, 1916.

[1] Trans. Am.Soc.M.E., Vol. 35, page 731.

ITEMS OF INTEREST

The use of aluminum when filed to a powder is little understood. In this condition it forms part of two of the most destructive of agents, one of which is known as ammonal, a mixture of five or eight parts of ammonium nitrate with one part of finely powdered aluminum, and used to charge shells. Its explosive violence is tremendous, and it is one of the few explosions that have never been used as propellants, as its suddenness would smash the explosion chamber of any gun known to warfare.—*The Brass World*, XII-5, May 1916.

From an engineering standpoint, intense heat can be used for carrying out many industrial processes to which at present other means are applied. Ordinary fuel furnaces can seldom be raised to a high temperature, but oxy-acetylene furnaces are capable of giving out great heat. One of the most interesting and industrially useful processes for which a high temperature is necessary is the fusing of quartz, which, when brought to a fluid state by means of an oxy-acetylene blowpipe, is moulded into flasks, bowls, tubes, and other vessels for chemical purposes and for domestic applications of electricity, cooking utensils, etc.—*Acetylene Lighting and Welding Journal*, February, 1916.

While the use of the electric one-direction drive for rolling mills is not new, when it comes to the reversing mill the steam engine is probably still largely considered the better adapted prime mover.

Nevertheless in a paper by William Sykes and David Hall, before the A.I.E.E. at this year's Cleveland, Ohio, meeting, on "Electric Drive for Reversing Rolling Mills" the authors state that within the last few years the electrically driven reversing mill has been considerably developed and a number of installations made with great success; and as an indication of the position which the electrical form of drive has reached, the engineers of one of the large steel companies stated that the electric drive would undoubtedly in the very near future entirely supplant the reversing steam engine, except in perhaps certain peculiar cases.—*Proc. A.I.E.E.*, XXXV-6.

Spur Gearing is the subject of a paper by Daniel Adamson, read before the Institution of Mechanical Engineers.

The difference between cycloidal and involute shapes for teeth are mentioned, the advantage claimed for the latter being that it lends itself better to satisfactory production by generating machines.

The proportions of length of tooth to pitch and also the angle of obliquity are considered.

The various materials used in the construction of gearing are named, leading up to the present practice of using steel almost universally.

Allowable working stresses are reviewed, beginning with data published by Walker in 1868, upon which were based later what is known as the "Lewis" formula. Permissible working speeds are given ranging from 600 ft. per min. up to 5000 ft. per min.—*Jour. Inst. Mech. Eng.*, May 1916.

Tests of a surface-combustion type of furnace for laboratory use were recently made by E. Schramm and J. R. Cain. Measurements were made coincidently of the consumptions of air and gas, the compositions of the flue gas, and the temperature resulting from different rates of combustion.

Observations were made of the varying temperature due to altering the ratio of air to gas.

It was clearly established that such a ratio of 5.5 gives most nearly the ideal condition of perfect combustion without any excess of oxygen; and it was seen that a 20 per cent excess of air caused a lowering of the furnace temperature of 100 deg. cent (180 deg. fahr.).

A temperature of about 1650 deg. cent. (3000 deg. fahr.) was reached in a little over half an hour and maintained for 10 minutes, when the alundum muffle caved in.—*Jour. Ind. and Eng. Chem.*, VIII-4.

Stresses in connecting rods are set forth in a paper by Lieutenant Karl F. Smith, before the American Society of Naval Engineers.

Tension stresses are not considered, failure due only to compression and the stresses of centrifugal force is dealt with.

In the plane parallel to the shaft, the rod, due to the form of the wrist and crank-pin bearings, may be considered as a column with *fixed ends*, while in the plane of oscillation it is a column with *pin ends*, and free to take up any angular position in this plane, and as all theories and experiments show that the collapsing load is much greater for fixed ends, it is necessary to consider only yielding by bending in the plane of oscillation.

Stress diagrams are given, and it is pointed out that one stress has generally been neglected, though of extreme importance.—*Jour. Am. Soc. Nav. Eng.*, May 1916.

In a lecture before The Royal Institution, Professor E. G. Coker dealt with "Polarised Light and its Application to Engineering." He said that the remarkable discovery of Sir David Brewster, made in 1816, that transparent materials when stressed became doubly refractive, might well have been more frequently pressed into service. The discoverer pointed out that the stress in arched rings of bridges could be rendered visible in a glass model.

Professor Coker stated that in applying this discovery to cases of practical importance it was evidently necessary that that material used should have physical characteristics similar to steel, iron and other materials of general use by engineers, and in this respect glass has many desirable qualities, but that little success has resulted, due mainly to the difficulties experienced in shaping glass models; but that when these are overcome the value of the information gained is very great.

Nitro-cellulose preparations afford a material having nearly all the desirable features of glass and some other properties which make it in some respects superior thereto.

The lecturer showed a model of an arch-ring which, when loaded, glowed with color in the polariscope and gave a readily interpretable picture of the state of internal stress.—*Cassier's Engineering Monthly*, vol. 49, no. 4, April 1916.

DRAINAGE PUMPING

Discussion on the Evolution of Low-Lift Pumping Plants in the Gulf Coast Country Given at the Spring Meeting in New Orleans

Professor Gregory's paper, the discussion of which is here presented, related the history of low-lift pumping in the Gulf Coast country and gave examples of typical pumping plants.

The discussion supplements the author's record by examples of plants in the Upper Mississippi Valley.

It includes additional information regarding the unique low-lift screw pumps recently installed by the New Orleans Sewerage and Water Board. Each of these pumps has a capacity of 225,000 gal. per min., and the pumps have an efficiency of over 70 per cent for lifts between 3.5 and 10.5 ft.

The discussion also includes supplementary data on low-lift pump details, and considers types of pumping units other than those treated in the paper.

THE paper entitled The Evolution of Low-Lift Pumping Plants in the Gulf Coast Country, presented at the Spring Meeting held in New Orleans, April 11 to 14, by W. B. Gregory, Mem.Am.Soc.M.E., was published in the May issue of The Journal. This paper showed the part that pumping machinery has had in the development of the City of New Orleans and in the reclamation of the fertile wet prairie lands of Louisiana and Texas; also the importance of pumping plants to the rice industry of the Southwest. To this end the history of pumping in this section was briefly related and examples of typical pumping plants given.

About ten years ago a movement was started by Edward Wisner to reclaim the wet prairie lands lying at or near Gulf level. The work is now being carried out on an extensive scale. More than a quarter of a million acres of agricultural lands have been reclaimed or are at present in the process of reclamation in the state of Louisiana. The land reclamation has been of such recent development that there is no adequate record of the magnitude of the pumping plants, such as was furnished by the Special Censors of 1910 for irrigation, and this the paper aimed to furnish.

The paper drew out some very valuable discussion, not in criticism, however, but containing supplementary data of interest and importance in connection with the author's historical record of the development of low-lift pumping machinery and his presentation of test results. The paper and discussion furnish, therefore, an adequate source of reference on reclamation work as developed in the Mississippi Valley.

DESCRIPTION BY JOHN J. HARMAN OF THE PLANTS IN THE UPPER MISSISSIPPI VALLEY

JOHN J. HARMAN (written). In the Upper Mississippi Valley drainage pumps of other than the centrifugal type have hardly been used at all, although there has been quite a variety of different kinds of prime movers. The most predominant type of machinery used in the earliest plants was the low head centrifugal pump, driven by simple slide valve engine, the steam being supplied at about 100 lb. pressure from a fire tube boiler. The machinery in these plants was far from being high grade in materials and workmanship, and often the pumps did not have sufficient capacity to handle the drainage water under wet weather conditions. Another common fault was that the power units were not properly proportioned to the loads imposed upon them, so that in some cases where the pumps were abundantly large, the engines and boilers were too small to carry the load when the river was at a high stage. Add to this unstable foundations and poor management, and we have a fair conception of these earlier plants. Some of them were complete failures, and the ones which handled the water successfully were very expensive to operate, difficult to keep in repair and, like most agricultural machinery, very short-lived. A number of these plants have been completely rebuilt, long before the bond issue covering the original cost of installation was paid off. The great benefits derived by drainage, due to the high fertility of the reclaimed lands, however, offered a reward so tempting that the development went on apace in spite of the difficulties encountered.

The quality of machinery installed has gradually improved. Centrifugal pumps especially designed to meet the peculiar requirements of this service have been developed, which show an efficiency of from 65 to 80 per cent, or even higher, throughout the working range. Careful designs of suction and discharge pipes have been made, reducing the total pipe friction and velocity head losses to a mere fraction of the losses in the earlier plants. The power producing equipment has been vastly improved, both in quality of workmanship and materials and in economy of operation. Foundation designs of a highly permanent character and fireproof building construction have been introduced.

These improvements in pumping plant construction have not been accomplished without much persistent effort on the part of the engineering profession and the more far-sighted land owners. In many cases, of course, it has not been possible to design in accordance with the dictates of engineering judgment applied to the problem on account of first cost restrictions placed by the land owners and district officers.

Although there is a rapidly growing trend toward high grade pumping plant construction, there are still a great many who willfully close their ears to the advantages of: a reduction in the perpetual yearly operating cost of 50 per cent or more; permanent foundations having a life of 100 years or more, particularly the part below normal water level, which offers great construction difficulties; a substantial fireproof building having a life of 50 years or more; high grade heavy type machinery on stable foundations, having a

life of 30 years or more; a substantial reliable confidence-breeding pumping plant, the heart of the reclamation project, which adds dollars to the value of every acre of land in the district. It is encouraging to note that during the past five or six years a number of this type of high grade pumping plants have been constructed.

As typical of these high grade plants, a brief description of three plants is given below, together with a statement of the economy guarantees and the results of the acceptance tests.

Elsberry Drainage District.—The Elsberry Drainage District is located in the State of Missouri on the west bank of the Mississippi River, about 70 miles above St. Louis, Missouri. It contains 25,000 acres of reclaimed land. About 113,000 acres of hill drainage is diverted to the Mississippi River above and below the district by means of diversion channels.

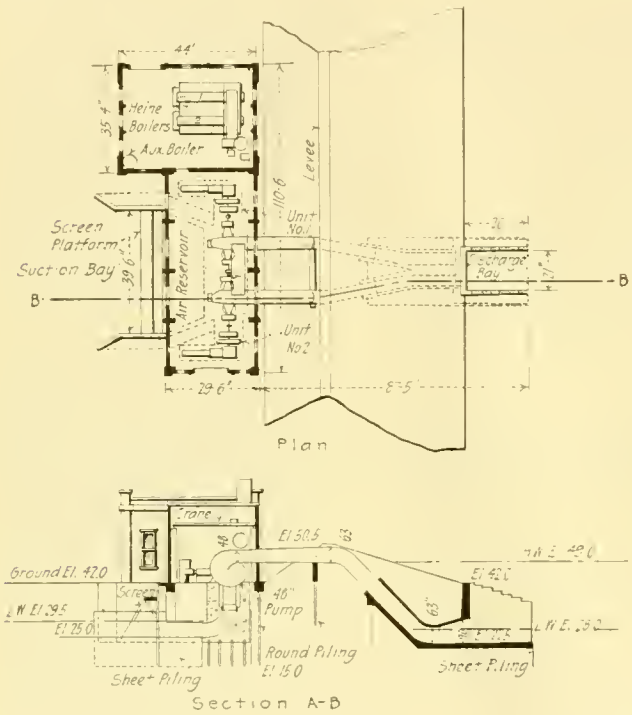

Fig. 1 Pumping Plant of the Elsberry Drainage District

The pumping plant contains the following principal equipment:

Two 48-in. Alberger low head centrifugal pumps
Two 21 in. x 26 in. Fleming-Harrisburg Heavy Duty Uniflow Engines
Two American jet condensers driven by silent chain drives from the main engine shafts
Two 168-h.p. Heine water tube boilers, equipped with shaking grates, soot blowers and induced draft apparatus
One Webster open feed water heater, together with miscellaneous auxiliaries and appurtenances.

Fig. 1 shows the general layout of this plant, while Fig. 2 shows on a larger scale the suction intake arrangement. Particular attention is directed to the permanent character of this design, the intakes being built in solid concrete and the discharge pipes being encased in concrete below normal water level. The friction loss in this intake is so small as to be almost unmeasurable, and the total friction and velocity head loss in the intake and discharge pipes, with the pumps operating at normal capacity, is less than one foot.

Another feature of this design is the cross-connection of the two units, so that one or both pumps may be operated from either engine. For ordinary pumping heads up to about 7 ft. both pumps are operated by one engine, thus securing much better engine economy at the low heads.

The acceptance test of this plant was made in 1915. The pumping head during the test averaged 7.52 ft., and by converting the data to guarantee conditions the following results were secured:

a	Pounds of 10,800 B.t.u. coal per acre-foot of water pumped against a 6-ft. static head	36.6
b	Pounds of 10,800 B.t.u. coal burned, per useful water horsepower	4.43
c	Contractor's guarantee: Pounds of 10,800 B.t.u. coal per acre-foot of water pumped against a 6-ft. static head	38

Muscatine-Louisa Drainage District No. 13.—The Muscatine-Louisa Drainage District No. 13 is located in the State of Iowa on the west bank of the Mississippi River, just below Muscatine, Iowa. It contains 21,400 acres of reclaimed land, and 30,000 acres of additional land drains into the district and has to be pumped. Much of the land is of a sandy nature, so that the run-off is delivered slowly to the ditches. The plant contains the following principal equipment:

Two 54-in. Worthington low head centrifugal pumps
One 36-in. Worthington low head centrifugal pump
Two 20 x 30 Filer & Stowell Uniflow engines, direct connected to the 54-in. pumps
One 14 x 30 Filer & Stowell Uniflow engine, direct connected to the 36-in. pump
Two 7-in. Schutte-Koerting Eductor Condensers
One 5-in. Schutte-Koerting Eductor Condenser
Two 200-h.p. and one 100-h.p. water tube boilers, equipped with Heine superheaters, shaking grates, soot blowers and induced draft apparatus
One Cochrane feed water heater and purifier, together with miscellaneous auxiliaries and appurtenances.

The steam is generated at 175 lb. pressure and carries 100 deg. superheat. The condensers produce a vacuum of 26 in., the circulating pumps being driven by silent chain drives from the main engines.

The general layout of this plant is shown in Fig. 3, p. 47, of the U. S. Department of Agriculture Bulletin 304.

The contractor's guarantees on the economy of this plant read as follows: The coal per acre-foot when pumping against a 6-ft. static head is estimated from manufacturer's guarantees not to exceed 46 lb., and will not in any event exceed 56½ lb. when tested as required by the specifications.

The acceptance test of this plant was conducted in June, 1915. The pumping head at the time of making the test was only about 4 ft., but by converting the data to the guarantee conditions by means of the contractor's efficiency and capacity curves, the final results secured were as follows:

a	Pounds of 10,500 B.t.u. coal, per acre-foot of water pumped against a 6-ft. static head	35.4
b	Pounds of 10,500 B.t.u. coal burned, per useful water horsepower	4.29
c	Contractor's guarantee: Pounds of 10,500 B.t.u. coal per acre-foot of water pumped against a 6-ft. static head	56.5

Fabius River Drainage District.—The Fabius River Drainage District is located in the State of Missouri on the west bank of the Mississippi River, opposite Quincy, Illinois. The district contains 14,250 acres of reclaimed land. The North and South Fabius Rivers, having a drainage area of about 1,000,000 acres, are diverted around the lower end of the district, and about 19,000 acres of hill land drainage is diverted to the river at the upper end of the district.

The pumping plant is now under process of construction, and when completed will contain the following principal equipment:

Two 42-in. Southwark double suction low head drainage pumps
Two 250-h.p. Southwark-Harris valveless oil engines (Diesel principle)
One 60-h.p. Winslow high pressure oil burning steam boiler for auxiliaries. The layout of this plant is very similar in general character to the layout of the Elsberry Drainage District plant.

While this plant has not been tested, it is expected to meet the contractor's guarantees without difficulty. The guarantees are as follows:

a	Pounds of 18,500 B.t.u. 25 deg. Baumé fuel oil, per acre-foot of water pumped against a 6-ft. static head	7.76
b	Pounds of 18,500 B.t.u. 25 deg. Baumé fuel oil burned per useful water horsepower	0.94

Another phase of the problem of drainage pumping, fully as important as design and construction, is the proper maintenance and economical operation of the plant from day to day and from year to year. Reclaimed lands of this type are encumbered perpetually to the extent of this maintenance and operation cost. Like interest, it runs on forever, but unlike interest, it is far from being a fixed charge. In some districts, through uneconomical operation, mismanagement and other causes, this has become a very serious burden, amounting in one instance to considerably over $3.00 per acre, per year, as compared with 30 to 60 cents per acre in fair sized districts having economical and well managed plants. There are a great many factors affecting the cost of operation which cause the operating cost to vary quite materially, even when the plant is well operated and maintained, such as size of district, kind of plant, exceptionally long periods of high water in river, exceptional heavy rainfall, rainfall not well distributed, seepage through leaky levees, and last but by no means least, spring water.

Experience along the Illinois and Upper Mississippi Rivers has demonstrated that spring water may easily add 100 per cent to the normal yearly pumping requirements. The unavoidable variations in operating cost from year to year make it too hazardous for the operation to be contracted on the lump sum basis, and the only plan which has been used to any extent in this region to increase the operating efficiency of the plants is to employ a supervising engineer, who makes tests at the plant under various operating conditions and determines the most economical pump speeds throughout the range of pumping head. He also keeps in touch with the plant by means of daily reports from the station engineer, containing data which, combined with the pump ratings, will give a complete plant test for each operating day. If anything goes wrong with the machinery in any way, it is thus discovered at once and corrected before any material amount of money is wasted in inefficient operation.

The matter of proper pump speed is of much greater importance in the Upper Mississippi Valley than in the Gulf Coast Region on account of the very much greater variation in pumping head, and consequent losses when the pumps are operated at the wrong speeds.

Another common cause for inefficiency is the partial obstruction of the waterways in the pumps or pipes by some foreign substance. Instances of this kind have been found where the obstruction had seriously reduced the pump capacity for a long period of time without being discovered and removed. The pump capacity is also oftentimes seriously reduced without the knowledge of the attendant by air pockets in the summit of the discharge pipes. The data contained in the daily operating reports would immediately disclose troubles of this kind to the supervising engineer.

Another valuable service rendered by the supervising engineer is in seeing to the proper maintenance of the plants and making the necessary repairs.

These plants always have a season during the summer and fall when they are completely shut down for long periods, and this affords an excellent opportunity for overhauling the plant, making any necessary repairs and putting all the equipment into first-class operating condition for the next pumping season.

Engineering supervision insures reliable pumping service, economical operation and proper plant maintenance, results which are of far more value to the drainage district than the cost of the service.

As previously stated, the experience in the region under discussion seems to indicate that engineering supervision of operation is fully as important to the continued success of these pumping plant projects as engineering design and supervision of construction, but it would appear that the general run of landowners and district officials must be educated considerably before engineering service will be employed in this connection to any great extent. The writer feels that the Drainage Investigation Division of the U. S. Department of Agriculture might very properly make this matter of pumping plant operation and maintenance the subject of a thorough investigation and bulletin.

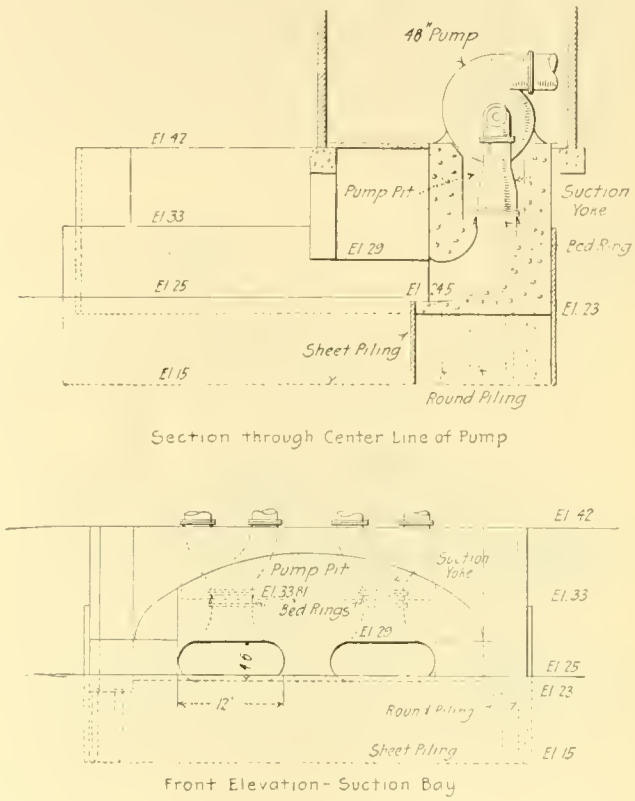

Fig. 2 Foundation Details of the Pumping Plant in Fig. 1

MAXIMUM ULTIMATE ECONOMY OF THE WOOD SCREW PUMP POINTED OUT BY S. L. MENGE

S. L. Menge (written). The function of a drainage-pumping station is to maintain the water level on its suction side lower than the water on its discharge side. When it has just ceased to do this, it becomes an obstruction instead of an asset, and its crucial test is its capacity to discharge more and more water with less and less power per unit discharged as the lift decreases and the necessity to pump therefore is most urgent. At the most crucial point, if the power and the pumping capacity are properly adjusted, one will be able to pump with the same power expenditure from three to five times as much water per applied brake horsepower with pumps having the characteristics of the new Wood screw pumps as with pumps having characteristics of the earlier type of pumps installed in New Orleans—or with the best design of centrifugal units.

The development of low-lift pumping machinery has necessarily been undertaken principally by the large pump manufacturers where competition involved simply the reliability,

economy and first cost of the pumps only, without consideration of the other essential features, which must be considered in the ultimate system.

The experience heretofore of the Sewerage and Water Board has been that during great storms, when lifts were much below the rated lifts, the older forms of pumps overloaded their motors and also overloaded the power stations, so that all pumping-station units could not be maintained in service. With the eleven additional screw pumps, which the Sewerage and Water Board proposes to install, and less than enough additional power to operate them at their rated lift, because the flow at rated lift can never supply all pumps, this condition will be reversed. The decreasing amount of power required to operate the new pumps as their lift decreases will more than compensate for the excess amount required by the old ones when their lift decreases and the necessity to pump is at its greatest.

According to a test conducted by Prof. W. H. P. Creighton, Dean of the Department of Technology, Tulane University,

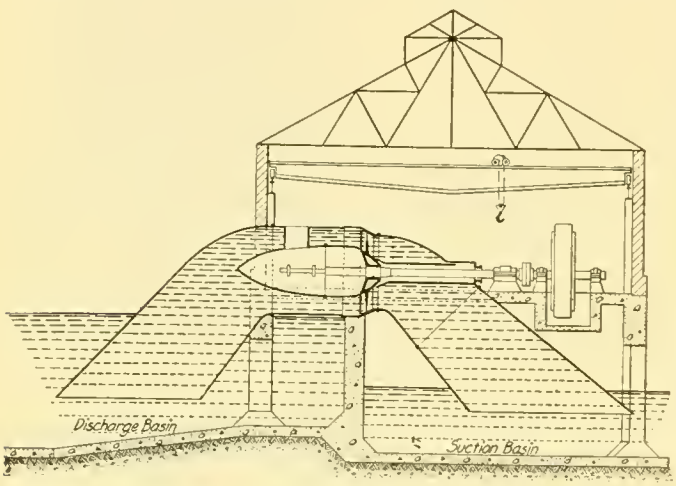

Fig. 3 Section through 12-ft. Screw Pump

New Orleans, the Wood screw pumps of the New Orleans Sewerage and Water Board give their best efficiency at 7 to 8-ft. lift, and show a better figure for 7½ ft. than the best of the Board's old centrifugal pumps at its best point, 11 ft. The advantages of accessibility, operation, first cost, etc., are, however, more than sufficient to dictate the use of the screw pump even if the power consumption characteristics were the same as those of the centrifugal.

Passing over the improvements which are apparent in the examination of the diagram of the comparative efficiency curves, it seems that the local benefit is best illustrated by comparing the cubic feet per second discharge per applied brake horsepower of the 76 r.p.m screw pump than for the other groups of pumps.

The best of these pumps, measured by this yardstick, adds only 50 per cent to its capacity per applied brake horsepower as its lift drops from its point of maximum efficiency, which is 11 ft., down to zero, while the new screw pump increases its capacity per applied brake horsepower 300 per cent from its lift for maximum efficiency at 7½ ft. down to zero.

In a system like that in New Orleans, operated electrically with power and pump capacity designed to give the required output under those low-lift conditions which require the greatest quantity of discharge, the power requirement to operate all units will be much less with screw than with centrifugal pumps. Since as the lift increases, the available flow approaching the stations decreases and fewer pumping units have to be operated, the power required to operate the pumps at a low lift will still suffice to operate enough units as the lift increases to take care of the decreasing flow. With pumps driven by power units capable of some speed variations, the characteristic of the screw pump is such that available power can be utilized at an increased speed at lifts far below the rated lift, without the serious sacrifice of efficiency which an increase of speed entails with centrifugal pumps.

Professor Creighton's test was made with a view towards determining the amount of water that one of the new 12-ft. Wood screw pumps could lift, and the efficiency of performance. The result shows that the pump raised 559 cu. ft. per sec. through a height of 5.6 ft. and 519.8 cu. ft. per sec. to 7.6 ft., the pump making between 75 and 76 r.p.m. and the efficiency varying between 76 and 80 per cent.

It should be noted that these pumps are not designed to fit a certain condition of lift, which may be more or less arbitrary and theoretical, but are designed to work with the maximum economy on widely varying lifts, such as actually obtain in service on practically every drainage problem.

The New Orleans units, with capacity of 500 to 600 cu. ft. per sec., can be advantageously installed in a space only slightly wider than the suction bells themselves (22 ft.) and depth of building of 50 ft. inside. They are particularly free from any vibration and, therefore, require little foundation mass. They operate at relatively high speeds, being particularly suited for direct connection to electric motors at constant speed. They are entirely self-oiling, no bearing coming in contact with the water or subject to grit and wear. A section of one of these pumps is given in Fig. 3.

Additional Data by B. S. Nelson Relating to Pipe Ends, Suction Basins, Etc.

B. Stanley Nelson (written). The author shows clearly the importance of enlarging the ends of the suction and discharge pipes to recover velocity head, because this head, unless converted to pressure head, and so recovered, represents a considerable portion of the total lift.

An important feature in the design of these expanding ends on the suction pipes is the angle of the plane of entrance with relation to the water line. The center line of the suction usually makes an angle of from 30 to 60 deg. with the water, and three types of ends naturally suggest themselves, as shown in Fig. 4, *A* being where the end is at right angles to the center line, *B* at right angles to the water and *C* parallel to the water.

The writer has had occasion to design and observe the behavior of a number of installations where one or other of the three forms of ends or modifications of them was used, and the conclusion is that type *C* is the best. Both *A* and *B* (particularly *A*) cause suckholes to be formed,—sometimes with a considerable depth of water over them, while with *C* it is possible to pump down to within a few inches of the end of the pipe. Suckholes are objectionable, as they admit air to the pump, and air in a centrifugal reduces both the capacity and efficiency.

The design of the discharge end of the pipes is not so important other than the ends should expand sufficiently to recover velocity head. In the typical drainage plant of this region, where the pumps discharge into an outfall canal close to the plant foundation, care must be taken to direct the flow

of water so as not to cause scouring of the canal bottom, and the design shown as *D*, Fig. 5, works very well. The flattened end, *D'*, is used on large pipes to reduce the depth at which the pipes must be set to maintain the siphon seal.

In his description of the test of the Louisiana Meadows oil engine driven plant, the author has touched on a feature of the typical drainage plant of this region, where pumps of large size with very short suction pipes are set in a dam across a canal, and that is the relation of the suction basin to the efficiency of the pumps.

At first thought, it would seem that if the suction basin were deep enough at the end of the pipe, it would need no further consideration, and that if there were some obstruction, the only effect would be to slightly increase the friction head due to restriction of area at entrance. It has been found, however, that where the suction basin is too shallow, or, if deep enough, through some irregularity of contour causes greater velocity of approach at one side than the other, or if there is a mud lump in front of the suction, the effect is not only to reduce the capacity, but also the efficiency of the pump. This is probably due to the fact that any disturbance at entrance goes on up through the suction into the pump impeller because the pipe is too short to allow the velocities across a section of the pipe to smooth out before reaching the pump. In the case of the Citrus plant, tests showed an increase in efficiency of about 8.5 per cent after dredging out the suction basin. The remedy is to give more thought to the design of the suction basin. This has usually been given but slight consideration, because it is the junction point of the dredging and machinery contractors, and each feels that it is the work of the other.

A very interesting and important feature of two of the plants mentioned, namely, the motor driven Citrus plant, and the oil engine driven Raceland plant, is the power characteristics of the pumps. The usual centrifugal pump power curve called for a great increase in power at heads much lower than normal working head, if the speed were kept constant. This presented no great difficulty in the case of the steam engine driven unit, for the steam engine is flexible, and the speed and cut-off could be varied to suit the head. But in the case of the motor driven plant it was, for obvious reasons, preferable to use a constant speed induction motor; it was also desirable to have the motors fully loaded at normal head, to get best motor efficiency. The problem was to design a pump which, when run at constant speed at all heads by a motor which would be fully loaded at normal head would not overload that motor at zero or intermediate heads. The pump builders met these conditions by using an impeller which is a combination of the centrifugal types—the pumps have a characteristic such that the ratios of the power input at 2, 4, 6, 8 and 10 feet to the power at normal head of 6 ft. are as follows: 0.93, 1.00, 1.00, 0.99 and 0.88.

In the case of the Raceland plant, the pump designer had additional problems to contend with in the characteristics of the oil engine. An oil engine should not be overloaded beyond about 10 per cent of its full load rating; its speed, for best results, is fixed, or nearly so; and in this size unit, this speed is considerably higher than the usual speed for a pump with 4 or 5-ft. lift. Direct connection was necessary because the initial cost of the oil engine precluded the use of a gear reduction such as was justifiable in the case of the motor driven plant. By the use of the combination impeller mentioned, the designer has built these pumps with a practically straight line power curve, the variation in horsepower at all working heads between zero and 7-ft. lift being about 5 per cent.

INDORSES MR. GREGORY'S PAPER AS SOURCE OF REFERENCE

A. M. Shaw (written). The author's careful exposition of the various types of pumps which have been used and the description of the conditions under which they have operated will do much toward reducing the labor and annoyances of engineers engaged in preparing plans for future installations for this kind of service.

Reference to this paper should suffice as an answer to many of the questions over which we are now wasting time and patience. It contains much valuable data which have hitherto been unavailable, and its net result will be a benefit to the profession and a still greater benefit to the public, as it will enable their designers, the engineers, to make use of past experience in the development of low-lift pumping machinery and to avoid the errors in design to which our attention has been called.

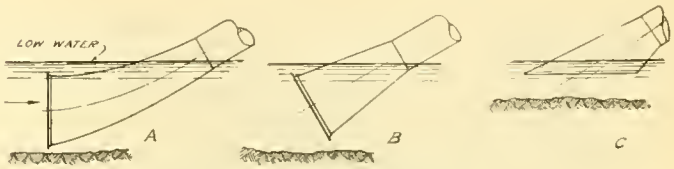

Fig. 4 Typical Suction Pipe Ends

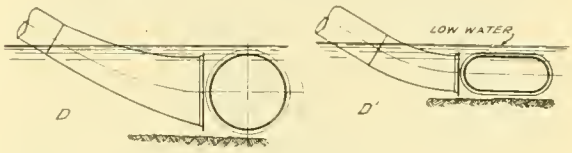

Fig. 5 Typical Discharge Pipe Ends

DISCUSSION OF THE POSSIBILITIES OF OTHER TYPES OF PUMPING UNITS FOR THIS SERVICE

Charles C. Trump (written). There are new types of pumping engines already entering this field. The four-stroke cycle type of Humphrey pump, which uses internal combustion in direct contact with the liquid to be pumped, is hardly suitable for lifts under 15 ft., on which it depends for the compression which makes for efficiency of combustion. A two-stroke type now in process of development gives promise of working well on heads of 8 to 10 ft., but is somewhat high in first cost.

An entirely new type of pumping engine, known as the Tube pump, based in part on the principle of the Humphrey pump, has just been developed, and gives promise of working out, not only for large volumes with low lifts, but especially for small plants taking water from wells at lifts from 50 to 100 ft. or more for irrigation. This type of pumping engine may be driven by power cylinders using either internal combustion or steam.

As has already been discussed in recent papers before the Society, higher steam pressures present opportunities for improving the economies of steam power plants. Why should not such improvements be made as well in pumping engines?

It would seem as if marine engines adapted to high pressures would be suitable for driving screw pumps. Even steam turbines might be used; but an engine still better adapted to utilize the theoretical advantage of higher pressures is now available in the unaflow steam engine.

Designs of pumping engines on the unaflow principle, which uses a large ratio of expansion in one cylinder without condensation losses, and with few valves, have already been made by the Stumpf Una-Flow Engine Co. for many classes of service. A flywheel and crank engine with double acting plunger pump and steam cylinder with but two steam valves of the poppet type; a screw pump with vertical shaft and engine crank rotating in a horizontal plane; a marine type engine for high pressure steam (500-600 lb.) for driving a propeller in a tube for lifting water only 3 to 5 ft., and power cylinders of the unaflow type for Tube pumps have all been worked out and some of them are now in the shop. It should not be long, therefore, before some of these modern pumping engines are in the service this paper describes.

For generating high pressure steam economically in large units the Winslow Safety High Pressure boiler is now being built, the first unit of 500-h.p. capacity now being made for the City of Chicago. A small unit is being worked out with automatic control of water feed pump and fuel oil burner for use with a Tube pump of 800 gal. per min. capacity at 40 to 60-ft. lift, suitable for irrigation from artesian wells on individual farms without the need of skilled mechanical attendance. The first of these small units will probably be installed in the Nueces Valley in Texas in the near future, not far from the Gulf.

When some of the above pumping engines have proved their advance in economy, measured by the actual total cost of pumping under conditions of which I hope to have intimate knowledge, it would be a great pleasure to me to present before the Society for discussion one or more papers on this subject, with the hope that they may prove as interesting as this one by Professor Gregory.

S. T. Wellman also thought that the conditions described in the paper were ideal for the working of the Humphrey gas pump which has been developed in England and in which a mixture of gas and air is exploded in direct contact with the liquid to be pumped. In this type of pump heavy moving pistons are avoided and the only moving parts are the valves. The gas is made in a common gas producer and does not have to be purified. The economy of the pump is very high, while the cost is very low, as all the weighty parts are not finished at all.

W. B. Gregory said that an installation of the Humphrey pump for irrigation work existed at Del Rio, Texas, but it did not yet appear that this type of pump is yet suited to the low lifts in drainage work. Most of the pumping in the Gulf Coast country for drainage and agriculture is done with a difference of level of from 3 to 5 ft., chiefly of the former. There are great differences to be overcome in applying the Humphrey pump to these low lifts. For high lifts he thought this pump had a future, particularly in parts of Texas and other parts of the country where lignite and cheap fuels from which producer gas may be made are available.

At present, some form of internal combustion engine seems to offer the best solution of the power problem for pumping plants in this section. Steam plants use much more fuel for an equal output of work and the boiler problems are often perplexing, especially in drainage plants where the feed water available is liable to cause trouble. Compound condensing Corliss engines have been used quite generally in irrigation and have also been used in some drainage plants. Superheated steam has been employed only in a few cases.

Designers of pumping plants must keep in mind the service for which the plant is intended. If the operation is to be continuous and the lift is through a considerable height it will pay to embody devices to save fuel and superheaters, economizers, expensive engines and all other refinements may be justified.

Irrigation plants are operated but 75 to 80 days per year. Drainage plants are often operated but 20 days per year. Due to the nature of the work the operation of both types of plant in a humid country, with occasional heavy rainfall, is intermittent and this is especially true of drainage plants. The fuel economies for these short runs must be balanced against the interest and depreciation of the more expensive plant. Furthermore, reliability of operation is of greater importance than economy and complications decrease reliability.

The rapid development of internal combustion engines, the varying price of fuel oil and the troubles incident to boilers and to steam plants generally all will have a bearing on the future pumping plants for irrigation and for drainage. Doubtless the future will witness changes that we may not today foresee.

At present pumps of the centrifugal and the screw types appear to hold undisputed sway in the field of low-lift pumping.

The influence of pressure on the explosibility of acetylene, as investigated by the U. S. Bureau of Mines, is given in the Bureau's Technical Paper No. 112, prepared by George A. Burrell and G. G. Oberfell from experiments made to determine the limits of complete propagation of flame in mixtures of acetylene and air.

Acetylene, not mixed with air, was enclosed in over mercury in a 100 c.c. glass vessel and its pressure slowly increased by means of a column of mercury until a maximum pressure of 5 atmospheres was obtained. There was no explosion. The experiment was twice repeated, and each time under a pressure of 5 atmospheres a mild explosion with the formation of much carbon resulted when a platinum coil in the gas was electrically brought to a white heat, while with the spark from an induction coil there was a violent explosion at 3 atmospheres.

When acetylene was mixed with air so as to form 10, 20, 30, 40, 50, 60, 70, 80 and 90 per cent acetylene mixtures, there was no explosion from compressing the mixtures to 1, 2, 3, 4, and 5 atmospheres. There was no use of any means of ignition such as an electric spark or a heated platinum coil.

The experiments showed that the smallest proportion of acetylene capable of propagating a flame in a mixture of acetylene and air was 2.53 per cent; the largest was about 73.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

THE GREAT DOMINION TELESCOPE

To the Editor:

Many attempts by the writer to picture mentally the distance to the nearest fixed star ended in a beggared imagination, until last year at the Spring Meeting of the A. S. M. E. he heard "Uncle John" Brashear measure the millions of miles with tons of iridescent spider web 1-5,000 inch in diameter.

Recently with 500 engineers and many other citizens he viewed the new 72-in. reflecting telescope temporarily mounted in the works of The Warner and Swasey Company in Cleveland. The story of the spider web came back with many other delightful recollections of that remarkable triumvirate, Warner, Swasey, and Brashear who share the distinction of manufacturing the world's greatest telescope. He felt that in

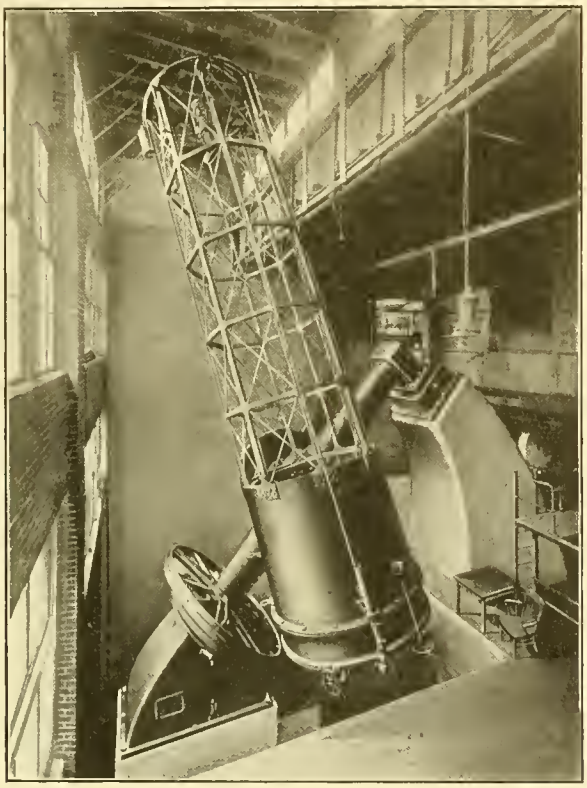

Fig. 1 72-in. Reflecting Telescope in Works of The Warner & Swasey Company

the heart of the crowd was a desire to pay tribute to the engineers and scientist greater than to see the engine of science which may push back the celestial veil a few more million miles or reveal a few more million stars.

The telescope is for the Dominion Astronomical Observatory, Victoria, Canada. The principal mirror or speculum and all optical accessories are from the works of The John A. Brashear Company, of Pittsburgh. The reflecting surface of the 72-in. mirror is ground with such precision that it nowhere deviates from the parabolic theoretical curve more than two one-hundred-thousandths of an inch. The mirror is a casting of glass 12-in. thick at the edge and weighs two and a quarter tons, the great thickness being necessary to prevent all flexure. A full-sized model was on exhibition with the tube and may be seen near the right edge of the photograph, Fig. 1, as a white disk with a hole in the center, not unlike a huge grindstone.

All structural parts, including the revolving dome and observing bridge, were designed and constructed by The Warner and Swasey Company. A working model was made in the early stages of manufacture of cast aluminum at a cost of about $10,000, shown in Fig. 2.

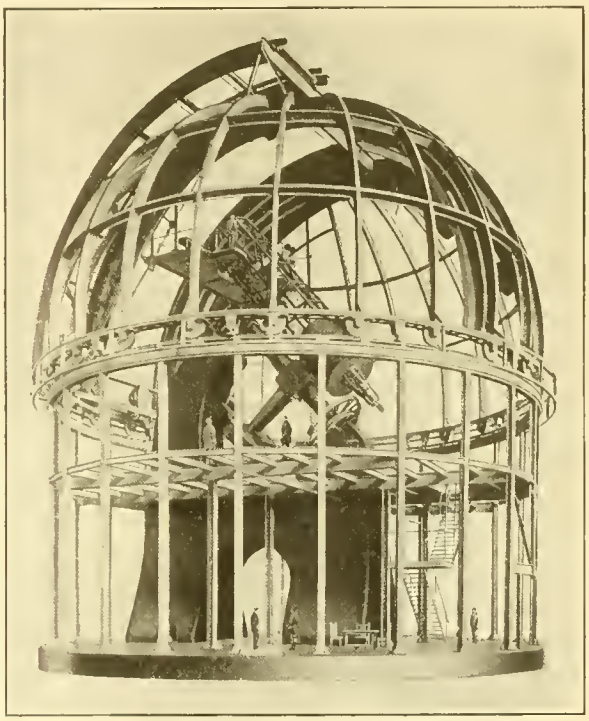

Fig. 2 Working Model of Telescope

The telescope is of the equatorial-mounting type, supported at the north and south ends by bearings in a direction parallel to the earth's axis. The declination axis, to which the tube is attached at 90 deg. passes rectangularly through the central cubical portion of the polar axis. The instrument weighs 55 tons and will be mounted on reinforced concrete piers. It may be used in three forms, observations being made at the Prime focus, at the Newtonian focus, or at the Cassegrain focus. The principal work at the Cassegrain focus will be to analyze the light of the stars with spectograph. The resulting photographed spectra not only tell us the composition of the stars' atmosphere, but give by their flame length an accurate determination of their velocity toward or from us.

A precision driving-clock moves the telescope with great accuracy. With the Cassegrain focal length of 108 ft., the guiding speed of the star image at the focal plane is one three-hundredth inch per second.

The engineering and mechanical problems involved in designing and constructing a telescope of such proportions and accuracy are apparent only when an appreciation is had of the fineness of astronomical work. Accuracy in astronomy is illustrated by the study which accounts for the motion of the perigee of the moon within 1-300,000 per cent. Also by the fact that astronomers are searching for the cause of a monthly change of less than 1-1,000 of a second in the length of the month.

D. P. Clevens.

Cleveland, Ohio.

AMERICAN GAS CENTENARY

To the Editor:

The American Gas Centenary was celebrated in Baltimore on June 16 and 17 in an interesting and impressive manner. On June 17, 1816, the Mayor and City Council of Baltimore granted a franchise to The Gas Light Company of Baltimore to lay pipes for the distribution of gas in the highways of the city. In the following February, the General Assembly of Maryland granted a charter to The Gas Light Company of Baltimore. This pioneer charter devolved upon the present Consolidated Gas Electric Light and Power Company of Baltimore.

The Gas Light Company was the first gas company on this continent, its founding following only a few years after the incorporation of The Gas Light and Coke Company of London, the premier gas undertaking of the world. Since gas was first turned into the pipes in Baltimore, there has never been a failure in the supply.

To celebrate the introduction of gas lighting on this continent, as signalized by the founding of the first gas company in America, the Johns Hopkins University held a commemorative meeting on the evening of June 16 at McCoy Hall. President Frank J. Goodnow of the University presided, and the speakers were: Arthur Graham Glasgow, consulting engineer, of London, England; L. H. Baekeland, past-president of the American Electro-Chemical Society; Walton Clark, president of The Franklin Institute; J. E. Aldred, chairman of the board of directors of the Consolidated Gas Electric Light and Power Company of Baltimore; and Jansen Haines, president of the National Commercial Gas Association. President Goodnow read a message of congratulation on the celebration of the American Gas Centenary from The Gas Light and Coke Company of London, and announced the receipt of transcontinental telephone messages from John A. Britton, vice-president and general manager of the Pacific Gas and Electric Company, San Francisco, Cal., and E. C. Jones, chief engineer.

On the afternoon of June 16, a meeting was held of 841 employees of the Consolidated company whose length of service covered a period of more than five years. A number of these men had been associated with the company for more than half a century. Service badges, designating the length of service, were awarded to all of these employees, including forty-one men who have been retired and receive service annuities under the company's pension plan. It was announced that in addition to the present plan the company would institute a sick and death benefit system, under which all of its employees, after a few years of service, would be assured of a certain amount in the event of illness, and that payments would be made to their relatives in the event of their death. Under this plan, as well as under the pension plan, no contributions are made by employees.

On the morning of June 17, a tablet was erected on Peale's Museum, still standing in Baltimore, where, in 1816, Rembrandt Peale, artist, naturalist, and technologist, gave an exhibition of gas lighting, to witness which he charged an admission fee to those citizens of Baltimore who were interested in viewing the new light. Later, Rembrandt Peale in association with an architect, a newspaper man and a banker formed The Gas Light Company of Baltimore, and introduced the new illuminant to America. The tablet was presented by Charles M. Cohn, vice-president of the Consolidated company, and accepted by the officials of the city.

Following these exercises there was given, under the auspices of the Consolidated company, an educational and historical pageant. This consisted of a procession four miles in length, including 52 symbolic and allegorical floats, 2500 marchers, 200 motor vehicles, several hundred horses, and 10 bands. The purpose of the parade was to demonstrate graphically the development of the industry and the plant requirements made necessary by the obligation imposed upon a gas company to supply good and adequate service under all conditions. Thousands of people lined the streets to witness the procession, which was reviewed by the officials of the city and of the company.

C. C. Thomas.

Baltimore, Md.

STANDARDS FOR ABBREVIATIONS

To the Editor:

In the April issue of The Journal on pages 319 and 320, appears a short article headed, "Conference on Abbreviations and Terminology." The following is quoted from this article: "Careful study was made of the abbreviations in general use, and complete agreement was reached concerning the abbreviations given in the list below. All abbreviations upon which unanimous agreement could not be had were omitted from consideration."

This is followed by a list of words, abbreviations and rules.

May I ask if one is to interpret the foregoing to mean that this list is hereafter to be the standard for The Journal? It shows some radical departures from the forms heretofore used in The Journal and Transactions, and there seems to be no good reason for the change.

In this connection attention should be called to the Preliminary Report of the Committee on Technical Nomenclature of the Society for the Promotion of Engineering Education, which appears in the June bulletin of that society. The purpose of the latter committee is to secure agreement throughout as wide a circle of technical men as possible, on the spelling, hyphenating and abbreviation of disputed technical terms.

The method followed by this committee of the S. P. E. E. was interesting. The various reports of the other national societies of engineering, that dealt with the questions of technical nomenclature, were compiled into one list of words. A number of inconsistencies were discovered, as would be expected. The list was then published in June, 1915, as a Preliminary Report. It was sent to teachers, writers and engineers all over the country with a request for criticisms and suggestions. All criticisms relating to a given word were written on a card assigned to that word, with the names of those making the criticisms. In addition, many lists of rules and suggestions were received by the committee from technical writers who were interested in technical nomenclature. The correspondence relating to this work was carried on for over

a year and the conclusions of the committee, as given in their report, should give a very fair idea of present tendencies among technical men in this country.

An effort was made to express the general tendency in a set of rules, although the variations were so great that no set of rules could be drawn that would give universal satisfaction. A great variation occurred in the use of the hyphen, and quite a tendency to omit hyphens was noted.

To attempt to quote from the report of this committee would carry one out of the bounds of a short letter, and a comparison of their recommendations with the practice of The American Society of Mechanical Engineers would be out of place until it is clear just what the practice of the latter society is at the present time.

John T. Faig.

Cincinnati, Ohio.

The list of abbreviations published in The Journal for April, to which Professor Faig refers, is the result of the work of a committee appointed by the National Electric Light Association to consider standards for "electrical measurements, values and terminology." When this committee met to consider the subject of abbreviations, invitations to attend were courteously extended to representatives of various engineering journals. In the case of the engineering societies, at least, these representatives appeared as individuals only and not as official appointees by these societies. The findings of the committee, therefore, are not applicable to the publications of The American Society of Mechanical Engineers except in so far as they are in accord with the standards already in use.

The standards now followed by our Society are based on a report issued in 1904 by a committee representing the four national societies of Civil, Mechanical, Mining and Electrical engineers. As a matter of convenience to those who contribute papers and discussions, the essential parts of this report are reprinted below. The chief divergence between this report and the list of the National Electric Light Association is in the writing of compound abbreviations. For example, in abbreviating kilowatt-hour our practice is kw-hr.; while that of the National Electric Light Association is kw.hr.

In a few particulars our present standard departs from the report of the four societies, notably in writing large numbers (see 12 below). The Mechanical, Mining and Electrical Engineers use commas to separate the periods of figures, while the Civil Engineers adhere to the report and use spaces without the commas. In some particulars this report needs revision to bring it into accord with present-day tendencies: as, for example, it is now quite usual to write horsepower as one word instead of as two words and to abbreviate it by hp. instead of by h.p.; and indicated horsepower by i.hp. instead of i.h.p.
—Editor.

EXTRACT FROM REPORT OF THE FOUR SOCIETIES

1. Use abbreviations only after nouns denoting a definite quantity. Example: "The power plant has a capacity of 10 h.p.," not "10 horse power;" but, "The capacity of the plant, in horse power, is ten."

2. Do not abbreviate abstract or descriptive words. Example: "horizontal return tubular boilers," not "h.r.t. boilers."

3. Use lower-case characters for abbreviations. An exception to this rule may be made in the case of words spelled normally with a capital. Example: "B.t.u." and not "b.t.u." or "B.T.U." (British thermal unit); "U. S. gal." (United States gallon), "B. & S. gauge" (Brown and Sharpe gauge).

4. Use a period after each abbreviation. In a compound abbreviation, do not use a space after the period. Example: "i.h.p." and not "i. h. p." (indicated horse power).

5. Use a hyphen to connect abbreviations in cases where the words would take a hyphen if written out in full. When a hyphen is used, omit the period immediately preceding the hyphen. Example: "3 kw-hr." and not "3 kw. hr." (3 kilowatt-hours).

6. Use all abbreviations in the singular. Example: "17 lb." and not "17 lbs." (17 pounds), "14 in." and not "14 ins." (14 inches).

7. Never use "p." for "per," but spell out the word. Example: "100 ft-lb. per ton" (100 foot-pounds per ton); "60 miles per hr." (60 miles per hour).

8. Use decimals, as far as possible, in place of vulgar fractions. Example: "1.25 ft.," not "1¼ ft."

9. In general, spell out an adjective qualifying the name of a unit. Example: "boiler h.p." (boiler horse power). The exceptions to this rule are "i.h.p." (indicated horse power), "e.h.p." (electric horse power), "b.h.p." (brake horse power), "e.m.f." (electromotive force), "m.m.f." (magnetomotive force).

10. Use "Fig.," not "Figure." Example: "Fig. 3," and not "Figure 3."

11. In all decimal numbers having no units a cipher should be placed before the decimal point. Example: "0.32 lb.," not ".32 lb."

12. In the notation of large numbers, use "en" spaces instead of commas. Example: "1 520 125," not "1,520,125."

13. Use the word "by" instead of "x" in giving dimensions. Example: "8 by 12 in.," not "8 x 12 in."

14. Never use the characters (′) or (″) to indicate either feet and inches; or minutes and seconds as periods of time.

The following forms are given as illustrations of these rules, and are recommended to be used:

Name	Abbreviation
Inches	in.
Feet	ft.
Yards	yd.
Miles	spell out
Pounds	lb.
Grains	gr.
Tons	spell out
Gallons	gal.
Metres	m.
Millimetres	mm.
Centimetres	cm.
Kilometres	km.
Kilogrammes	kg.
Grammes	g.
Milligrammes	mg.
Kilogramme-metres	kg-m.
Metre-kilogrammes	n-kg.
Seconds	sec.
Minutes	min.
Hours	hr.
Linear	lin.
Square	sq.
Cubic	cu.
Per	spell out
Fahrenheit	fahr.
Centigrade	cent.
Per cent	% or per cent
Volts	spell out
Ohms	spell out
Watts	spell out
Kilowatts	kw.
Kilowatt-hours	kw-hr.
Watt-hours	watt-hr.
Amperes	spell out
Brake horse power	b.h.p.
Electric horse power	e.h.p.
Indicated horse power	i.h.p.
British thermal units	B.t.u.
Gramme-calories	g-cal.
Kilogramme-calories	kg-cal.
Magnetomotive force	m.m.f.
Electromotive force	e.m.f.
Revolutions per minute	rev. per min.
Circular mils	cir. mils.
Miles per hour per second	miles per hr. per sec.
Candle-power	c-p.
Watts per candle-power	watts per c-p.
Mean effective pressure	spell out
High pressure cylinder	spell out
Diameter	spell out

COMMENTS ON RECLAMATION PLANT

To the Editor:

The writer has found the paper by Mr. Noble on the reclamation plant in the Sacramento Valley[1] of great interest

[1] The Journal, May, 1916.

because of its points of similarity with drainage problems of the Gulf Coast country and especially because of its points of dissimilarity. The heads are much greater than in Louisiana and Texas and are more in line with those found in the reclamation projects of the Mississippi Valley.

With a normal head of 29 ft., perhaps one may leave out refinements in the discharge pipes. While the suction pipes seem to have been carefully designed, the discharge pipes as shown in Figs. 7 and 9 are not so easy to understand. In Fig. 8 there is shown a condition where the water level is at least 6 ft. below the bottom of the discharge pipe. In this part of the country it is usual to design the piping for drainage pumping plants so that it forms, with the pump, a siphon; also to enlarge the discharge end until the final velocity is low. In this way the pumps, besides overcoming entrance losses, friction and discharge losses have only to elevate the water through a height equivalent to the difference of level of suction and discharge basins and the energy thrown away at the discharge is small.

When each of the units is pumping 175 sec-ft. the velocity in the 50-in. discharge pipes is 12.85 ft. per sec. and the velocity head about 2.56 ft., while at the final discharge, which is 78 in. in diameter, the velocity is 10.5 ft. per sec., corresponding to a velocity head of 1.72 ft. It would be interesting to know what the mean head pumped against amounts to or what it was assumed to be in designing the plant. Since for lower heads than 29 ft. the discharge velocities would be greater than those given above and the losses in the discharge pipe, whether running the pumps singly or in pairs, must be a fairly large per cent of the total head. It would seem to be worth while to have carried each discharge pipe down to such a level that the end would be water sealed except possibly at extreme low water. It would also seem desirable to have large end areas and consequently low discharge velocity.

Each discharge pipe is provided with a 50-in. gate valve. Could not these expensive valves have been eliminated by carrying the discharge pipes over the levees instead of through them? The writer would like to ask Mr. Noble whether the advantages of a straight pipe with a gate valve are sufficient to justify the added expense.

It is evident that conditions are quite different in California from those in the South, also that many details necessary to a thorough understanding of the problem are omitted. For these reasons the above questions are raised in order to clarify the problem.

W. B. GREGORY.

New Orleans, La.

ORIGIN OF UNIFLOW ENGINE

To the Editor:

I noticed a statement in the April issue of The Journal that a paper was presented before the Minnesota Section of the Society, consisting "mainly of a description, the origin of the Uniflow engine in Germany, together with its manufacture, etc." I presume that the author of the paper, in giving his talk, claimed the German origin of this principle on the basis of the recent work by Prof. Johann Stumpf, of Charlottenburg, on the development of the Uniflow engine. It is generally conceded that the uniflow principle was invented in England by L. J. Todd, who took out his patent for this invention in 1886. Apparently Todd's invention was never put into practice, but on December 10, 1895, the two brothers Cleveland took out an American patent for a uniflow cylinder, which was first put on a traction engine and later on locomotive No. 59 of the Canadian Intercolonial Railway.

Some time since, the writer had occasion to look into the history of the uniflow engine, and found an early American patent showing, although not claiming, the uniflow principle. The date of this patent was November 12, 1867, and the patent was granted John M. Hirlinger for an Improvement in Steam Engines (U. S. Patent No. 70,841).

Hirlinger's invention is illustrated in Fig. 3. It consists of a steam cylinder, *A*, with both ends permanently closed. Upon one side is formed a V-shaped channel, in which works a similarly-shaped slide, *H*. *G* is a bolt which passes through *H* and has its inner end secured fast in the piston *B*. The steam chest has within it a cut-off valve, *D*, which has on its

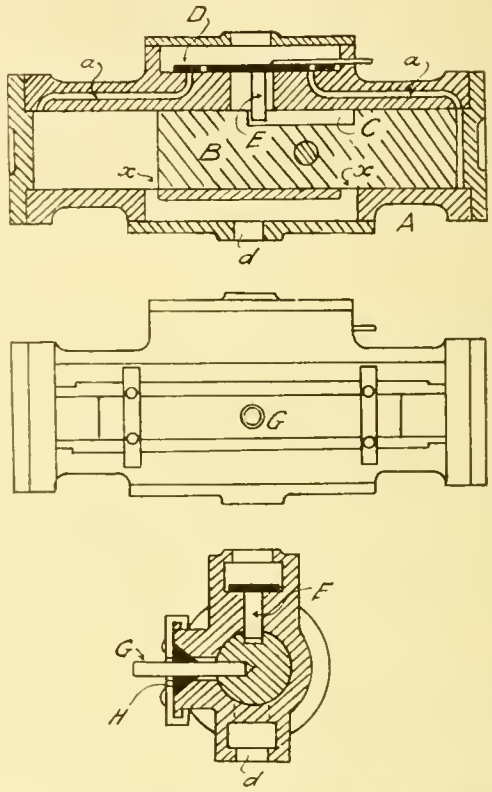

FIG. 3 1867 INVENTION SHOWING UNIFORM PRINCIPLE

underside a pin, *E*, extending into the cylinder into the recess, *C*, in the piston. The valve *D* has two steam openings communicating with the steam ways, *a,a*, which admit steam to the cylinder. The playing of the piston in the cylinder causes the valve to move so as to admit steam at each end. This arrangement of valve with its pin and the piston with its recess dispenses with the necessity of having cams and rods for working the valve. *The steam, when exhausted, escapes through the openings x,x, and d, at the under side of the cylinder.*

As stated above, the inventor did not claim the embodiment of the uniflow principle, from which we must assume that the idea of exhausting the steam from a cylinder through ports at or near the center of its length, and of controlling the opening of the exhaust ports by the ends of the piston, was not patentable (had already been utilized) in 1867, or was not regarded as of sufficient merit to warrant protection by a patent.

WILLIAM E. BULLOCK.

Jamaica, N. Y.

Society Affairs

Engineering Survey

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SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

THE total number of applications for membership listed in The Journal this month is 236. This represents an increase of 124 over last month, and brings the total number of new applications since the beginning of the current fiscal year up to 913.

The main activities of the Sections and Student Branches are now suspended for the season. The year has been a record one in number of professional and social meetings held and variety and value of topics discussed. The work of the Sections for the year is summarized below.

The plans of the Committee on Meetings for the Annual Meeting to be held in New York, December 5 to 8, 1916, are beginning to assume a definite form. The Committee has now practically completed arrangements for a session on Valuation.

The Publication Committee met jointly with the Executive Committee during the month just closed and voted unanimously to include in the volume of Condensed Catalogues now in course of preparation a classified index of manufacturers.

The Publication Committee has approved the contents of Volume 37 of Transactions, and the volume is now being printed and will be issued at an early date.

The President has appointed E. M. Herr, *Chairman,* Henry Hess, S. M. Vauclain, L. D. Burlingame and F. A. Halsey as a Committee on the Metric System to ascertain the views of the membership regarding the adoption of this system as a standard in this country and to represent the Society in conferences with other societies upon this question.

The name of the Committee on Flanges for Hydraulic Work has been changed to Committee on Standard Flanges and Pipe Fittings, and the committee enlarged as follows: Henry G. Stott, *Chairman,* A. R. Baylis, Stanley Flagg, Jr., E. M. Herr, A. M. Houser, Julian Kennedy, E. A. Stillman, A. M. White, meetings and will appear in the Transactions.

Upon the request of the Organization Committee of the City of New York on the celebration of the bringing of water from the Catskill Mountains into New York, the following committee was appointed to represent the Society on the Mayor's Citizens' Committee: The President, Henry R. Towne, Past-President, who originated the suggestion for the celebration, John R. Freeman, Past President and Consulting Engineer for the City of New York during the inception and construction of the city's additional water supply, Fred J. Miller and Charles Whiting Baker.

E. G. Spillsbury has been appointed a trustee of the United Engineering Society.

Fred J. Miller has been appointed on the Committee on Engineering Education.

WHAT THE SECTIONS HAVE DONE THIS YEAR

The spirit of coöperation among engineers has influenced to a remarkable degree the activities of the Sections during the season just closed. Local problems of affiliation of Sections with other societies have been successfully worked out, and in practically all of the fifteen centers of established Sections joint meetings have now become the custom.

Meetings in Atlanta have been held in conjunction with the affiliated technical societies in that city. Coöperation among the engineering societies of Boston has been followed from the inception of the Section six years ago. In Buffalo the Section has coöperated with the Buffalo Engineering Society. The meetings in Cincinnati have generally been joint meetings with the Engineers' Club, as also in Milwaukee and St. Louis. A recent meeting of the Los Angeles Section was held with all the technical societies in that city, the meeting being under the auspices of our Section. The Minnesota Section has held meetings in three cities, St. Paul, Minneapolis and Duluth. In Philadelphia joint meetings have been held with the Engineers' Club and The Franklin Institute. The meetings in Providence have been those of the Providence Association of Mechanical Engineers, now the Providence Engineering Society, affiliated with our Society. In New York there has been coöperation with other organizations and a number of joint meetings have been held, also in New Haven.

It is very gratifying to note that in this matter of bringing the local societies together, our Sections have in many cases taken the initiative. The Society has no jealousies, and its fundamental purpose is Service to the engineering profession.

MEETINGS AND PAPERS

In all, one hundred and six meetings have been held this season and all have been reported in The Journal. Nineteen of the papers presented locally have been published in The Journal in full and fourteen others will be published in due course. Eight papers originally presented at Section meetings during the season have been subsequently delivered at general meetings and will appear in the Transactions.

This plan is a definite purpose of the Meetings Committee, approved by the Council, to enhance the dignity of the Section meetings and develop the interest. On account of the necessarily crowded program of the Annual Meetings of the Society, for which there is no relief in sight, it is obvious that a more extended discussion can be obtained by presentation of papers before Section meetings.

THE SECTIONS AND THE SOCIETY

The same coöperative spirit which has brought the Sections into close contact with other local organizations is now mani-

fest in the relations between the Sections themselves and the Sections and the Society proper, and also between the National Engineering Societies.

The first Conference of Sections was held at the 1915 Spring Meeting, and was such a success that a second Conference was arranged at the Annual Meeting in New York, December, 1915. A representative from each of the fourteen Sections then established was present, and also delegates from the Providence Engineering Society and from several industrial centers where members of the Society were interested in the formation of Sections. Three business meetings were held and the delegates had opportunity to discuss matters with the officers and members of the Council.

The Nominating Committee for officers of the Society was this year chosen by the Sections at the request of President Jacobus. The report of this Committee appears elsewhere in this issue of The Journal.

Two very fine examples of coöperation between the Sections and the parent organization were the receptions accorded the Society at San Francisco and Birmingham, the former on the occasion of the September, 1915, meeting of the Society and the latter when the officers and members were en route to the Spring Meeting in New Orleans.

GOVERNMENT OF SECTIONS

The plan for having all the Sections elect their officers at a uniform time and by a uniform method, either by vote at an open meeting or by letter ballot, has now been consummated, and the officers for all the Sections for the ensuing year will assume their duties on July 1. A list of the new officers appears elsewhere in this issue.

There has been evidenced a necessity for a Code which would tend to put the activities of all the Sections upon a more uniform basis, and the Committee on Sections has been engaged in formulating such a Code. The Committee is hopeful of securing the coöperation of all the national engineering societies in putting their respective Sections upon the same general basis.

NEW SECTIONS

A new Section has just been established in Detroit. The first meeting of this Section will be held next September and the policy will be to coöperate completely with the Detroit Engineering Society and the Michigan Society of Engineers.

As noted in the last issue of The Journal, plans are also now under consideration for the establishment of a Section in Baltimore.

THE SECTIONS AND VISITS OF OFFICERS

Probably no greater series of receptions have ever been accorded the officer of any society than those which were extended to Past-President Brashear upon the occasions of his visits to San Francisco, St. Louis, Milwaukee, Washington and the many other cities where he made addresses during his term of office. His plea for the development of the "human factor in engineering" was as well received as it was timely, and he brought to the members of those Sections which were fortunate enough to arrange to have him visit them, a better understanding of the meaning of "coöperation among engineers."

During the current year President Jacobus has similarly visited the Sections at Philadelphia, Chicago, Milwaukee and St. Paul to consult the members upon matters of import to the Society, and he plans to extend these visits in the forthcoming season to include all Sections by the end of the year if possible. The Secretary has also attended meetings of the New Haven, Philadelphia, Providence, Buffalo, Boston and Birmingham Sections.

REPORTS OF ACTIVITIES FROM CHAIRMEN

Below are given reports from the Chairmen of the Sections which have now come to hand. Other reports are expected and will be published in the next issue of The Journal.

EXPERIENCES OF BIRMINGHAM, OUR NEWEST WORKING SECTION

To the Secretary:

The Birmingham Section was organized in November 1915, and we have had a meeting each month since that time. Most of these meetings were given to the details of complete organization and preparing for the entertaining of the visiting engineers who stopped over to visit us on their way to the Spring Convention at New Orleans in April.

During the coming year we do not expect to hold meetings each month but we will have a meeting at least once every two months. I think that where there is no organization of all the engineers in a district forming a general engineering association of the members of National Societies it is asking too much of the members of a local organization to meet every month and at the same time try to have some specially written papers to present at each meeting.

All of our meetings have been well attended and were of the nature of a dinner at a moderate cost preceding the regular business meeting. The members were given their option of coming to the dinner or reporting later for the business meeting, and we are happy to state that all were on hand for the dinner part of the meeting. We held our meetings at the different clubs and hotel parlors in the city, not having any regular designated place of meeting.

I believe that a meeting which combines the social with the business is the best kind of a meeting for all concerned and especially so for those Sections not located in the big cities. As a rule the members composing the smaller Sections are men who are busy all day at their respective work and do but little writing and are entirely out of practice in writing for publication, and therefore hesitate about writing a paper for presentation to the Section and afterward for publication in The Journal. For sections composed of membership of this make-up the social side appeals very strongly as it affords another way of getting better acquainted with one's fellow engineers.

I believe that all Sections should make it a practice to invite, from time to time, the more prominent business men and the heads of manufacturing establishments in their district, to their meetings. We need to develop a better and more intimate acquaintance among those who require the advice of engineers.

I think that the plan that the Society has for loaning out special moving picture films is a good one and it is one that the Sections ought to take advantage of. I might suggest, however, that it would be much better in the case of some films, if the makers would send a copy of the lecture with them.

Another thing which I think is vitally needed by the Sections is each Section should be visited at least once each year by the President of the Society. In fact it would not be a bad idea if the President and Secretary would arrange to leave

New York, either in the early Fall or early Spring and visit each Section, allowing the Sections time enough in advance to properly prepare a meeting suitable for the occasion. I believe that the cause of engineering would be given a great boost and certainly the members of Sections would feel a greater pride in their membership and be spurred to put forth greater efforts in behalf of the Society and engineering.

Our Section anticipated with much pleasure the stop-over here by the Society on its way to the Spring meeting in New Orleans, and we would have been particularly happy had President Jacobus been able then to visit the newest Section and the greatest industrial district of the South. I think that the Council should consider making some arrangement to give all Sections the pleasure of a visit by the President every year.

Yours very truly,

R. E. Brakeman,
Chairman, Birmingham Section.

THE BUFFALO SECTION AND THE ENGINEERING SOCIETY THERE

To the Secretary:

During the last year we had only one distinct local meeting of the members of the Society, and this meeting was a lunch meeting at noon. We had only twelve members present at this meeting, which was called for the purpose of determination regarding chairmanship of the Section, and the motion was carried that the chairman of the Buffalo Section would be the President of the Engineering Society of Buffalo, providing he was a member of the Society. The election is to take effect at the annual election of the Engineering Society of Buffalo.

The Engineering Society of Buffalo did not hold an annual meeting this season for the reason that at a regular meeting, it was decided to continue the present officers for another year. Therefore, John Younger is President for the coming year of the Engineering Society of Buffalo.

Very truly yours,

D. Bell,
Chairman, Buffalo Section.

CINCINNATI HAS ITS MOST SUCCESSFUL YEAR. LOOKS FORWARD TO SPRING MEETING, 1917

To the Secretary:

The year just past has been the most successful in the life of the Cincinnati Section, since its organization in May 1912. Each year there has been an increase in interest and in attendance at the meetings. The present year, however, has been characterized by more ambitious programs than in the past, particularly the March program, which began at 2:30 in the afternoon and continued until 10 o'clock at night. Four papers were presented on this occasion. These four papers were of wide variety and yet all were of general interest. The afternoon session of the meeting on March 16 was an experiment and a rather slender attendance was anticipated. To the surprise of the members of the Section the afternoon session was very well attended and the session proved to be one of the most enjoyable of the year. The March meeting was notable in that it attracted more persons from out of town than was the usual experience.

Meetings of the Cincinnati Section are held as joint meetings with the Engineers' Club of Cincinnati. The meetings are held in the handsome rooms of the Literary Club of Cincinnati, which are on the first floor of a building located very close to the center of the city and within easy access of all parts of the city. About four times a year the Cincinnati Section takes over the program and arranges the entire meeting. This happened to be the case in March and also happens to be the case in June, when Major P. S. Bond of the Engineer Corps of the United States Army will address a joint meeting on Preparedness from the Point of View of the Engineer. This is a topic of unquestioned timeliness, and will probably result in a definite program looking toward preparedness on the part of engineers in this vicinity under the auspices of the Cincinnati Section, Am.Soc.M.E.

The proposal that the 1917 Spring meeting of the Society be held in Cincinnati was greeted with great enthusiasm by the members of the Section, and it was through their earnest coöperation that the meeting was secured for the Queen City.

Of the fact that Cincinnati is a very excellent place for a Spring Meeting there can be no doubt. Its nearness to the center of population of the country; the wide variety of the industries which it has fostered; and its resources from an artistic and musical point of view all combine to make it of interest both to technical men and their relatives and friends. Cincinnati is within easy distance of the famous Blue Grass region of Kentucky, and there is no doubt that an opportunity for a visit will be afforded to such as are interested in this region at the time of the Spring Meeting.

Naturally the activities of the Society for the coming year will focus about the Spring Meeting of the Society. The formation of committees to handle the preliminary work which is necessary to make any convention a success and the working out of a program for the outside features of the meeting will require much time and thought. There is no doubt that the meeting will end in a blaze of enthusiasm as far as the Cincinnati members are concerned, and that the membership of the Society will be greatly increased in this immediate vicinity.

Very truly yours,

John T. Faig,
Secretary, Cincinnati Section.

LUNCH MEETINGS SUCCESSFUL AT LOS ANGELES

To the Secretary:

Owing to our limited membership, we have not deemed it wise to attempt to hold a large number of professional sessions. During the past year, in addition to four regular meetings, we inaugurated the weekly luncheon meeting which has met with remarkable success. These meetings were started solely for the purpose of bringing the members together once a week for a "getting acquainted" purpose. We later began with a system of ten-minute talks which increased the attendance materially and added value to the meetings. These talks are very informal and all features that would tend to place them in the speech-making category have been barred. The members have responded ably and willingly at these luncheon meetings and the subjects discussed have been principally in the line of local work on which the members are engaged. Many of these little talks have brought out original data and reports on investigations which might never have been heard of otherwise.

These luncheon meetings have served another purpose of value equal to those previously mentioned, and that is, the bringing of new men into the Society. We aim to take up topics of local interest, and that attracts always. It is our intention to broaden these meetings, and with this in view a Committee from the Local Section A.I.E.E. is to meet with us shortly to discuss the joining of the two sections at these luncheon meetings. As we have no Engineers' Club in our city, we feel that this system will lead up to such an organization.

Next to the success of the meetings above mentioned, comes our work in connection with bringing together into closer relationship, the several engineering organizations of the city. During the past year we held two joint meetings, the first one for the entertainment of General George Goethals, and the second held on the evening of June 1, devoted to the subject of preparedness. This led up to our being part of the big Preparedness Parade held here on June 14, marching as the Joint Technical Societies of Los Angeles. We had over 400 technical men in line. Such affairs as these aid in cementing close ties among the engineering organizations, and our Section has been particularly active in this work. During the next year we hope to see much progress in this affiliation movement.

Our experience indicates that we must combine some social time with the technical part of the meetings. Our regular professional sessions are well attended as they are made attractive by social features. For example, one of our best meetings during the past year was an inspection of the Mt. Wilson Solar Observatory Laboratory, Pasadena, California, where the famous 100-in. reflector is being constructed, with a banquet in the evening followed by a lecture on the engineering and constructional features of this wonderful instrument and the building which is to house it, by F. G. Pease, Member of the Society, and engineer and astronomer for the Mt. Wilson Solar Observatory.

We take this occasion to suggest that the Increase of Membership Committee be consolidated with the Committee on Sections. The work is so closely allied that there should be no dividing line. Let the Executive Committee of each Section recommend the member to serve as the Chairman of the Increase of Membership Committee for that particular Section, he to be a member of the Executive Committee and to report direct to the Chairman of the Section who in turn reports to headquarters.

Yours very truly,

W. W. Smith,
Chairman, Los Angeles Section.

OUR BIGGEST SECTION HAS A PROGRESSIVE WINTER AND IS CONTINUING DURING SUMMER

To the Secretary:

Meetings of the local members of the Society in New York have been conducted after a different plan from those in other cities, until comparatively recently. The committee having them in charge was known as the Committee on Local Meetings in New York, and New York was not referred to or thought of as a Section like the Sections in other cities. Now, however, the practice has been changed to conform with other parts of the country, and the committee of five formerly appointed or self-perpetuating is being elected by popular vote, the change having just been made with the elections of last month.

The principal difference between our work during the six months previous as compared with the preceding year is that the committee of five was augmented by the appointment of three sub-committees, one of Entertainment, one on Excursions, and one on Acquaintanceship, of upwards of ten members each, who make it their special duty to look after these particular features of the section work. The results so far have been very gratifying; and whereas nothing special was done for either entertainment or excursion matters prior to this time, both of these committees, as well as the Acquaintanceship Committee, have been doing splendid work, and we feel that the interest in and attendance upon all of the activities of the Section have been considerably stimulated by this means.

Our technical meetings since the first of the year have been, we believe, up to a par with the high standard which had been prevailing prior to that time, and the attendance at the meetings has been very gratifying, being usually over four hundred.

We have made a special effort to have joint meetings with other societies wherever opportunity afforded, and two of them in the last few months have been of that order.

Briefly, our program since the first of the year has been as follows:

January 11, Standardization of Power Plant Operating Costs, Walter N. Polakov. This meeting brought out a very lively discussion of the paper and thus was of considerable value to those who attended.

February 8, Ways of Presenting Data for Executive Purposes, speaker T. Russell Robinson, Statistical Engineer for W. S. Barstow & Co., Inc., New York City. This was a very profitable if not spectacular meeting.

March 14, Joint Meeting with the Illuminating Engineering Society, to consider the Factory Lighting Code formulated by that Society. Prof. C. E. Clewell presented the Code for the Illuminating Engineers and L. P. Alford discussed it from the standpoint of the Mechanical Engineers.

Another Joint Meeting was that held April 21, with the Metropolitan Section of the Society of Automobile Engineers, at which the subject of the power plant of the automobile was discussed, particularly with reference to the four-cylinder motor. Two papers were presented, one by F. E. Watts, Chief Engineer of the Hupp Motor Car Corp., and one by Finley Robertson Porter, of the Finley Robertson Porter Co., Port Jefferson, L. I.

The meeting of May 9 considered a paper on the Report upon Efficiency Tests of a 30,000 kw. Cross-Compound Steam Turbine, by Henry G. Stott and W. S. Finlay, Jr., of the Interborough Rapid Transit Co.

It has been the practice to have an informal dinner before the meeting, usually at a cost of about 75 cents a plate, and these dinners have been very well attended.

The Entertainment Committee arranged for two events which have already transpired, one an informal dinner at the Machinery Club, March 29, to which ladies were invited, and which was followed by dancing. A very representative turnout was secured.

The latest event was the participation, with the Brooklyn Engineers' Club, the Municipal Engineers' Club, and the Harvard Engineering Society, in a moonlight sail on the Hudson River. About a hundred members of our Section participated in this trip on June 15.

The Excursion Committee expects to maintain its activities throughout the Summer, holding technical excursions, usually on Saturday afternoons, about every two weeks. So far, the only two held have been those to the Essex Power Station of the Public Service Company of New Jersey and the High-Pressure Fire Service Station at Gansevoort and West Streets. Another event contemplated is a theatre party some time in July, with a midnight supper and dance to follow, arrangements for which will be completed if enough signify an interest.

Our Excursion Bulletin, second issue, is an indication of how things are moving with this Section, even after the suspension of the technical affairs during the summer months. Plans for the Fall are already quite well under way, and more subjects have been suggested than could possibly be covered in several years.

A joint meeting of all of the committee members, held a short time ago, was very fruitful in getting out suggestions for future meetings, and this Section can give it as its conviction from experience that getting a large number of people to work is great for enthusiasm and the bringing out of suggestions for new things. As an entertainment feature in the Fall we are planning a smoker, for we believe that the social side of the engineer must not be neglected.

We do not like the idea of attempting to mix the social and technical too intimately, and we believe that on our regular meeting nights the subjects should be more or less technical, but that some extra meetings as far as our appropriation will allow, can be indulged in with benefit where there is no attempt to do other than amuse and entertain. The excursions so far have been practically altogether technical, but we are hoping that there may be some element of the social mixed in with them at times. They always afford a splendid opportunity for extending acquaintance, which is one of their big advantages.

Our Section is also very strong for joint meetings, and we believe the intermingling of engineers of somewhat different interests is broadening to all, and conducive to that ultimate goal which so many of us hope to attain, when engineers of all persuasions will be more united, all to the greater effectiveness of their influence on engineering questions affecting the general public welfare.

Very truly yours,

H. R. Cobleigh,
Chairman, New York Section.

EXCURSION BULLETIN

NEW YORK SECTION

The American Society of Mechanical Engineers
29 West 39th St., New York

Vol. 1, No. 2. JUNE 1916 All Welcome

Technical Excursion June 10, 1916, 3:00 p. m.
Moonlight Sail and Dance June 15, 1916, 7:20 p. m.

TECHNICAL EXCURSION

June 10, 1916

The members of the New York Section and their friends are invited to visit the Gansevoort High Pressure Fire Service Station on Saturday afternoon, June 10, 1916, at three o'clock (3:00 p.m.).

This interesting municipal installation is located at Gansevoort and West Streets, and can most readily be reached by taking the 14th Street Crosstown Car to 10th Avenue, and walking South four blocks.

MOONLIGHT SAIL AND DANCE

June 15, 1916

All the local members of The American Society of Mechanical Engineers and their friends are invited to participate in a moonlight sail and dance on the Steamer "Mandalay" on the evening of June 15.

By co-operating with the Brooklyn Engineers' Club, the Municipal Engineers of the City of New York and The Harvard Engineering Society, the entire boat (licensed to carry 3000 persons) has been chartered for the exclusive use of the engineering societies and as only 750 tickets will be sold there will be no crowding. The trip itself is a delightful one and as an unusual opportunity will be afforded to meet engineers of various interests it is cer ain that those who can avail themselves of this occasion will be well repaid.

The Steamer "Mandalay" will leave the Battery Landing, Thursday evening, June 15 at 7:20 and will return to the same place about midnight.

Tickets are $1.00 each and may be obtained from

James W. Nelson, 82 Broome St., New York.
(Telephone, Orchard 2075)

to whose order checks should be drawn.

The allotment to our Society is only 250 tickets which will be issued in the order the requests are received, accompanied by cash or check

THEATRE PARTY, MIDNIGHT SUPPER AND DANCE

The Committee has under advisement the holding of a Theatre Party with a Mid-night Supper and Dance, and would like to know whether or not the New York membership and their friends would support such a venture. It is proposed to take the party some time during the first half of July to the Winter Garden furnishing the best seats in the house ($3.00), afterwards convey the party to Shanley's where a table d'hote supper ($1.50) will be served with dancing in a private room, at a total cost not to exceed $2 50 per person. All those who would like to avail themselves of this unusual opportunity should send their names and addresses to Edward Van Winkle, 90 West Street, New York City. Should a sufficient number signify their intention of attending, the date will be fixed and a subsequent notice will be sent out. Forward your acceptance not later than June 10th.

(Tear Off)

. 1916

MR JAMES W NELSON
82 Broome St., New York.

Dear Sir:-

Enclosed please find { Cash / Check } for $ . . for which please send me . tickets for the Moonlight Sail and Dance to be held June 15, 1916.

Name . . . . . .

Address . . .

(Tear Off)

. . . . . 1916.

MR EDWARD VAN WINKLE
90 West St., New York.

Dear Sir:-

I wish to participate in the Theatre Party, Mid-night Supper and Dance to be held in July

I will desire tickets for persons at not to exceed $2 60 each to cover the entire expense and upon notice that the party will be held, will forward my remittance.

Name

Address . . . . . .

(REPRODUCTION OF THE 2ND EXCURSION BULLETIN ISSUED BY THE NEW YORK SECTION WHICH HAS EXTENDED ITS ACTIVITIES INTO THE SUMMER)

PHILADELPHIA HAS CONSUMMATED PLANS FOR COMPLETE COÖPERATION

To the Secretary:

In arranging the program for the Philadelphia Section for the year 1915-1916, special attention was given to securing subjects of general rather than specifically technical interest in order to stimulate enthusiastic support from the entire local membership. With this in mind J. A. Steinmetz, President of the Pennsylvania Aero Club, and a member of the Society, was called upon to present the first paper of the year on Aero Warfare and Some Devices Terrestrial and Submarine.

At the second meeting held on November 23, 1915, W. P. Barba, General Manager of the Midvale Steel Company, presented a paper on Industrial Safety. The Section was gratified to hear that Mr. Barba's paper was subsequently chosen for presentation at the annual meeting.

Developments of the Pumping Engine was the subject of a paper presented at the meeting of the Section on February 3 by Prof. A. M. Greene, Jr., of Rensselaer Polytechnic Institute, with whom many members of the Section are well acquainted on account of his former Philadelphia associations. This meeting was a joint one with The Franklin Institute and was held at the Institute. Before the meeting Professor Greene was entertained at dinner by the officers of the two organizations.

On April 10 a joint meeting with the American Institute of Electrical Engineers was held at the Engineers' Club. The general subject was Some Prime Movers Now Under Development. Three papers were presented on live subjects,—The Uniflow Engine; Future Possibilities of the Large Steam Turbine Generator in Electric Generating Service, and the Diesel Engine.

At the meeting of April 25, the Section was honored by the presence of Dr. D. S. Jacobus, President of the Society, who gave the members of the Section a much clearer insight into the affairs and problems of the Society. The President's talk was preceded by an informal dinner which was well attended by the members.

The last meeting of the season was held Tuesday evening, May 23, at the Engineers' Club. A paper was presented by Lieut-Com. H. C. Dinger, U. S. N., on Efficiency of Propulsive Machinery and Late Developments in Naval Engineering. Besides reviewing in an able manner the progress of engineering in the Navy, the speaker made an appeal to the engineering profession to coöperate with the Navy in placing our country in a better state of preparedness. In expressing appreciation of the spirit in which this appeal was made, the Secretary of the Society, Calvin W. Rice, spoke with special earnestness and promised the fullest coöperation from the members of the Society. Following the paper the Chairman-elect of the Section, E. B. Carter, who also has the honor of being President of the Engineers' Club for the present year, was presented and expressed his belief that one of the principal obligations of the Philadelphia Section is to make itself especially useful in assisting to get the entire engineering profession in Philadelphia and vicinity to center around the Engineers' Club.

As an earnest of this coöperative spirit, the retiring local committee gave a dinner at the University Club, prior to the meeting, to which invitations had been extended to the officers of the local technical organizations. Mr. Rice was also present. The occasion was very enjoyable and presaged a successful forthcoming season.

The spirit of coöperation, which has taken such a positive hold among the various engineering organizations of Philadelphia, is bringing the engineers of this community closer and closer together and the question of the exact field for the sections of the various national societies is likely to change as this coöperation progresses.

At the present time, there seems to be a feeling that the more distinctly technical subjects should be discussed by the local sections of the various engineering bodies and that subjects of general engineering interest should be taken up by the Engineers' Club of Philadelphia which is the main body about which the various local sections of the national societies center.

The future of these local sections depends also upon the final plan for the development of the Engineers' Club. This Club now has a membership of approximately 2500 and with the affiliated societies the total membership in Philadelphia aggregates 3800, not including The Franklin Institute. Within the next year the development plans of the Engineers' Club will undoubtedly be definitely determined and the relation of the Section of The American Society of Mechanical Engineers and other similar affiliated societies to this development problem will unquestionably be of interest to all other Sections of the Society.

Very truly yours,

R. H. Fernald,
Chairman, Philadelphia Section.

SAN FRANCISCO HAS PROBLEMS AND APPARENTLY WAYS OF MEETING THEM

To the Secretary:

Last year we had with us many delegates from our National Scientific Bodies and one International in scope. With the many meetings of these conventions and the almost innumerable subjects upon which papers and discussions were prepared, we thought it best to postpone all meetings of our local section A.S.M.E. until early in 1916. However, the Committee met from time to time and made plans for this year's program. As a unit the Committee decided that the quality of papers presented, four in all, in order to be of the highest standard, demanded that the authors should be given a greater length of time for preparation. The subjects therefore were all selected early in the year, and the authors except one, decided upon.

Last year we discussed the advisability of having joint meetings of the A.I.E.E., A.I.M.E., A.S.C.E., A.C.S. and A.S.M.E. The first meeting this year was held June 2 with a large attendance representing each Society. *Short* talks were given by representatives from each branch, corn-cob pipes and tobacco were distributed gratis, and a half-hour talk given on the electrification of part of the system of one of our large railroads. Later we had beer, crackers, etc., unpretentiously and wholly informally. The Committee in charge were so well pleased with the attendance that other meetings of similar character are planned for the year. We feel that attendance will be larger in the future, as several said they had no idea what a good time they would have.

We therefore plan for this year four formal papers with discussions, four or more smokers, and a number, as yet undetermined, of joint meetings of the five Societies. We have also arranged to notify the Secretaries of other Societies when we are to hold meetings and they are to post notice and invitation to attend on their bulletin board. Similar notice to be posted on Bulletin Board of the Engineers' Club.

The Engineers' Club is the logical headquarters for our Section as well as for the other engineering societies and we feel that the club members should belong to the various societies and that the society members should belong to the Club. The human element in Engineers collectively is just as strong as in members of other professions, but we think the individual does not know this; it is to be our endeavor to prove it.

We feel that a larger percentage of our members should attend the meetings. Just how to get them there we have not as yet discovered. We have frankly asked them what they want in the line of papers or entertainment. So far we have not received any definite recommendations. The Committee has decided, however, that the quality of a paper must be excellent, the subject one of interest to the majority and ample time allowed for preparation. It is our hope to have the papers printed and distributed before presentation in the future to the end that discussions shall represent more mature analysis and deliberation.

It is proposed to induce the Engineers' Club to purchase a moving picture and stereopticon outfit, the branches of the various societies to pay, say, $10 for the use of the machine at each meeting until cost has been absorbed. After that no charge to be made for the use of the outfit. It so happens that one of our Committee is a director of the Club and this, to us at least is a very attractive arrangement, of advantage to the Club and to our Section in many ways.

The Club has also arranged for the various local branch committees to meet at the Club quarters if they so desire without expense.

It is also thought advisable to offer inducements to the younger men to attend our meetings. The presentation of technical papers is as a whole probably of less interest to them than purely social gatherings. This is our reason for planning to hold alternate formal and informal meetings. This also, with other reasons, has led us to meet after dinner rather than before. It is planned during the coming winter to have informal meetings monthly on Saturday afternoon preceded by a buffet lunch without cost to those who attend.

Very truly yours,

F. W. Gay,
Chairman, San Francisco Section.

REPORT OF NOMINATING COMMITTEE

The Secretary announces the receipt of the report of the Nominating Committee charged by President Jacobus with the duty of nominating candidates for the forthcoming vacancies in elective offices. It will be recalled that the Nominating Committee was this year appointed by the President from five groups of the different geographic sections of the Society with the object of securing the greatest possible democracy. The Committee consisted of Walter B. Snow, Chairman, representing the Boston, New Haven and Worcester Sections; H. M. Montgomery, representing the Chicago, Milwaukee and Minnesota Sections; E. H. Ohle, representing the Atlanta, Birmingham, St. Louis and Cincinnati Sections; J. T. Whittlesey, representing the San Francisco and Los Angeles Sections, and D. Robert Yarnall, representing the New York, Philadelphia and Buffalo Sections. The report from the Chairman follows:

To the Secretary:

Dear Sir: Acting for the Nominating Committee, which you advised upon February 24, 1916 of their appointment by the President, I have the honor to submit the following report.

As the result of several meetings at New Orleans in April, and subsequent personal interviews on the part of individual members, the following names of nominees for the various elective offices next falling vacant under the Constitution, together with the written consent of each nominee, are herewith presented:

For President, for one year:

Ira N. Hollis, Worcester, Mass.

For Vice-Presidents, for two years:

Charles H. Benjamin, Lafayette, Ind.
Arthur M. Greene, Jr., Troy, N. Y.
Charles T. Plunkett, Adams, Mass.

For Managers, for three years:

Robert H. Fernald, Philadelphia, Pa.
William B. Gregory, New Orleans, La.
C. R. Weymouth, Berkeley, Cal.

For Treasurer:

William H. Wiley, New York, N. Y.

Respectfully submitted,

For the Committee,
(*Signed*) Walter B. Snow, *Chairman.*

ACKNOWLEDGMENT

Attention has been called to the unfortunate omission from the report of the Committee on Standardization of Flanges as published in Volume 36 of the Transactions of the Society of the name of the National Association of Master Steam and Hot Water Fitters. Acknowledgment is hereby made by the Committee on Standardization of Flanges to the Association for its generous support and work in the preparation of this report, and the name of the Association will appear hereafter on any publication of the report by the Society.

It will be found that the dimensions published by the Master Steam and Hot Water Fitters Association under the title of 1915 U. S. Standard are identical with the dimensions in the American Standard published by the Society.

INDUSTRIAL PREPAREDNESS

The War Department has detailed five officers of the Regular Army to duty with the United States Naval Consulting Board, to assist the Committee on Industrial Preparedness, of which Howard E. Coffin, Mem.Am.Soc.M.E., is Chairman, in mobilizing for war purposes the various munitions-making and other industries of the country. These officers are Colonel Abiel L. Smith, of the Quartermaster Corps; Major William D. Connor, of the General Staff; Captain Douglas MacArthur, of the Corps of Engineers and the General Staff; Captain Richard H. Somers, of the Ordnance Department, and Captain Charles S. Wallace, of the Signal Corps.

The following statement, announcing the detail of the army officers to aid Mr. Coffin and the committee, was issued on June 23 from the office of the Board in the Engineering Societies' Building:

"In view of present conditions, the Committee on Industrial Preparedness of the Naval Consulting Board of the United States is exerting all possible pressure to complete its great industrial survey, and is rushing its work to the limit.

"Supervising Director W. S. Gifford announces that the War Department, for the purpose of helping rush to completion the nation-wide inventory, has just assigned five officers of the regular service to duty at the committee's headquarters in the Engineering Societies' Building, New York. Mr. Gifford states that these officers will immediately begin to classify the returns now coming in from the committee's army of engineers in the field, particularly with reference to items of army supplies.

"The Government is especially desirous of knowing in a specific way how the manufacturers of America can transform their plants to producing munitions of war and the thousand and one things needed in an unending stream in a modern conflict. Particular attention is being given to the adaptability of plants along this line in the Southwestern States. It goes without saying that the Government will gain enormous benefit by receiving at this time the vast data being collected by the Committee on Industrial Preparedness, and Secretary of War Baker is co-operating with Chairman Howard E. Coffin in every way.

"The business men of the country continue to respond in the most patriotic manner to the committee's survey, and the returns from the industrial inventory are pouring in from every part of the Union."

Through the efforts of the members of the national engineering societies acting as State Directors on the industrial census, the names of more than 100,000 American manufacturing concerns willing to aid in every possible way in the manufacture of munitions and supplies of all kinds that will be needed in the event of war have been secured.

ROLL OF HONOR

The Society is compiling a list of all members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Navy, or in any other capacity in the services of the country; and in order that this list may be as complete as possible, members connected with military or naval units are requested to send to the Secretary, The American Society of Mechanical Engineers, 29 West 39th St., New York, N. Y., particulars of their rank and the unit in which they are serving or expect to serve.

As, obviously, on account of their being in the service of the country, some men may not see this notice, every member of the Society who knows of any other member now engaged or about to be engaged in the service of the country in any capacity is invited to notify the Secretary.

DEATH OF DR. CORTHELL

It is with profound regret that we record the death of Dr. Elmer Lawrence Corthell, president of the American Society of Civil Engineers.

Dr. Corthell's professional activities covered a remarkably wide range—bridges, railways, terminals, river channel rectification, harbors, canals, waterworks, and protection of sea coasts, and earned for him a brilliant reputation in three continents.

He also participated actively in the affairs of the engineer, particularly as they related to matters of public policy. He was always prominent at international congresses of engineers, where his European and South American experience made him an invaluable member of committees.

To a greater extent, perhaps, than any engineer living today did he come into close contact with important men and projects of national magnitude, and his death leaves a void in the profession which only time can fill.

Dr. Corthell was a member, in many cases honorary or life member, of nearly sixty engineering and scientific organizations. Before his death he not only gave his library of several thousand volumes to Brown University, but provided for the proceedings of these societies to be sent in perpetuity to Brown University.

As early as 1893, the time of the International Engineering Congress, of which he was general chairman, and perhaps even before that time, Dr. Corthell had the desire "to unite in closer social and professional relations the engineers of the world." This was stated in a paper he prepared in 1895.

Later he was active in the organization of the International Association of Engineers which, with headquarters in Brussels, is realizing Dr. Corthell's dream of twenty years ago.

With the closer coöperation of the engineering societies in America, in which he was active, we hope still further to consummate his world-wide ambition of the engineering profession.

COÖPERATION AT LOS ANGELES

It is exceedingly gratifying to note the hard work being done by the Sections to coördinate their activities with those of other local organizations. Two months ago we were able to report a remarkable meeting of the New Haven Section in which seven other organizations participated, and now we are advised that the Los Angeles Section held on June 1

a joint dinner-meeting with the local branches of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Institute of Electrical Engineers, the American Chemical Society and the Engineers and Architects Association. As in the case at New Haven, the joint meeting was the result of the activity of the Chairman of our Section.

The subject of the meeting was Industrial Preparedness, and there was a general discussion on the plans of the U. S. Naval Consulting Board and of its Associate Members to secure, through the Board's Committee on Industrial Preparedness, an accurate industrial inventory of this country's manufacturing and producing resources for the purpose of national defense.

Mr. Arthur Benton presided and Dean George A. Damon, of the Throop College of Technology, acted as toastmaster. The speakers of the evening were: Rev. George N. Davidson; Earle Remington, President of the Aero Club of Los Angeles; Capt. Charles T. Leeds, U.S.A. (retired); Major George B. Pillsbury, U.S.A., in charge of fortifications, San Pedro; George W. Dickie, Vice-President Am.Soc.M.E., and Willis H. Booth, Vice-President of the Security National Bank.

VICE-PRESIDENT DICKIE DISCUSSES PREPAREDNESS

The subject of Mr. Dickie's address was Industrial Preparedness. Mr. Dickie outlined the Naval Consulting Board's plan for taking the industrial census, and expressed his confidence that the members of the organizations now being called upon to render service in connection with this inventory would welcome the opportunity to coöperate in this important and purely defensive work undertaken for the protection of our country.

He drew upon the European War to emphasize what it meant to a nation to be prepared and what unprepared. He said that at the outbreak of the war, Great Britain was notoriously short of munitions, whereas to-day she had an abundance. The story of the industrial transformation that made such a change possible is one of the most remarkable chapters in the romance of motor-driven automatic and semi-automatic lathes. He gave the following unique results of urging every manufacturer in that country to utilize his equipment for the service of the army and navy.

INTERESTING EXAMPLES FROM EUROPE

A concern engaged before the war in preparing infant's food is now delivering thousands of plugs for shell. A well-known manufacturer of baking machinery has become an expert contractor for 6-in. high explosive shells. A jewelery house is devoting itself exclusively to the manufacture of periscopes. Among the producers of finished shell are found candle-makers, flour mills, tobacco manufacturers and makers of sporting goods.

In some cases the adaptation of old plants and their tool equipment to the making of munitions has been incredibly rapid. Thus the government prevailed on a firm making textile machinery to take an order for field-kitchens. The firm was one of the largest and best known in Great Britain and employed some 8000 hands; so it made over one of its shops to furnish field-kitchens. Their men, very likely, had never seen one of these until they went to work, but in an amazingly short time they completed the delivery of what quartermasters described as the finest field-kitchens they had ever had. Thus encouraged, the Minister of Munitions prevailed on the company to begin the manufacture of 4.5 shell. The whole plant was readjusted and is now reckoned one of the most reliable of all government contractors. The credit for such results belongs not only to the Minister of Munitions and the manufacturers, but in a large measure to the workmen and especially to the women volunteers.

There have been mustered into the machine shops of Great Britain over 200,000 women, who are largely engaged on the most intricate processes of shell making. One young dressmaker who volunteered was put at a machine which was supposed, in the hands of a good workman, to turn out thirty shell parts an hour. This woman's regular output is now seventy-five an hour. Another expert is a young typist who had five brothers in the army; one was killed, another was disabled, and the others still bear their part in the fighting. Not to be behindhand in patriotism, this girl deserted the office for the factory, and is now one of the most expert machinists in the empire. Her passionate hatred of the enemy makes her disobey every order to slow down.

Besides heroic women, many men have left unnecessary professions for the munitions plants. Several members of the House of Lords are regular machinists. In one city every lawyer and court official goes on Saturday afternoon to a factory and works steadily, with just enough time off for sleep, until the sessions are resumed on Monday. The effect of this industrial mobilization on the British Army and Navy may in a sense be measured; things which are now possible were impossible a year ago.

WHAT THIS COUNTRY WOULD NEED

For present day war needs, he questioned how many of us realize that to produce the gages and jigs necessary to manufacture the 200,000 shells daily required by an adequate artillery force in action would swamp the facilities of the three largest plants in this country now making these articles—swamp them from now until the year 1921, and that preliminary item alone would cost $18,000,000. In the event of even a medium-sized war with a first-class power we would need 120 times our present number of machines fitted and instantly ready for munition manufacture. More than that we would need three men sweating in a factory for every soldier or sailor at the front. If we were to plan for an army of a million men, and that is not big compared with the armies now at war in Europe, we must also plan another army of three million men to supply the necessary things required by the million in the field.

To-day the Frankford arsenal is the only one we have equipped for the making of field gun ammunition; if it worked night and day for 365 days it would be able to supply just about enough shells for a single day's shooting by an army of a million men so that, in the event of war, to supply ammunition for field guns alone for such an army we would need 365 duplicates of the Frankford arsenal.

Years ago Germany knew how many shells and other mechanical things that were necessary for war, and how many parts each little machine shop in the country could make, and she gave these shops actual practice in making them, so that on the afternoon of July 28, 1914, two hours after the declaration of war, every concern in Germany that could make munitions was working full capacity on such work. Great Britain got ready in about a year.

Of course, merely taking an inventory of our manufacturing plants to determine their possibilities in case of war would in itself be useless. These plants must be furnished in advance with all necessary designs and the jigs and gages for the manufacture of such war material as they are fitted for, and they must be regularly inspected to insure their ability to shift without loss of time from the products of peace to the products of war.

Then our railroads must be ready for the job that war

would bring them, should the misfortune of war overtake us. Our 250,000 miles of steel highway would become the very backbone of our power to stand. Yet how little are we prepared to care for the extraordinary quantity of traffic that would be headed for strategic points in that emergency. He would not advocate for our country's railroad tracts to be dedicated to the promotion of war, but he did believe that if our Government would begin to regard our railroads as a link, the most important link in the chain of preparedness, they would soon be able to respond with increased facilities to care for extraordinary needs the Government might have for their service.

BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th Street, New York City.

Since the issue of the first edition of the Code, the demand for copies has averaged almost 1000 a month.

DEDICATION OF NEW TECHNOLOGY BUILDINGS

The dedication of "New Technology" at Cambridge, Mass., on June 12-14 marked an epoch in the history of technical education in this country and in the fullest sense was a golden anniversary for the Massachusetts Institute of Technology and the many alumni and friends of this great institution.

In 1846 William Barton Rogers, the founder of the Institute, enunciated a "Plan for a Polytechnic School in Boston," which comprised the study of physical laws and scientific principles as the basis for the processes of the industries,—a radical conception in those early days of empiricalism. Exactly fifty years ago, in 1866, his life's desire was fulfilled in the erection on Boylston Street, Boston, of the stately "Rogers Building," the first home of the Institute and ever since its main or administration building.

This, and the other buildings occupied by the school in different parts of the city, have long been inadequate, their arrangements inconvenient, and with all there has been no dormitory, no gymnasium, and but little opportunity to care for the social and physical welfare of the students.

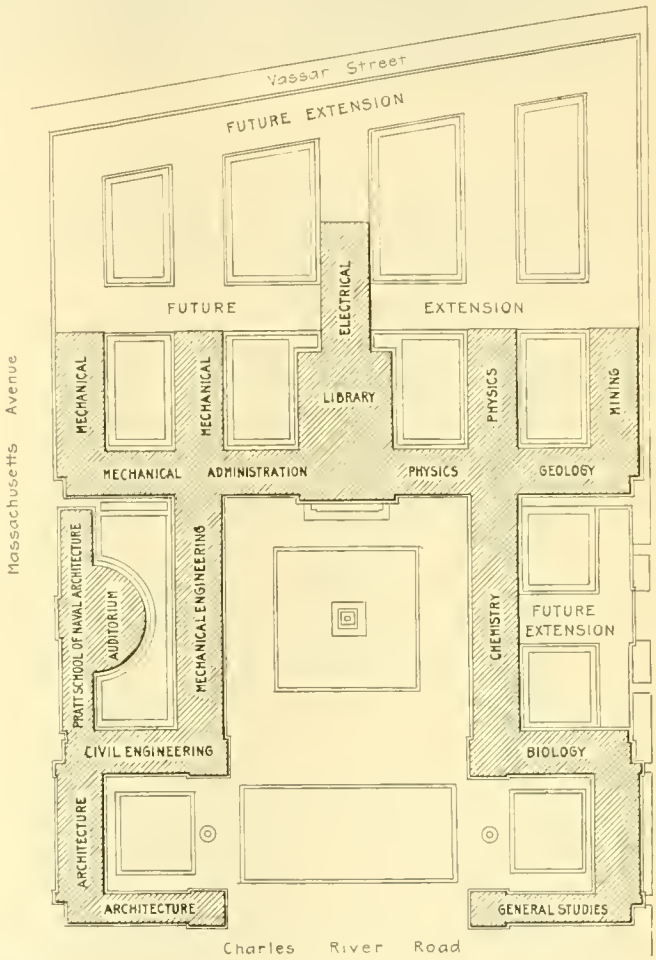
Now all this is to be changed and in accordance with a plan so complete and on a scale so great as to partake of an element of grandeur in its final realization. Through the gifts of alumni and friends, and of an unknown donor, the "mysterious Mr. Smith," it has been made possible to erect on a tract of land bordering on the Charles River, Cambridge, a $7,000,000 group of buildings, of which the main or educational building is practically completed and the others are in process of construction.

At the exercises in June a formal farewell was paid to the old Rogers Building which has meant so much in the life of the Institute, and with elaborate ceremonies and a wonderful pageant the new buildings across the river were dedicated to the continuation of the work of education and enlightenment.

After a long study of the problem by engineers, notably by John R. Freeman, Mem.Am.Soc.M.E., and finally by the architect, Wm. W. Bosworth, it was decided to adopt a single building type of construction to meet the educational needs, instead of the usual group of detached buildings.

The library, which must be so important a factor in any system of education, has been made the central feature of this building, with a great dome nearly two hundred feet high. The various wings are grouped about a great court, the immense proportions of which may be indicated by an illustrative statement which seems appropriate under present conditions, that it would easily harbour ten of the largest battleships of the U. S. Navy.

The building is of concrete, faced with limestone, and probably is the largest monolithic structure in the world. Its fundamental principle of construction is a system of bays of uniform size throughout, which constitute units for growth



Floor Plan of New Educational Building of Massachusetts Institute of Technology

and future extensions. The floors are supported entirely by the exterior walls, independent of the dividing partitions, and the rooms for the different departments can be changed in size at will, in any multiple of the single-bay unit, to suit conditions of development. It is the sectional book case idea applied to architectural planning.

Like the stacks of a book case, also, the building may be added to by erecting extensions or wings, as shown in the plan view herewith. As it now stands it will accommodate 2000 students and there can be future extensions for as many more.

The classic type of architecture has been followed and into it has been moulded with rare skill an adaptation to modern requirements in the way of window space and overhead light-

Courtesy of Stone & Webster.

New Educational Building of the Massachusetts Institute of Technology

There are 18 acres of floor space, and in its construction were used 465 carloads of stone, 5,000,000 brick, and 80,000 bags of cement. The dome is 180 ft. high and the great court would hold the Boston Public Library, with room for a city street on either side. The power house has 2000 h.p. steam capacity, and there are 2½ acres of drafting rooms and large laboratories for the various departments, including a hydraulic laboratory, with 800 ft. of canals and pumps of 22,000 gal. per min. capacity, and an aëro-dynamic laboratory, with 4-ft blowing tunnel of 40 miles an hour capacity.

ing and other utility features such as are usually found only in the most recent factory type of building.

Five thousand Technology men, hundreds of Technology women, and other thousands of interested friends gathered from far and near for the dedication exercises. The jubilee started in lively fashion with the arrival of the New York contingent, 700 strong, by boat on Monday morning.

The exercises on that day comprised the impressive "farewell to Rogers" at which James P. Munroe, long associated in the affairs of the Institute, was the orator; the laying of the cornerstone of the Walker Memorial; and in the interims the various luncheons, inspection of the new buildings, a water festival on the Charles River basin; and class dinners in the evening.

No incident of the day was more impressive than the gathering late in the evening of the thousands of graduates and undergraduates in front of the Rogers Building to bid final adieu, when the flag was lowered for the last time.

Mr. Munroe in his address likened the Rogers Building to a Westminster Abbey for Technology and pointed out the many influences which have contributed to build up its power and influence over its men. He spoke of the splendid "Spirit of Technology" which had developed there and expressed the belief that it had the vigor to grow to far greater proportions and still higher fame when transplanted to the Charles River site.

"Into the Rogers Building," said Mr. Munroe, "we have builded the multiform labors of 100 great leaders and thousands of their neophytes, all seeking the one enduring thing in life, the truth; all scorning to reach their ends by any other road than that of hard work; all ambitious, but for the general good; all fired with the desire to contribute something toward the bettering of human conditions and the uplifting of the world; all striving for the greatest of human possessions, character."

"But the soul of it, the legacy of Presidents Rogers, Runkle and Walker and all the rest, we take with us, not in memory, but in actuality, and we believe that in conveying it across the Charles we are leading it to opportunities, far more full of promise than even those which today we so proudly and gratefully commemorate."

On Tuesday throngs of the visitors went by boat to Nantasket to witness the class stunts and in the evening was the wonderful pageant in the great court of the new educational building.

Starting with the formal and impressive transfer of the charter and seal of the Institute from the old to the new temples of learning, by the State Barge "Bucentaur" which proceeded across the Charles under the glare of searchlights and fireworks; and continuing with the several episodes of the majestic "Masque of Power," it constituted an elaborate and brilliant spectacle of surpassing beauty.

The first episode of the Masque of Power represented Chaos; the second the Dance of the Elements,—air, water, fire, etc. Then came primitive man and his efforts at mastery of the elements portrayed. But man alone could not triumph over nature and Will and Wisdom appeared and led historic groups of the ages,—Egypt, Greece, Rome, and the various Centuries in succession, each contributing its share of progress under growing enlightenment, the whole making a most impressive grouping under the colored lights in the grand court.

Then out of darkness came Greed, Selfishness and War, and a return to Chaos; but there was a rift in the clouds, a ray of light appeared, and Righteousness, Will and Wisdom swept irresistibly forward, breaking the war, overcoming the elements, and finally reigning supreme.

In the afternoon were the formal exercises of dedication with addresses by Governor McCall of Massachusetts, President Lowell of Harvard, Henry Cabot Lodge and President Maclaurin of the Institute. There were in attendance the representatives of many educational institutions and a very large audience in the great Court of the New Technology. President Maclaurin fittingly announced the purpose of Technology as that of "strengthening American industry at its base by fixing it firmly on the solid rock of science."

The concluding event was the banquet in the evening, with a combined attendance of 4000 diners and guests. The feature of the occasion was telephonic communication for every one

present and for 2000 or more other Technology men in 33 other cities, with the speakers at the banquet and with those who spoke in the other connected cities. Undoubtedly this was the climax of the many similar transcontinental demonstrations which have been arranged through the courtesy of the officials of the American Telephone and Telegraph Company.

At exactly 9 o'clock Eastern time, the connections were made for a period of two hours and without interruption to the regular service of the several cities. In rapid succession was the roll call of the cities, with prompt response from each. There followed telephonic addresses by President Stone of the Alumni Association, President Maclaurin, J. J. Carty, chief engineer of the American Telephone and Telegraph Company, and others; after which there were exchanges of greetings between Dr. Alexander Graham Bell, Orville Wright, Thomas A. Edison, Theodore N. Vail and various speakers in Boston and other cities. It was a remarkable demonstration of the marvelous advance of telephonic science from the barely audible message of the inventor, Alexander Graham Bell, to this great national convocation, made possible by the vision and organizing skill of Theodore N. Vail and the engineering triumphs of J. J. Carty, his predecessors and associates.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON AFTER AUGUST 10, 1916

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. Unless objection is made to any of the candidates posted, by July 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary about September 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ADELMAN, Arthur, Draftsman,
Ordnance Office, War Dept., Washington, D. C.
BALDWIN, Harry G., Supt.,
S. K. F. Ball Bearing Co., Hartford, Conn.
BELCHER, Paul W., Junior Mech. Engr.,
U. S. Engr. Dept., War Dept., San Francisco, Cal
BENJAMIN, Louis S., Ch. Engr.,
Atlantic Sugar Refineries, Ltd., St. John, N. B., Canada
BENTLEY, Louis L., Superintendent,
Armstrong Cork Co., Beaver Falls, Pa
BERGMAN, Lars H., Engineer,
Midvale Steel Co., Philadelphia, Pa.
BIGGS, William E., Master Mechanic and Chief Engineer,
Aluminum Co. of America, Maryville, Tenn.
BILGER, Henry E., Supt. of Tools and Gauges,
The Baldwin Locomotive Works, Eddystone, Pa.
BISBEE, D. A., Asst. Supt.,
South Brooklyn Mch. Corp., Brooklyn, N. Y.
BLISS, Albert L., Asst. Supt.,
Baxter Stove Co., Mansfield, Ohio
BODINSON, Lars W., Chief Engr.,
The American Well Works, Aurora, Ill.
BRISTOL, Charles F., Genl. Supt.,
Armstrong Whitworth of Canada, Ltd., Montreal, Canada
BROWER, Clarence L., Chief Engr.,
U. S. Metals Refining Co., Chrome, N. J.
BROWN, Davis, Supt. Engrg. Dept.,
The American Clay Mchy. Co., Bucyrus, Ohio
BUNKER, Walter D., Genl. Supt.,
Judson Manufacturing Co., Emeryville, Oakland, Cal.
CARPENDER, Sydney B., Vice-Pres.,
Brunswick Refrigerating Co., New Brunswick, N. J.
CHAMBERLAIN, Frederick H., Genl. Mgr.,
Alabama Power Co., Birmingham, Ala.
CHAMP, Joseph H., Pres.,
Iceless Machine Co., Cleveland, Ohio
CLARK, William L., Supt. of Power,
West Point Mfg. Co., West Point, Ga.
CLEVELAND, Clarence E., Mfr.,
Intervale Mills, Quinebaug, Conn.
COLLINS, Palmer, Asst. Supt.,
American Steel & Wire Co., South Works, Worcester, Mass.
CONN, Thomas D., Engrg. Dept.,
Poole Engineering & Machine Co., Baltimore, Md.
COOK, Glenn W., Insptr.,
Travelers Ins. Co., Cleveland, Ohio
COOK, James C., Vice-Pres.,
The J. B. McCrary Co., Municipal Engrs., Atlanta, Ga.
CORPUT, Rex V., Captain,
Coast Artillery Corps, U. S. Army, Fort Pickens, Fla.
CRAWFORD, Thomas G., Supvr. of Drafting,
General Electric Co., Pittsfield, Mass.
DARLINGTON, Wayne, Consulting Engineer, Georgetown, S. C.
DAVOL, Frank H., Jr.,
Mech. Engr. and Exporter, New York
DICKERSON, Walter H., Secy. and Plant Mgr.,
Muskegon Extract Co., Muskegon, Mich.
DUNBAR, Harold F., Mech. Engr.,
Keith Paper Co., Turners Falls, Mass.
DURBIN, Fletcher M., Asst. Genl. Mgr.,
The Sefton Mfg. Co., Chicago, Ill.
EGLESTON, Oliver J., Engineer in charge of design,
United States Smelting Co., Blackwell, Okla.
EVANS, Powell, Pres.,
Merchant & Evans Co., Philadelphia, Pa.
FIELD, Frederick C., Pres. and Genl. Mgr.,
Standard Arms Mfg. Co., Wilmington, Del.
FIELD, Herbert E., Pres.,
Wheeling Mold & Fdy. Co., Wheeling, W. Va.
FISHER, William C., Asst. Supt.,
The Flatbush Gas & Elec. Co. Brooklyn, N. Y.
FORTNEY, Camden P., Asst. Engr.,
U. S. Engineer Dept., U. S. Army, Louisville, Ky.
FUQUA, Lawrence M., Genl. Foreman,
Southern Rwy. Co., Monroe, Va.
GABY, Frederick A., Chief Engr.,
Hydro Electric Power Commission of Ontario, Toronto, Canada.
GARRETT, Seymour S., Asst. Prof. Mech. Engrg.,
Sibley College, Cornell Univ., Ithaca, N. Y.
GOETZ, John, Works Mgr.,
Kempsmith Mfg. Co., Milwaukee, Wis.
GRANT, George P., Jr., Treas.,
Grant Yarn Co., Fitchburg, Mass.
HALL, John A.,
with Cleveland Machinery & Supply Co., New York
HAM, Clarence W., Asst. Professor of Mch. Design,
Cornell University, Ithaca, N. Y.
HAMPSON, Donald A., Engineer,
Morgans & Wilcox Mfg. Co., Middletown, N. Y.
HARRIS, Albert J. B., Mech. Engr.,
Merchants Despatch Transportation Co., E. Rochester, N. Y.

HAZLEHURST, James N.,
Consulting Engineer, Chattanooga, Tenn.
HECK, George D., Designer,
The S. S. White Dental Mfg. Co., Prince Bay, N. Y.
HELWIG, Alfred, Engr. Steam Operation,
Edison Electric Illuminating Co., Brooklyn, N. Y.
HIGGINS, Aldus C., Secy.,
Norton Company, Worcester, Mass.
HOOD, Richard H.,
Retired Contracting Engineer, New York
HORBACH, Paul W., Secy.,
Woolf Graphite Lubricator Co., Inc., Omaha, Nebr.
HUGHES, James W., Genl. Mgr.,
Defiance Mfg. Co., Philadelphia, Pa.
HUNTER, David E., Constr. Engr.,
The Shaw-Walker Co., Muskegon, Mich.
HUTCHINSON, Henry H., Supt., Vaudreuil Works,
Canadian Explosives, Ltd., Vaudreuil, Que., Canada
JENKS, Walter H., Vice-Pres.,
The Marathon Tire & Rubber Co., Cuyahoga Falls, Ohio
JOHNSON, Edmund R., Chief Engr.,
Haslett Spiral Chute Co., Philadelphia, Pa.
JOHNSON, Nelson C., Secy.,
Foster Merriam & Co., Meriden, Conn.
JONES, Lloyd B., Asst. Engr. Motive Pwr.,
Pennsylvania R. R., Williamsport, Pa.
KEITH, James, Chief Engineer,
James Keith & Blackman Co., London, England
KELLY, William M., Mgr., Kelly Press Dept.,
American Type Founders' Co., Jersey City, N. J.
KENFIELD, Louis E., Charge of Tool Design,
R. Hoe & Co., New York
KIMBERLEY, John A., Jr.,
with Paine Lumber Co., Ltd., Oshkosh, Wis.
KIRK, Jay B., Pres.,
J. B. Kirk Gas & Smelting Co., Iola, Kan.
LARSEN, Othmar I., Supt.,
Canadian-Fairbanks-Morse Co., Ltd., Toronto, Canada
LAWRENCE, Samuel E., Junior Mech. Engr.,
U. S. Engr. Dept., Dam No. 43, Ohio River, Pilcher, Ky.
LEE, Gilmer T., Chief Engineer,
Solvay Process Co., Hutchinson, Kan.
LINDBERG, Ingustinus J., Mech. Engr. and Asst. Supt.,
Abendroth & Root Mfg. Co., Newburgh, N. Y.
LONG, Howard E., Chief Draftsman and Designer,
American District Steam Co., North Tonawanda, N. Y.
LOTZ, Charles W., Chief Engineer,
Coxe Travelling Grate Co., Port Carbon, Pa.
LUCAS, Clarence W., Mech. Engr.,
Faries Mfg. Co., Decatur, Ill.
McGAHEY, Calvert R.,
with Crook-Kries Co., Baltimore, Md.
McKENNEY, Paul K., Treas. and Genl. Mgr.,
Texas Cotton Mill Co., McKinney, Tex.
MEISTERHUTT, Herbert,
with De La Vergne Mch. Co., New York
MERKT, Oswald L., Engineer in charge,
Westinghouse, Church, Kerr & Co., New York
MERRILL, Carle J., Pres.,
C. J. Merrill Inc., Portland, Me.
MIDDLETON, H. A., Estimating Engr.,
Crane Co., Birmingham, Ala.
MONROE, F. Adair, Jr., Vice-Pres.,
The Dyer Co., Cleveland, Ohio
MOORE, Hugh K., Chief Chemist, Berlin Mills,
Burgess Sulphite Fibre Co., Berlin, N. H.
MUNSON, Horace D., Mech. Engr.,
American Encaustic Tiling Co., Ltd., Zanesville, Ohio
NALON, Thomas M., Chief Engineer,
Pratt & Ford, Cons. Engrs., Atlanta, Ga.
NIEMEYER, John, Mgr., Engrg and Statistical Depts.,
Baker, Vawter & Wolf, Chicago, Ill.
NOBLE, Harvey S., Asst. Road Foreman of Engines,
Penn. R. R., Renovo, Pa.
OAKES, William H., Vice-Pres.,
Buerkel & Co., Inc., Boston, Mass.
OLDS, Alfred W.,
with Power Manufacturing Co., Lima, Ohio
PECK, John, Ch. Insptr.,
Steam Boilers and Mchy., New Westminster, B. C., Canada
POLK, Roger W., Cons. Gas. Engr. Providence, R. I.
PRATT, Arthur D., Asst. to Advisory Engr.,
The Babcock & Wilcox Co., New York
PRINDLE, Harry B., Export Dept.,
G. P. Morgan & Co., New York
QUINN, Edward O., Mechanical and Civil Engineer,
Cowell Portland Cement Co., Cowell, Cal.
RALPH, Paul J., Mgr. Power Plant,
The N. K. Fairbank Co., Chicago, Ill.
RAYNER, Carus T., Jr., Asst. Eng.,
Board of Levee Commissioners of Orleans Levee District,
New Orleans, La.
RAMSAY, William G., Vice-Pres. and Chief Engineer,
E. I. du Pont de Nemours & Co., Wilmington, Del.
REED, William S., Cons. Mech. Engr., Partner,
Reed & Glaser, Indianapolis, Ind.
RIDER, Joseph B., Consulting Engineer, New York
ROBERTS, Theodore C., Chief Engineer,
United Verde Copper Co., Jerome, Ariz.
ROGERS, Charles O., Chief Engr.,
The Charles J. Jager Co., Boston, Mass.
ROWLEY, Horace T., Vice-Pres.,
Standard Compress & Warehouse Corp., New York
SARGISSON, Zaccheus E., Designing Engr.,
Illinois Traction System, Peoria, Ill.
SEYMOUR, Charles R., Chief Draftsman,
M. D. Knowlton Co., Rochester, N. Y.
SHALLCROSS, Augustus W., Draftsman and Designer,
Layne & Bowler Co., Houston, Tex.
SMITH, Herman R., Mech. Engr.,
Raymond Concrete Pile Co., New York
SMITH, Thomas A., Works Engineer's Dept.,
Union Metallic Cartridge Co., Bridgeport, Conn.
SMITHWICK, Nathaniel A., Formerly Chief Engr.,
Goulds Mfg. Co., Seneca Falls, N. Y.
STOCK, William A.,
Patent Attorney, Oakland, Cal.
TAUSSIG, John H., Engineer of Design,
The United Gas Improvement Co., Philadelphia, Pa.
THORSBY, Karl J., Engineer,
California Corrugated Culvert Co., W. Berkeley, Cal.
TOWNSEND, Harry W., Factory Manager,
Aldrich Pump Co., Allentown, Pa.
VAN WORMER, Ralph B., Genl. Foreman Motive Pwr.,
Atlantic Coast Line R. R., Waycross, Ga.
VOORHEES, Lee J., Designer,
The Celluloid Co., Newark, N. J.
VREELAND, Elmer L., Genl. Foreman,
Melil Machine Tool & Die Co., Newark, N. J.
WALSH, Francis, Chief Engineer, S. S. Havana,
Ward Line, New York
WEBER, August, Jr., Vice-Pres.,
Weber Electric Co., Schenectady, N. Y.
WETMORE, Wade L., Mech. Engr.,
Granby Consolidated Mining, Smelting & Power Co., Ltd.,
Anyox, B. C., Canada
WILSON, James H., Formerly Mech. Engr.,
McCleary, Wallin & Crouse, Amsterdam, N. Y.
WINE, William E., Pres.,
The Wine Railway Appliance Co., Toledo, Ohio
YINGLING, Frank B., Secy.,
The Ceramic Mchy. Co., Hamilton, Ohio

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

AVNSOE, Oskar O. T., Mech. Engr.,
The Iola Portland Cement Co., Iola, Kan.
BAKER, C. T., Chief Engr.,
Southern Utilities Co., Jacksonville, Fla.
BARANY, Edmund, Machine Designer,
Singer Mfg. Co., Elizabethport, N. J.
BIRKENBEUL, Clarence E., Draftsman,
The Holt Mfg. Co., Stockton, Cal.
BROEKER, Frederick G., Mech. Draftsman,
Braden Copper Co., Rancagua, Chile
BRYSON, Tandy A., Engineer,
Tolhurst Machine Works, Troy, N. Y.
BULLARD, Maurice L., Chief Engineer,
W. H. McElwain Co., Manchester, N. H.
BYLUND, Walter R., Charge Publicity Dept.,
Hyatt Roller Bearing Co., Newark, N. J.
CABLE, Davis A., Genl. Supt.,
The United States Roofing Tile Co., E. Sparta, Ohio
CLEMMER, David P., Asst. Supt.,
Southern Stove Works., Richmond, Va.
COLBY, Clyde W.,
with National Regulator Co., Toledo, Ohio
DAGAVARIAN, Nishan A., Mech. Draftsman,
Nordyke & Marmon Co., Indianapolis, Ind.
DONAHUE, Bartholomew A.,
with Pratt & Whitney Co., Hartford, Conn.
EAGAN, Henry E., Manager Dublin Branch,
Atlantic Ice & Coal Corp., Dublin, Ga.
ESTWING, Ernest O., Industrial Engineer,
Remington Typewriter Co., Yost Works, Bridgeport, Conn.
FEAR, Thomas G., Superintendent, Bay View Div.,
Tenn. Coal, Iron & R. R. Co., Birmingham, Ala.

FICKES, Alfred C., Mech. Engr.,
Lancaster Iron Works, Lancaster, Pa.
FISCHER, Otto W., Chief Draftsman,
L. O. Koven & Bro., Jersey City, N. J.
FRANKEL, Monroe J., Asst. Insptr. Gas & Electricity,
City of Louisville, Ky.
GATES, Sam J., Commercial Engineer,
The Milwaukee Elec. Rwy. & Light Co., Milwaukee, Wis.
GREGG, Robert, Secy.,
Atlantic Steel Co., Atlanta, Ga.
GEDDIS, Robert H.,
with Jones & Laughlin Steel Co., Pittsburgh, Pa.
HANSEN, Herbert C., Office Engineer,
City Light & Water Co., Amarillo, Tex.
HARVISON, Louis H., Engineer,
The M. W. Kellogg Co., New York
HENDRIE, George A., Plant Supt.,
Ammo-Phos Corporation, Warner's, N. J.
HOOVER, Clayton A.,
with Southwark Fdy. & Mch. Co., Philadelphia, Pa.
JACOBSON, Franz,
with Pressed Steel Car Co., Pittsburgh, Pa.
KEHOE, Daniel E.,
Kehoe's Iron Works, Savannah, Ga.
LAPHAM, Jared S., Adjunct Professor of Exper. Engrg.,
University of Virginia, University, Va.
LEWIS, Warren D., Asst. Engr.,
Edison Electric Illuminating Co., Brooklyn, N. Y.
LITTLE, Edwin R., Mech. Engr., Member of Firm.
Little & Shepard, Mech. and Elec. Engrs., Detroit, Mich.
McCORD, Charles D., Chief Electrician.
The Carbon Limestone Co., Edenburg, Pa.
MACKINTOSH, Edward B., Drafting.
American Brass Co., Torrington, Conn.
MALM, Carl P. A., Marine Draftsman,
Newport News Shipbuilding & Dry Dock Co., Newport News, Va.
MEYNCKE, George M., Head of Educational Dept.,
The Dayton Engrg Laboratories Co., Dayton, Ohio
MEYER, Arthur E., Sheet-Metal Specialist,
The Pressed Metal Mchy. Co. (Owner), Chicago, Ill.
MURRAY, Ethan F.,
with Lummus Cotton Gin Sales Co., Dallas, Tex.
OSBORNE, Robert E., Chief Engineer,
Bayard Chemical Co., Inc., Woodbridge, N. J.
OWENS, Robert H., Instructional Corps.
Purdue University, Lafayette, Ind.
PATERSON, William, Testing Engr.,
Armour & Co., Chicago, Ill.
QUINLIVAN, Edward C., Steam Engr.,
U. S. E. D. Troy, N. Y.
ROBINSON, Max B., Shop Co-ordinator,
University of Cincinnati, Cincinnati, Ohio
SANCHEZ, Jules A.,
with W. F. Wendt Publishing Co., Buffalo, N. Y.
SCHULTZ, William W., Asst. to Engr. of Constr.,
The Barrett Co., New York
SEMANS, Frank W.,
with Cambria Steel Co., Johnstown, Pa.
SERVICE, Jesse S., Draftsman,
The Babcock & Wilcox Co., Bayonne, N. J.
SHERMAN, Waldo L., Asst. Mech. Engr.,
Boston Woven Hose & Rubber Co., Cambridge, Mass.
SPENCER, Furman G., Efficiency Engineer,
The Emerson Co., Chicago, Ill.
STEPHEN, Charles W., In charge of experimental work,
Crane Co., Bridgeport, Conn.
SWAIN, Philip W., Instr. in Mech. Engrg., S. S. S.,
Yale University, New Haven, Conn.
TURNER, Channing, Asst. to Indus. Engr., Gun Dept.,
Winchester Repeating Arms Co., New Haven, Conn.
VENNEMA, Augustus W., Engineer,
The Manhattan Rubber Mfg. Co., Passaic, N. J.
VOORHEES, John R., Service Engineer,
United Piece Dye Works, Lodi, N. J.
WATTS, Robert B., Chief Engineer,
Eastern State Hospital, Williamsburg, Va.
WEAVER, Gilbert G., Supervisor,
York Co-operative Industrial School, York, Pa.
WEBER, John, Asst. Prof Mech. Engrg.,
Univ. of Pittsburgh, Pittsburgh, Pa.
WINTERCORN, John, Jr., Machine Designer,
Joseph T. Ryerson & Son, Chicago, Ill.
WYMAN, Laurence W., Estimator and Designer,
California Corrugated Culvert Co., W. Berkeley, Cal.

FOR CONSIDERATION AS JUNIOR

ANDERSON, Oscar A., Office Engrg.,
Armour & Co., Chicago, Ill.
BAXTER, William C., Mech. Engr.,
Wichita Pipe Line Co., Bartlesville, Okla.
BIRDSEYE, Garner K.,
with Remington Arms Union Metallic Cartridge Co.,
Bridgeport, Conn.
BONAWITZ, David J., Designer,
Pyrene Mfg. Co., New York
BORROMEO, Canuto O.,
with The Vitter Mfg. Co., Milwaukee, Wis.
BRAUER, Rudolph C., Draftsman,
City Engrg. Dept., Richmond, Va.
BROWN, Carlton L., Safety Engr.,
The B. F. Goodrich Co., Akron, Ohio
BROWN, Edmund K.,
with Lake Torpedo Boat Co., Bridgeport, Conn.
CHAPIN, Harry A., Asst. to Vice-Pres.,
American Lead Pencil Co., Hoboken, N. J.
CHAPIN, Henry L., Grad. Student,
Purdue University, Lafayette, Ind.
COBB, H. Elmore, Asst. Engr., Dept. of Production Control,
Remington Arms U. M. C. Co., Bridgeport, Conn.
COLLYER, William C.,
with Ingersoll-Rand Co., Juneau, Alaska
CONNELL, Earle W., Asst. Chief Engr., Power Plants,
American Agricultural Chemical Co. Pierce, Fla.
CROSS, Charles D.,
with New York Central R. R. Co., Elkhart, Ind.
CURTIS, Aaron B., Jr.,
with Crandall Packing Co., Cleveland, Ohio
DAYTON, Birge S., Asst. Mech. Engr.,
The Mechanical Efficiency Co., Akron, Ohio
DONATH, William T., Asst. to Asst. Supt.,
Remington Arms U. M. C. Co., Bridgeport, Conn.
ELMENDORF, Harold H.,
with The Aultman & Taylor Mchy. Co., Mansfield, Ohio
FISHER, Sydney, Electrical Engineer,
The Remington Arms Co., Bridgeport, Conn.
FITZSIMONS, John E., Draftsman,
Pyrene Mfg. Co., New York
GOODIER, Homer W., Engrg. Dept.,
Cayuga Cement Corp., Portland Point, N. Y.
GRAY, H. Liggett,
with Valvoline Oil Co., New York
GUITERAS, Julian G.,
Hall-Scott Motor Car Co., W. Berkeley, Cal.
HAWKINS, Robert D.,
with Remington Arms Co., Eddystone, Pa.
HENRY, Alexander S., Jr., Student,
Columbia University, New York
HENRY, Harold W., Mech. Engr.,
Sherman & Co., Mineville, N. Y.
KEELER, Edwin H., Engr.,
Ousatonic Water Power Co., Derby, Conn.
KELLER, Parry,
with Reed-Prentice Co., Worcester, Mass.
LAMOREE, James K., Asst. Master Mech., Shenango Wks.,
American Sheet & Tin Plate Co., New Castle, Pa.
LESCHINSKY, Frederic J., Student,
University of Nebraska, Lincoln, Nebr.
LINCOLN, Clovis W., Mech. Engr.,
Curtiss Aeroplane Co., Buffalo, N. Y.
LOVE, Thomas J., Asst. Mech. Engr.,
The Dodge Sales & Engrg. Co., New York
McCUE, John M., Draftsman, Bridge Dept.,
Chesapeake & Ohio Rwy. Co., Richmond, Va.
MANIER, Ralph L., Machine Insptr.,
U. S. E. D., Troy, N. Y
MENDEZ, Alvaro,
with Pressed Steel Car Co., McKees Rocks, Pa.
MOON, Alfred G.,
with Hercules Power Co., Kenvil, N. J.
MORRISON, Barrett W., Apprentice,
Westinghouse Mch. Co., E. Pittsburgh, Pa.
NIELSEN, Lawrence H.,
with Public Service Electric Co., Newark, N. J.
OCHTMAN, Leonard, Jr., Asst. Engr.,
Van Blerck Motor Co., Monroe, Mich.
PETER, Albert G., Efficiency Engineer,
Chain Belt Co., Milwaukee, Wis.
PETERS, Clifford H., Engineer,
The L. L. Harr Corp., Cleveland, Ohio
PHELPS, John T.,
with General Electric Co., Everett, Mass.
RAYSOR, Earl L.,
Brier Hill Steel Co., Youngstown, Ohio
ROGERS, Theodore B.,
with Buckeye Cotton Oil Co., Jackson, Miss.

RUSSELL, Troy,
with Toledo Furnace Co., Toledo, Ohio
ST. CLAIR, Palmer, Jr.,
with E. I. du Pont de Nemours & Co., City Point, Va.
SETH, George L.,
with The Leeds & Northrup Co., Philadelphia, Pa.
SICKENBERGER, Ernest F., Jr.,
with Western Electric Co., New York
SMITH, Peter P., Jr., Engrg. and Drafting,
Robert Sayre Kent, Cons. Engrs., Brooklyn, N. Y.
STEM, Clifford H., Asst. to City Engr., New Orleans, La.
STOLL, John, Jr.,
with The Remington Arms & Ammunition Co., Bridgeport, Conn.
STRAUSS, Jerome, Chemist and Metallurgist,
Western Drop Forge Co., Marion, Ind.
TEAGUE, Newton N.,
with Augusta-Aiken Rwy. & Elec. Corp., Augusta, Ga.
VAN DENBURGH, Otis A., Jr., Engrg. Dept.,
Cambria Steel Co. Johnstown, Pa.
VIEDT, Harold B., Cadet Engr.,
Public Service Electric Co., Jersey City, N. J.
WALLACE, Robert H., Exper. Engr.,
Remington Arms & Ammunition Co., Bridgeport, Conn.
WIGHTMAN, George A., Asst. to Chief Engineer,
Hawthorne Paper Co., Kalamazoo, Mich.
WISSCHUSEN, Walter, Exper. Engrg.,
The Barrett Co., New York
WOOD, Harold J.,
with Remington Arms U. M. C. Co., Bridgeport, Conn.
WORK, Clayton W., Erecting Engr.,
Westinghouse Elec. & Mfg. Co., New York
YAGER, John E., Draftsman,
Bucyrus Co., So. Milwaukee, Wis.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

DOWD, Bernard J.,
with Royal Typewriter Co., Inc., Hartford, Conn.
SEATON, Roy A., Prof. of Applied Mechanics and Mch. Design,
Kansas State Agri. College, Manhattan, Kan.

PROMOTION FROM JUNIOR

BORCHARDT, Albert H.,
with Worthington Pump & Machy. Co., Harrison, N. J.
DOOLITTLE, Harold L., Asst. Constr. Engr.,
Southern California Edison Co., Los Angeles, Cal.
DUDLEY, Samuel W., Chief Engineer,
Westinghouse Air Brake Co., Wilmerding, Pa.
FARR, Arthur V., Tech. Publicity Mgr.,
S K F Ball Bearing Co., Hartford, Conn.
GRANT, Albert W., Jr.,
with The United Gas Improvement Co., Philadelphia, Pa.
HATMAN, Julius G., Efficiency Engr.,
Senet Solvay Co., Ensley, Ala.
WILBUR, Ralph S., Asst. Prof. of Steam Engrg.,
State Univ. of Iowa, Iowa City, Ia.

SUMMARY

New Applications	236
Applications for change of grading:	
Promotion from Associate-Member	2
Promotion from Junior	7
Total	245

GEOGRAPHICAL LIST

(Applications for promotion from any grade will be indicated by the initials of that grade)

Alabama
Birmingham—Chamberlain, F. H.
Fear, T. G.
Middleton, H. A.
Ensley—Hatman, J. G. (J.)
Alaska
Juneau—Collyer, W. C.
Arizona
Jerome—Roberts, T. C.
California
Colwell—Quinn, E. O.
Los Angeles—Doolittle, H. L. (J.)
Oakland—Bunker, W. D.
Stock, W. A.
San Francisco—Belcher, P. W.
Stockton—Birkenbeul, C. E.
W. Berkeley—Guiteras, J. G.
Thorsby, K. J.
Wyman, L. W.
Canada
Anyox—Wetmore, W. L.
Montreal—Bristol, C. F.
New Westminster—Peek, J.
St. John—Benjamin, L. S.
Toronto—Gaby, F. A.
Larsen, O. I.
Vandreuil—Hutchinson, H. H.
Connecticut
Bridgeport—Birdseye, G. K.
Brown, E. K.
Cobb, H. E.
Donath, W. T.
Estwing, E. O.
Fisher, S.
Smith, T. A.
Stephen, C. W.
Stoll, J., Jr.
Wallace, R. H.
Wood, H. J.
Derby—Keeler, E. H.
Hartford—Baldwin, H. G.
Donahue, B. A. (A. M.)
Dowd, B. J.
Farr, A. V. (J.)
Meriden—Johnson, N. C.
New Haven—Swain, P. W.
Turner, C.
Quinebaug—Cleveland, C. E.
Torrington—Mackintosh, E. E.
Delaware
Wilmington—Field, F. C.
Ramsay, W. G.
District of Columbia
Washington—Adelman, A.
Florida
Ft. Pickens—Corput, R. V.
Jacksonville—Baker, C. T.
Pierce—Connell, E. W.
Georgia
Atlanta—Cook, J. C.
Gregg, R.
Nalon, T. M.
Augusta—Teague, N. H
Dublin—Eagan, H. E.
Savannah—Kehoe, D. E.
Waycross—Van Wormer, R. B.
West Point—Clark, W. L.
Illinois
Aurora—Bodinson, L. W.
Chicago—Anderson, O. A.
Ralph, P. J.
Durbin, F. M.
Meyer, A. E.
Niemeyer, J.
Paterson, W.
Spencer, F. G.
Wintercorn, J., Jr.
Decatur—Lucas, C. W.
Peoria—Sargisson, Z. E.
Indiana
Elkhart—Cross, C. D.
Indianapolis—Dagavarian, N. A.
Reed, W. S.
Lafayette—Chapin, H. L.
Owens, R. H.
Marion—Strauss, J.
Iowa
Iowa City—Wilbur, R. S. (J.)
Louisiana
New Orleans—Rayner, C. T., Jr.
Stem, C. H.
Kansas
Hutchinson—Lee, G. T.
Iola—Aynsoe, O. O. T.
Kirk, J. B.
Manhattan—Seaton, R. A. (A. M.)
Kentucky
Louisville—Fortney, C. P.
Frankell, M. J.
Pilcher—Lawrence, S. E.
Maryland
Baltimore—Coun, T. D.
McGahey, C. R.
Massachusetts
Boston—Oakes, W. H.
Robers, C. O.
Cambridge—Sherman, W. L.
Everett—Phelps, J. T.
Fitchburg—Grant, G. P., Jr.
Pittsfield—Crawford, T. G.
Turners' Falls—Dunbar, H. F.
Worcester—Collins, P.
Higgins, A. C.
Keller, P.
Maine
Portland—Merrill, C. J.
Michigan
Detroit—Little, E. R.
Kalamazoo—Wightman, G. A.
Monroe—Ochtman, L., Jr.
Muskegon—Dickerson, W. H.
Hunter, D. E.
Mississippi
Jackson—Rogers, T. B.
Nebraska
Lincoln—Leschinsky, F. J.
Omaha—Horbach, P. W.
New Hampshire
Berlin—Moore, H. K.
Manchester—Bullard, M. L.
New Jersey
Bayonne—Service, J. S.
Chrome—Brower, C. L.
Elizabethport—Barany, E.
Harrison—Borchardt, A. H. (J.)
Hoboken—Chapin, H. A.
Jersey City—Fischer, O. W.
Kelly, W. M.
Viedt, H. B.
Kenvil—Moon, A. G.
Lodi—Voorhees, J. R.
Newark—Bylund, W. R.
Nielsen, L. H.
Voorhees, L. J.
Vreeland, E. L.
New Brunswick—Carpender, S. B.
Passaic—Vennema, A. W.
Warner's—Hendrie, G. A.
Woodbridge—Osborne, R. E.
New York
Amsterdam—Wilson, J. H.
Brooklyn—Bisbee, D. A.
Fisher, W. C.
Helwig, A.
Lewis, W. D.
Smith, P. P., Jr.
Buffalo—Lincoln, C. W.
Sanchez, J. A.
E. Rochester—Harris, A. J. B.
Ithaca—Garrett, S. S.
Ham, C. W.
Newburgh—Lindberg, I. J.
Middletown—Hampson, D. A.
Mineville—Henry, H. W.
New York—Bonawitz, D. J.
Davol, F. H., Jr.
Fitzsimons, J. E.
Gray, H. L.
Hall, J. A.
Harvison, J. H.
Henry, A. S., Jr.
Hood, R. H.
Kenfield, L. E.
Love, T. J.
Meisterhutt, H.
Merkt, O. L.
Pratt, A. D.
Prindle, H. B.
Rider, J. B.
Rowley, H. T.
Schultz, W. W.
Sickenberger, E. F., Jr.
Smith, H. R.
Walsh, F.
Wisschusen, W.
Work, C. W.
Portland Pt.—Goodier, H. W.
Rochester—Seymour, C. R.
Schenectady—Weber, A., Jr.
Seneca—Smithwick, N. A.
Troy—Bryson, T. A.
Manier, R. L.
Quinlivan, E. C.
Ohio
Akron—Brown, C. L.
Dayton, B. S.
Bucyrus—Brown, D.
Cincinnati—Robinson, M. B.

Cleveland—Champ, J. H.
Cook, G. W.
Curtis, A. B., Jr.
Monroe, F. A., Jr.
Peters, C. H.
Cuyahoga Falls—Jenks, W. H.
Dayton—Meyncke, G. M.
Hamilton—Yingling, F. B.
Lima—Olds, A. W.
Mansfield—Bliss, A. L.
Elmendorf, H. H.
Sparta—Cable, D. A.
Toledo—Colby, C. W.
Russell, T.
Wine, W. E.
Youngstown—Raysor, E. L.
Zanesville—Munson, H. D.

Oklahoma
Bartlesville—Baxter, W. C.
Blockwell—Egleston, O. J.

Pennsylvania
Allentown—Townsend, H. W.
Beaver Falls—Bentley, L. L.
E. Pittsburgh—Morrison, H. W.
Edenburg—McCord, C. D.
Eddystone—Bilger, H. E.
Hawkins, R. D.
Johnstown—Semans, F. W.
Van Denburgh, C. A., Jr.
Lancaster—Fickes, A. C.
McKees Rocks—Mendez, A.
New Castle—Lamoree, J. K.
Philadelphia—Bergman, L. H.
Evans, P.
Grant, A. W., Jr. (J.)
Hoover, C. A.
Hughes, J. W.
Johnson, E. R.
Taussig, J. H.
Pittsburgh—Jacobson, F.
Seth, G. L.
Weber, J.
Port Carbon—Lotz, C. W.
Renovo—Noble, H. S.
Williamsport—Jones, L. B.
Wilmerding—Dudley, S. W. (J.)
York—Weaver, G. G.

Rhode Island
Providence—Polk, R. W.

South Carolina
Georgetown—Darlington, W.

Tennessee
Chattanooga—Hazlehurst, J. N.
Maryville—Biggs, W. E.

Texas
Amarillo—Hansen, H. C.
Dallas—Murray, E. F.
Houston—Shallcross, A. W.
McKinney—McKenney, P. K.

Virginia
City Point—St. Clair, P., Jr.
Newport News—Malm, C. P. A.
Monroe—Fuqua, L. M.
Richmond—Brauer, R. C.
Clemmer, D. P.
McCue, J. M.
University—Lapham, J. S.
Williamsburg—Watts, R. B.

West Virginia
Wheeling—Field, H. E.

Wisconsin
Milwaukee—Borromeo, C. O.
Gates, S. J.
Goetz, J.
Peter, A. G.
Yager, J. E.
Oshkosh—Kimberley, J. A., Jr.

Chile
Raucagua—Broeker, F. G.

England
London—Keith, J.

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

CHANGES OF POSITION

Herbert J. White has accepted a position with the Ross Rifle Company of Quebec, Canada.

Edward Schildhauer has assumed the presidency of the Artillery Fuse Company of Wilmington, Del.

Hugh L. Thompson has accepted a position with the A. S. Cameron Steam Pump Works, St. Louis, Mo.

Walter J. Sykes has accepted a position with the Canadian Copper Company, Copper Cliff, Ont., Canada.

Louis Mardaga has become associated with the Mickle-Milnor Engineering Company of Philadelphia, Pa.

David B. Morgan has become affiliated with the Carolina Wood Products Company, Asheville, N. C.

Burt C. Wear, formerly connected with the Youngstown Sheet and Tube Company, Youngstown, O., has entered the employ of the Gary Tube Company.

Arthur S. Hawks has accepted a position with the Busch Sulzer Bros.-Diesel Engine Company, St. Louis, Mo., in the capacity of assistant chief engineer.

Stevenson Taylor, until recently vice-president of the Quintard Iron Works Company, New York, has assumed the presidency of the American Bureau of Shipping, New York.

Franklin W. Gilman, now associated with the B. F. Sturtevant Company, Chicago, Ill., was formerly connected with the Sanford Riley Stoker Company, Ltd., of Worcester, Mass.

Perry R. Cassidy, formerly assistant professor of thermodynamics, University of Kentucky, Lexington, Ky., has accepted a position with the Babcock and Wilcox Company, Barberton, O.

L. S. Voigt, formerly mechanical engineer with the Hydraulic Press Manufacturing Company, Mt. Gilead, O., is now employed in the coke and by-products department of the Illinois Steel Company of Gary, Ind.

Lloyd W. Ganschow, formerly electrolysis engineer of the Central Union Telephone Company, Columbus, O., has become associated with the Western Union Telegraph Company, Cleveland, O., in a similar capacity.

Archer Davidson, district engineer of the Westinghouse Machine Company, Atlanta, Ga., is now connected with the Westinghouse Electric and Manufacturing Company, Boston, Mass., in the capacity of salesman.

Albert W. Grant, Jr., formerly identified with the photometrical department of the United States Improvement Company, Philadelphia, Pa., has accepted a position with the H. Koppers Company of Pittsburgh, Pa.

F. Donald Fenhagen, formerly associated with Henry Adams, consulting engineer of Baltimore, Md., as assistant engineer, has become designing engineer with the Barrett Company of Frankford, Philadelphia, Pa.

A. L. G. Fritz has assumed the position of general superintendent of construction of the Oliver and Hill Construction Company, Kingsport, Tenn. He was until recently connected with Ford, Bacon and Davis of the same city.

Frederic O. Ebeling, formerly engineer and draftsman of the Robins Conveying Belt Company, New York, has become associated with the engineering department of the Gifford-Wood Company, Hudson, N. Y., as sales engineer.

D. Raymond McNeal has resigned his position with the Westinghouse Machine Company, East Pittsburgh, Pa., and has entered the employ of the Dravo-Doyle Company of Pittsburgh, Pa., with headquarters in the Philadelphia office.

Harold K. Beach, until recently connected with the staff of Lockwood, Greene and Company, New York, has accepted the position of mechanical superintendent of the Bronze, Copper and Brass Rolling Mills, New Toronto, Ont., Canada.

Walter P. Alexander has resigned as engineer and works manager of the Providence Engineering Works, Providence, R. I., to become steam and mechanical engineer of The Moulton Engineering Corporation, consulting engineers of Portland, Me.

Frederick R. Pratt, formerly in the employ of the Berkshire Cotton Manufacturing Company, Adams, Mass., as master mechanic and chief engineer, has joined the staff of Bird and Sons of East Walpole, Mass., in the capacity of mechanical engineer.

Fred C. Nichols has become affiliated with the engineering department of The Great Western Sugar Company, Denver, Colo., in the capacity of traveling engineer. He was until recently assistant engineer of the department of terminal construction of the Panama Canal, Balboa Heights, Canal Zone.

Sterling H. Bunnell has resigned from his engineering and sales connection with the Griscom-Russell Company, New York, which has extended over the past nine years, and has become chief engineer of R. Martens and Company, Inc., the New York connection of R. Martens and Company, Ltd., of London.

ANNOUNCEMENTS

Theodore A. Leisen was elected vice-president of the American Water-Works Association.

Leonard Metcalf was unanimously elected president of the American Water-Works Association.

William von Phul will succeed Charles N. Blake as vice-president of the United Railways of San Francisco.

Arthur M. Waitt has removed his offices from 165 Broadway, New York, to the Putnam Building, 2 W. 45th St., New York.

Wynn Meredith has resigned from the Electricity Commission of the city of Alameda, Cal., because of the pressure of other business.

Edwin B. Katte was elected one of the vice-presidents of the New York Electrical Society at the annual meeting in New York City, June 14.

William Smith, who has been with the Pennsylvania Steel Company since leaving the Jones and Laughlin Company three years ago, has resigned.

J. L. Moore, for the past seven years chief engineer of the Kerr Turbine Company, Wellsville, N. Y., has severed his connection with the company.

W. H. Van Dervoort, president of the Moline Automobile Company, has been elected president of the National Metal Trades Association, New York.

Hardy S. Ferguson of New York is engineer in charge of the erection of new pulp mills for the St. Maurice Paper Company near Three Rivers, Quebec. This is to include both sulphite and sulphate mills of considerable capacity.

Willard F. Rockwell, consulting engineer of Boston, Mass., has been commissioned to equip and organize a plant for manufacturing automobile parts. Unless a suitable location can be found and leased, it is expected that the new company will build a plant to be ready for occupancy not later than September 1. The location will be Cleveland, O., or vicinity.

Frederick C. Moore has established an office at 710 Engineers Building, Cleveland, O., as consulting and executive engineer. He will act as consultant in all matters pertaining to factory or foundry operation, organization, production, equipment and accounting and costs, and will make special investigations and reports on new manufacturing projects and on the financial, commercial and physical condition of established concerns.

W. S. Quigley corrects the statement in the June Journal that the Quigley Furnace Specialties Company, Inc., New York, recently organized, is a successor to the Quigley Furnace and Foundry Company. The Quigley Furnace and Foundry Company is still operating under the name of the Metals Production Equipment Company. Mr. Quigley is president of the new corporation, which comprises two departments, the furnace specialties department and the engineering and contracting department.

APPOINTMENTS

Fred. H. Hehemann, formerly mechanical draftsman of The Lunkenheimer Company, Cincinnati, O., has been appointed chief draftsman of the company.

Albert E. Cluett, member of the firm of Cluett, Peabody and Company of Troy, N. Y., has been made chairman of the recently organized harbor and dock commission of that city.

Edwin S. Pearce, special engineer of the Cleveland, Cincinnati, Chicago and St. Louis Railway at Indianapolis, Ind., has been appointed assistant mechanical engineer with headquarters at Beech Grove, Ind.

Henry A. Stringfellow, consulting engineer of Rochester, N. Y., has been made consulting engineer for the Sedgwick Machine Works of New York. He will work on the design and construction of elevators and hoisting machinery.

George H. Cunningham, superintendent of construction for the Zinc Electrolytic Plants, Washoe Reduction Works, Anaconda, Mont., has recently been appointed construction engineer in charge of the installation of equipment in the new 100-ton zinc plant which the Anaconda Copper Mining Company is building at Great Falls, Mont

AUTHORS OF PAPERS, ETC.

Roy A. Seaton is the author of a book, recently issued, on Concrete Construction for Rural Communities.

C. H. Bierbaum has contributed an article on Graphite as a Lubricant to the June number of *Machinery*.

An article on The Action of Air in Surface Condensers by Paul A. Bancel appears in the June 13 number of *Power*.

Arthur J. Wood is the author of a book recently published entitled Principles of Locomotive Operation and Train Control.

LeRoy A. Quayle has contributed an article on Performances of Uniflow Engine and Turbine Compared to the June 6 issue of *Power*.

John Airey has contributed an article on Autographic Cross-Sectioning by a New Instrument to the June 8 issue of *Engineering News*.

Determining the Capacity of Compressors is the subject of an article by Paul Diserens, which appears in the June 15 issue of *The Iron Age*.

R. F. Pohle is the author of an article entitled Jig and Fixture Details—Clamps and Straps, which appears in the June issue of *Machinery*.

William P. Kennedy has contributed an article entitled Central Station Promotion of Electric Vehicle Use to the June 1 issue of *The Commercial Vehicle*.

Dexter S. Kimball is the author of an article on Finding the Financial Basis of Special Tools which appears in the June 1 number of the *American Machinist*.

W. DeWitt Vosbury has contributed a paper on Conservation of Operating Head Controls Design of Oaklyn (N. J.) Sewage Plant to the June 17 issue of *Engineering Record*.

J. S. Unger presented a paper on Effect of Sulphur in Steel at the June 19-20 convention of the Boiler Manufacturers' Association of the United States and Canada, held in Cleveland, O.

Edward C. Worden presented a paper on Recent Developments in the Production of Nitrocellulose at the June 14 to 17 convention of the American Institute of Chemical Engineers, held in Cleveland, O.

Dabney H. Maury presented a paper on Waterworks Reservoirs at the June 7 meeting of the American Water-Works Association. An abstract of this paper appears in the June 15 issue of *The Canadian Engineer*.

The Distribution of the Charge Column and of the Ascending Gas Column, is the subject of an illustrated article contributed by J. E. Johnson, Jr., to the June 1 issue of *Metallurgical and Chemical Engineering*.

NECROLOGY

ALPHONSO H. CARPENTER

Alphonso H. Carpenter was born at Ludlow, Vermont, on October 22, 1850. He received his education in the ordinary home schools and at the age of 14 went to work for Helon M. Carpenter of Grafton, Vermont, as a blacksmith, remaining there until he was twenty. The rest of his life was spent in the machinery manufacturing and foundry business as commercial traveler and manager. At the time of his death he was vice-president of the Acme Machinery Company of Cleveland, Ohio, which position he had held for many years.

Mr. Carpenter was elected to membership in the Society in 1895.

JACQUES HENRI EDWARDS

Jacques Henri Edwards was born in Paris, France on February 11, 1889. He was graduated from the University of Paris in 1909 with the degree of B.S. During the following year he worked as sales and technical man with the firm of Jean Horowitz in Paris, exporting automobiles, steam trucks and herringbone gears to Russia. From there he accepted a position with the American Tobacco Company in Montreal for the purpose of improving his knowledge of the English language and business methods. He also worked in Detroit with the Zenith Carburetor Company as assistant manager and also for the Studebaker Corporation and the Northway Motor & Mfg. Company and was a member of the firm of Breeze & Chapman, carburetor makers of Detroit. In October, 1913,

he went to St. Louis on special efficiency work and in June, 1914, entered the employ of Stanley G. Flagg & Co., who sent him to London and Paris as sales engineer, which position he held at the time of his death which occurred in Paris on February 24, 1916.

Mr. Edwards was a member of the Automobile Association of America. He became a member of this Society in 1913.

WILLIAM LAING BUSS

William Laing Buss was born at Correy, Pa., on November 26, 1867, and died on May 3, 1916. He received his early education in the public and high schools of Troy, N. Y., following which he engaged in the drug business. In 1888, he moved to Chicago and entered the Rush Medical College, but at the end of two years he left to go into business with his father who was western manager for the Chapman Valve Company of Springfield, Mass.

Upon the death of his father in 1903, Mr. Buss succeeded him as manager and remained there until 1909. From 1910 to 1912 he was general manager of the Coffin Valve Company of Neponset, Mass. From there he returned to Chicago to accept a position as sales manager for the Pittsburgh Valve, Foundry and Construction Company of Pittsburgh, Pa., and remained with them until 1915. At the time of his death he was a manufacturers' broker with offices in Chicago.

Mr. Buss was a member of several Masonic lodges. He became a member of the Society in 1912.

GEORGE GILMOUR

George Gilmour was born at St. Petersburg, Russia, on December 25, 1864. He received his preparatory education in the public schools of Russia and England and his technical education at Anderson College, Glasgow, Scotland. He learned his trade as mechanical engineer with John Elder and Company, shipbuilders and engineers, of Glasgow, Scotland, and was subsequently sent by them as an engineer to South America. On his return by way of Panama, he was engaged by the French engineers to take charge of the mechanical department of the work on the Panama Canal, 1883, and he afterwards held a position with the Atlas Line of mail steamers.

When the West India Improvements Company bought the Jamaica Government Railway, Mr. Gilmour was appointed master mechanic of the Jamaican system, 1891, and he later became superintendent of motive power, and consulting engineer to the Jamaica Light and Power Company.

After eight years of service in Jamaica, Mr. Gilmour was appointed mechanical engineer to the New York Telephone Company, of New York City; and after eight years of experience in this capacity, he resigned in 1905 to become chief engineer of the Travelers Insurance Company, which position he held at the time of his death. In 1910, the New York Commission on Employers' Liability and Causes of Industrial Accidents appointed him its consulting engineer and in that capacity he made an extended tour abroad to investigate and report upon the European methods for lessening the number of industrial accidents.

Mr. Gilmour was a charter member and trustee of the American Museum of Safety, and he was also a member of the American Railway Master Mechanics Association, the International Boiler Makers Association, the American Society for Testing Materials, and the Engineers' Club of New York. He became a member of this Society in 1909. Mr. Gilmour died at his home in Brooklyn on June 15, 1916.

SOCIETY MEETINGS

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

CHICAGO, MAY 15

The fourth and last seasonal meeting of the Chicago Section of the Society was held on May 15. Following the dinner, H. M. Montgomery, *chairman* of the Section read the report of the nominating committee for the officers of the Section for next year, as follows: Joseph Harrington, advisory combustion engineer, *chairman;* Alexander D. Bailey, assistant chief engineer, Station 2 and 3, Commonwealth Edison Company, vice-chairman; Robert E. Thayer, western mechanical editor, Railway Age Gazette, secretary; other committee members, H. T. Bentley, superintendent motive power and machinery, Chicago & North Western, and Charles G. Lord, general patent attorney, International Harvester Company. The report was approved by the attending members. The meeting was attended by 191 members and guests, among the latter being included a representative body from the International Railway Fuel Association, which was meeting in convention at Chicago at that time.

After the dinner the speaker of the evening, Joseph Harrington, advisory combustion engineer, of Chicago, was introduced and presented a paper on Powdered Coal as a Fuel. The speaker reviewed the history of the use of powdered fuel, summarized the requirements for pulverization, described types of pulverizing machinery, discussed the objections to and difficulties of pulverization and enumerated the advantages. He followed with examples of some of the results being obtained in stationary and locomotive practice.

The paper was illustrated by a series of slides showing furnaces in which powdered coal is used as a fuel.

Among those who took part in the discussion which followed were J. E. Muhlfeld, president of the Locomotive Pulverized Fuel Company; A. G. Barnhurst of the Fuller Engineering Company; W. L. Robinson, of the Baltimore & Ohio; E. H. Stroud, A. J. Kinyon and others. Mr. Barnhurst presented a written discussion describing the pulverized fuel installation under ten 250-h.p. Heine boilers for the Missouri, Kansas & Texas Railway at Parsons, Kan.

Mr. Muhlfeld explained briefly the development of the use

of pulverized coal on locomotives. The use of pulverized coal in this service permits the using of cheaper grades of fuel with almost perfect combustion. There were five different methods developed for burning pulverized fuel in locomotives, and the one now in use on the Chicago & North Western locomotives was finally adopted. The bituminous coal installations have been working out very satisfactorily and experiments are being tried with a mixture of anthracite and bituminous coal. So far 40 per cent anthracite and 60 per cent bituminous coal has been used successfully, and it is believed that it will be possible on further experimentation to use a mixture of 80 per cent anthracite and 20 per cent bituminous. In stationary practice 100 per cent anthracite is used successfully.

Regarding the accumulation of slag in the powdered fuel installations, it was believed that those coals running high in iron content would give the greatest trouble. It is necessary that sufficient air be supplied to put what iron there is in coal into its ferric state. The illustrations shown by Mr. Harrington on the screen showed the very interesting and novel ways of getting away from this trouble of slag. The fusibility of the ash in the coal is also a factor to be considered. It was stated that lime had been added to the powdered fuel to assist in fluxing the slag so that it would flow more freely to the slag pan.

CINCINNATI, MAY 18

A meeting of the Cincinnati Section of the Society at which there was a special program for the entertainment of the ladies was held on May 18. The speaker of the evening was Prof. John M. Burnham, Professor of Latin at the University of Cincinnati, who gave an illustrated address on Engineering in Antiquity. An abstract of his remarks is given here:

Engineering may be said to have begun when early man made any sort of implement or weapon, however crude or simple and the engineer, at least the artisan, the skilful worker was recognized as early as the Neolithic Period (say from 7000 to 4000 years ago).

A high state of development is implied by the Famous Seven Wonders of the World, most in the Classical Greek domain, and in the Pyramids and the Hanging Gardens and Walls of Babylon, going back further in time and more distant in space. One must also remember that the peoples of Assyria, Babylon, Mesopotamia, Syria, Asia Minor and Egypt had elaborate systems of drainage and irrigation without which comfortable life, sanitation and agriculture would have been impossible; they also had canals and ditches on a large scale both to serve internal navigation and to connect large bodies of water. For instance, Ferdinand de Lesseps while cutting the Suez Canal found the traces of two similar projects ranging back several centuries B. C. The cutting around Mt. Athos by Xerxes and the running of tunnels at Jerusalem are samples of the same sort of activity; even the myth of the cleansing of the Augean Stables implies such work as a part of the very ancient Greek life.

Rome, too, had her system of engineering. There were drainage and irrigation ditches all the way from the Trasemene to the Fucine Lake. Scaurus in 110 B.C. rehabilitated the work of the Etruscans in the Po Region which must at the latest antedated 400 B. C. Dentatus in 300 B. C. turned a river bed and directed its new course over a precipice 140 ft. high. There was the Alban tunnel which was 1100 ft. long and also fossae, connecting ditches or canals uniting for instance the Meuse and the Rhine or the Rhone and the Mediterranean Sea which were built in the early years of A. D. Caesar revived an early project conceived by Periander undertaken and then abandoned by Demetrius Poliorcetes, but his death prevented the completion of this and other schemes. Caligula again took it up, fixed its lines and levels, and passed it on to Nero who actually began it but death once more intervened in 68 A. D.

One may refer to the mighty network of pikes and highways which began at Rome and crossed and recrossed the Italian Peninsula. These were connected at the Northern, Eastern and Western boundaries with similar roads reaching into Thrace to Constantinople, there meeting the Asiatic system which extended into Northern and Central Europe, modern Switzerland and Austria, into France and reaching the English Channel. They were also to be found in Southern England and Spain. Besides these pikes and highways there were the great aqueducts, which according to one text numbered 19. There were also numerous bridges spanning the Tiber and many another river, the innumerable colonnades of ancient Rome (nine miles of them, according to Lanciani), 67 parks of the Capital and 46,000 tenement houses.

The social standing of the engineer is stated by Cicero de Officiis 1 150 to have been that of the teachers and physicians . . . . good enough for people who adopted such a career. However, the engineer Frontinus to whom we owe most of our information about the water supply of Rome rose to the consulate i. e. was an aristocrat. In fact, under the Empire, certain engineering superintendencies required training and were granted only to those who had held the highest political stations. As for their education, Vitruvius demands an almost encyclopedic knowledge of the architect: drawing, geometry, history, philosophy music, medicine, law and astronomy (including meteorology).

CHICAGO, MAY 24

A special meeting of the Chicago Section of the Society was called on May 24 at the Chicago Engineers' Club to meet with President Jacobus and to talk over Society affairs. Dr. Jacobus presented some slides showing views of the Engineering Societies Building in New York, and also balance sheets indicating the financial condition of the Society. He asked for and obtained opinions of the members regarding the yearly Condensed Catalogues, the advisability of distributing the papers to be presented at the various meetings of the Society in advance of the meetings, and The Journal.

PROVIDENCE, MAY 24

The first meeting of the Providence Engineering Society which is the successor to the Providence Association of Mechanical Engineers was held on May 24. William Pickersgill, designing engineer of the Providence Water Supply Board, addressed the Society on The Fiskeville Weir which is being used in connection with the new water supply system of Providence. His talk was illustrated with charts and also with an experimental weir in the University of Brown laboratory.

Following Mr. Pickersgill, Prof. A. E. Watson of Brown University spoke on The New Wireless Installation at Brown. Following his remarks the engineers were invited to the electrical laboratory and were shown the workings of the new instruments.

BIRMINGHAM, MAY 30

A meeting of the Birmingham Section of the Society was held on May 30 at which pictures showing From Ore to Finished Product were shown by the National Tube Company. The pictures were explained by Mr. Schoekel from Atlanta, Ga.

Following the presentation of the pictures, an informal meeting was held by several interested in forming an affiliated society in Birmingham. Committees were appointed to report on the matter and the local Section of the Am.Soc.M.E. pledged its support.

LOS ANGELES, JUNE 1

A joint meeting of the Technical Societies of Los Angeles including The American Society of Mechanical Engineers, the American Chemical Society, The Engineers and Architects Association, the American Institute of Electrical Engineers, the American Institute of Mining Engineers and the American Society of Civil Engineers was held on June 1. The speakers were George N. Davidson, rector of St. John's Church, Earle Remington, president of the Aeronautical Society, Capt. Charles T. Leeds, U. S. Army (retired), Major George B. Pillsbury, in charge of the Fortifications, San Pedro, George W. Dickie, of the California Auxiliary Naval Consulting Board and Willis H. Booth, vice-president of the Security National Bank. An account of this meeting appears elsewhere in this issue.

CINCINNATI, JUNE 15

The June meeting of the Cincinnati Section which was a joint meeting with the Engineers' Club of Cincinnati was held on June 15. The speaker of the evening was Major P. S. Bond, Corps of Engineers, U. S. A. Major Bond is an Honor Graduate, Army Field Engineer College; a graduate of the Army Staff College; author of The Engineer in War; and the author of National Defense for Engineer and Contractor.

The speaker set forth in a clear cut and convincing manner the duty each citizen owes to his country. He alluded to the woeful inadequacy of our defenses and gave in detail the requirements of the men of every grade in the engineer corps, with an estimate of the length of time necessary to give such men the necessary training in tactics and in technics. He discouraged the rather hysterical forms of patriotism and urged the solution of the whole problem of our preparedness for offense and defense in a calm and intelligent manner. He stated that the details that are being so eagerly sought by the general public at this time regarding the state of our preparedness had been a matter of common knowledge among engineer officers for many years and that it was only recently that the general public could be induced to take any interest in them whatever.

Major Bond gave in detail the tremendous possibilities for defense which exist in this country, both in numbers of men available and in the ability of our country to turn out needed supplies and munitions at the proper rate. He cited an instance from one of the warring nations of Europe where a large factory concluded its work upon a given order at eleven o'clock of a certain morning and began the manufacture of rifles in an efficient manner at two o'clock of the same day.

Mr. Bond then outlined the general plans that had been proposed for surveys of our industries looking toward the supplying of the necessary materials and munitions in case of war, and showed how necessary it was to prepare for the manufacture of these supplies of munitions in time of peace. He declared that so large a time is required to prepare for the manufacture of materials and munitions in enormous quantities that months and frequently years of time had elapsed before a reasonable efficiency could be obtained in the manufacture of supplies and munitions. The fate of a war, he stated, might be decided before a reasonable efficiency had been obtained by a factory that had not carefully analyzed the problems that it would have to meet after the declaration of war. The speaker stated that in numbers of men and ability to furnish supplies and munitions, our country was so far ahead of any nation that the mere knowledge of the fact that our resources in these lines were being made directly available for immediate service in case of necessity would almost certainly insure peace.

The lecture was concluded by an exhibition of a large number of carefully selected lantern slides and a running commentary on the details shown by these showed the duties of the members of the Engineer Corps in the field. The slides were taken from actual service conditions in Mexico, the Philippine Islands and the European war. They showed the construction of bridges, the making of military roads, the making of trenches, the theory of trench warfare, the character and purpose of the various kinds of guns in use at the present time, the various styles of clothing and of implements that are required for the soldier in the trenches, some idea of the difficulties encountered in transportation and in feeding large numbers of men, and of the enormous amount of supplies and munitions required. The speaker touched upon a multitude of facts, driving home the points they were intended to emphasize in clear and forceful language and withal presented the subject in a wonderfully interesting manner.

At the conclusion of the meeting, a motion was unamiously carried that a committee of five be appointed with power to act in the matter of a survey of the industries that would be called upon to manufacture supplies and munitions in case of war. This committee is to secure the services of twenty-five or thirty engineers to make industrial surveys of Cincinnati and vicinity and assist the committees on industrial preparedness that were recently appointed by President Wilson.

STUDENT BRANCHES

BUCKNELL UNIVERSITY

The Bucknell University Student Branch of the Am. Soc. M. E. held its last meeting of the school year on June 5. After a short business session, the election of officers for the ensuing year took place. The officers elected were as follows: C. D. Maurer, '17, chairman; C. C. Kepple, '17, vice-chairman; C. M. Kriner, '17, secretary, and R. E. Sprenkle, '17, treasurer.

COLUMBIA UNIVERSITY

The following officers were elected at the annual meeting of the Student Branch of Columbia University on May 16: J. L. Kretzmer, president; William Henry, vice-president; Edward H. Shea, treasurer, and Ray W. Thompson, secretary.

CORNELL UNIVERSITY

The new officers chosen for the Cornell University Student Branch are as follows: Prof R. C. Carpenter, honorary chairman; William Carter Bliss, chairman; Ralph Osgood Compton, vice-president; Samuel Max Barr, recording secretary; William Wallace Robertson, Jr., treasurer, and Charles Edwin Thomas, corresponding secretary.

During the past year several meetings of the Branch have been held and all have been well attended. Lectures have been given before the Branch by Prof. Albert W. Smith on The Advantages of Engineering Organizations; by Prof. D. S. Kimball on Efficiency; and by Prof. R. C. Carpenter on The Panama Canal.

LOUISIANA STATE UNIVERSITY

A meeting of the Louisiana State University Student Branch was held on April 11, and the following officers were chosen: T. S. Gunby, chairman; S. A. Buckmaster, vice-chair-

man; J. A. Nadler, secretary, and R. E. H. Blomley, treasurer.

Following the election of officers, Mr. Spence gave a talk on the Westinghouse Air Brake.

A special meeting of the Branch was held on April 18. At this meeting C. C. Allen, construction engineer of Stone and Webster Corporation, gave a very interesting and practical lecture to the students in engineering. He urged the students to take a four years apprenticeship in some good shop, and laid especial stress upon the value of practical experience.

The third regular meeting was held on May 2, at which Maurice Adam addressed the Branch on the Adaptability of the Internal Combustion Engine to Sugar Factories in the Tropics and States, and M. M. Masson gave a brief discussion of the Spring Meeting of the Society at New Orleans.

OHIO STATE UNIVERSITY

The last meeting of the year of the Student Branch of Ohio State University was held on May 13, and was in the form of a banquet, following which there was a discussion of the recent eastern trip taken by the engineering students with Professors Marquis, Judd and Brown.

The officers for the coming year were chosen as follows: Fred W. Kelly, president; I. F. Rehn, vice-president; G. W. Geisinger, secretary; V. N. Braden, treasurer, and Cecil McGuiley, sergeant-at-arms.

THE PENNSYLVANIA STATE COLLEGE

The following officers of the Student Branch of Pennsylvania State College were chosen at a meeting of the Branch on May 18: F. G. Bright, president; R. S. Smith, treasurer, and R. S. Clark, secretary.

V. D. Longo discussed Ingersoll-Rand Compressed Air Machinery. His talk was illustrated with slides.

PURDUE UNIVERSITY

The officers of Purdue University Student Branch were chosen at the meeting of the Branch held on May 9 and were as follows: L. C. McAuley, chairman; J. A. Pearce, vice-chairman; H. L. Covert, recording secretary; G. A. Ruess, corresponding secretary; A. B. Birtles, treasurer, and J. B. Madden and E. R. Wagstaff, governing council, and Prof. L. V. Ludy, faculty member of the governing council.

STATE UNIVERSITY OF IOWA

A meeting of the Student Branch of the State University of Iowa was held on June 6, at which the officers for the coming year were elected: O. H. Beyer, chairman; H. V. Swanson, vice-chairman; F. J. Konvalinka, secretary and treasurer, and a governing committee consisting of R. S. Wilbur, Rex Harrington and S. E. Gibbs.

UNIVERSITY OF CINCINNATI

At a meeting of the Student Branch of the University of Cincinnati on May 18, 1916, the following officers were elected: W. Cowell, president; L. De Quasie, vice-president, and E. A. Botts, secretary and treasurer.

R. Rickwood, student member, read an article on The Importance of English in Technical Education, written by Lytle Harrington, who is a consulting engineer and a member of the Executive Council of Tau Beta Pi.

C. Joerger, instructor in Mechanical Engineering, gave a short talk to the men, giving a number of excellent suggestions for the Student Branch.

UNIVERSITY OF COLORADO

At a meeting of the University of Colorado Student Branch held on May 11, Walter F. Mallory read a paper by Luther D. Burlingame on The Evolution of the Milling Machine—Its Place in History. The paper was illustrated with slides and followed the development of the milling machine from the earliest attempts at milling metal to the present universal milling machine.

EMPLOYMENT BULLETIN

THE Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for Bulletin must be in hand before the 18th of the month. The notices appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

These advertisements are placed by members of the Society or persons vouched for by members. The Society is pleased to act as a "clearing house" but is not responsible for results.

In forwarding applications, stamps should be enclosed for transmittal of applications to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed by the Society.

CADET ENGINEERS: Recent graduates of technical schools, for work in connection with studies of central station power house operation, in line of improving their operation and methods. Salary starts at $60 per month. Further advance entirely a matter of personal ability to fit into the organization. Location New Jersey.—37.

DRAFTSMAN, experienced in heavy machinery work and if possible on chemical apparatus. Salary $25-$30. Location New Jersey.—50.

ASSISTANT CHIEF ENGINEER, young man who has had experience, or special duty in the operation of a power plant, to assist in running a wood working factory of 1000 h.p. Knowledge of the design of exhaust steam heating on a large scale, a desirable asset. Answer, stating age, past position and salary expected.—83.

DRAFTSMAN, experienced in design of heavy machinery, rolling mills, etc. Location Connecticut.—98.

ASSOCIATE PROFESSOR IN EXPERIMENTAL MECHANICAL ENGINEERING in large engineering school in Atlanta, Ga., wanted next September. Must have recognized engineering degree and teaching experience or extensive practical experience in experimental and research work. Give full details of education, post-graduate work and practical experience, including references.—293.

SUPERINTENDENT for plant for wood chipping machinery, and processes for oxidizing. Location near New York.—319.

ASSISTANT SUPERINTENDENT in special charge of production work in large machine shop in Middle West, manufacturing locomotive and wrecking cranes. It is desired to harmonize present methods and supplement them with scientific management processes as far as possible. Experience along these lines preferred. Exceptionally fine opening for the right man.—338.

INSTRUCTOR IN ELEMENTARY STRENGTH OF MATERIALS MECHANICS, and to act as Assistant in electrical laboratory. Previous experience in teaching not necessary but two or three years in practice. Salary $1200 for school term. Location Pratt Institute, Brooklyn.—342.

FIRST CLASS AND EXPERIENCED MACHINE TOOL DESIGNER capable of laying out tooling and special fixtures for quantity production. Apply P. O. Box 428, Hazleton, Pa., stating experience and salary expected.—344.

SALES ENGINEER; a young mechanical engineer with three to five years experience in both shop and drafting room, preferably in automobile work, to train into sales work. Location Detroit. Write, giving full particulars of experience, education and references.—345.

SALESMAN, experience in conveying machinery preferred but not essential. Splendid territory with branch office and good position are offered to right man. Exceptional opportunity but only live, energetic, successful salesman with A-1 record will be considered. Replies treated absolutely confidential, but must give full particulars of experience, amount of sales, record, salary expected, references, etc. Apply through Society, name confidential.—346.

DRAFTSMAN, on multi-color press design. State experience, age and expected salary. Location Rahway, N. J.—349.

PRODUCTION ENGINEER of experience, with knowledge of conveying machinery, to take charge of constructing details. State fully age, experience, education, salary wanted, and when available. Position offers good prospects, but only man who can produce results will be considered. All correspondence confidential.—350.

HEATING and VENTILATING ENGINEER for position in Toronto, Canada (interview through New York office)—heating and ventilating systems, involves getting out of specifications design and supervision of installations. Technical graduate preferred.—358.

SALESMAN having experience in tool steel, alloyed steels preferred; opportunity for advancement. Applicant must state age, experience and salary expected. Location New York.—360.

SALESMAN with technical education to sell high grade recorders and efficiency instruments. State age, education, experience and salary desired to start.—362.

ASSISTANT wanted in September in mechanical laboratories in eastern technical school. Must have been out of college at least a year and had some practical experience in the care and handling of mechanical equipment. Give full details of education, practical experience and references. Location near New York.—366.

CLERK for order and traffic department. Experienced in iron and steel, particularly tool and alloy steels and specialties preferred. To receive attention state age, experience and wages expected. Location New York.—367.

DRAFTSMAN experienced on drawings of dies, jigs and fixtures for pressed and drawn metal work. State reference, experience, salary expected, etc. Location New England.—372.

DRAFTSMAN, familiar with the design of piping and the layout and equipment for power plants. State training, experience and salary expected. Location New England.—379.

CHIEF ENGINEER for Chemical Works, one experienced in Power Plants, capable of taking full charge. Present plant of 3000 h.p. boilers generating power for electro-chemical work. Applicant must be not less than thirty years of age; salary to start about $2400.—376.

MEN AVAILABLE

Only members of the Society are listed in the published notices. Notices are not repeated in consecutive issues of the Bulletin.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

SALES ENGINEER, MANAGER or MANUFACTURERS' REPRESENTATIVE Graduate in mechanical engineering, Worcester Polytechnic Institute; age 36. Thirteen years broad practical experience selling and managing sales in New York City, pumping machinery, air compressors and internal combustion engines with their auxiliary equipment. Good business record with leading concerns in these lines. —G-245.

MECHANICAL or CHIEF ENGINEER, age 31, four years experience as superintendent of erection and chief operating engineer of large power and industrial plants; four years in charge of design and detailing of power plants; good executive ability, capable of assuming any responsibility in power plant lines and getting results from factory organization. Location in U. S. A. preferred. Salary $2500.—G-246.

MECHANICAL ENGINEER and EXECUTIVE. Graduate Stevens Institute of Technology, member A.S.M.E., 35 years old, orderly minded, resourceful, energetic, desires position of larger executive responsibility and future so that the location may be a permanent one. In the following positions during the past eleven years—chief draftsman, production superintendent, mechanical superintendent, efficiency engineer Present salary $3600 per year—G-247.

MEMBER, thirty-two, M. I. T., wishes position with an eastern manufacturing firm. Experienced in design and application of mechanical conveyors for the handling of materials; special machinery; six years office and sales experience. Apply through Society.—G-248.

DRAFTSMAN, SALES ENGINEER. Experience of 12 years. Working knowledge of steam engines, boilers, electricity, tools, etc. Conducted and compiled reports of tests. Only position with future considered. 32 years old. Technical education. Salary moderate; location immaterial.—G-249.

SALES ENGINEER, MANAGER or SUPERINTENDENT; age 35, 15 years experience in design, manufacture and sale of electrical machinery. A capable executive and organizer, thoroughly familiar with modern shop practice and well acquainted with trade, desires to communicate with manufacturer wishing services of a live and up-to-date executive. Assoc. Member A.S.M.E. Member A.I.E.E.—G-250.

PRODUCTION ENGINEER: 34, technical graduate, strong disciplinarian and successful handler of men, with organizing and executive ability, well versed in efficiency, rate setting, cost accounting and modern shop management, desires position along the lines of foundry, machine shop or sheet metal work. Compensation to be based on results.—G-251.

MECHANICAL ENGINEER, Columbia 1915, with good shop and drafting experience, seeks a position in or around New York City. At present employed.—G-252.

ASSISTANT ENGINEER or CHIEF DRAFTSMAN for one of the largest rubber manufacturing plants desires change. Technical graduate, ten years experience, five in above capacity. Would consider a position similar to that now held but prefers place where originality, organization or efficiency are required. Can make change in a reasonable length of time after engagement.—G-253.

MANAGER; mechanical engineering graduate; experience in machine shop and tool room, wishes a position in which training and experience will be necessities. Can furnish references.—G-254.

JUNIOR MEMBER, age 30, twelve years experience in patent practice, inventing, designing and developing automatic machinery; also executive in charge of manufacturing, factory and stock room system, wants opportunity to grow according to ability. Salary about $2500 —G-255.

FACTORY MANAGER or ASSISTANT TO EXECUTIVE of large corporation, ten years work in costs, statistics, efficiency engineering and factory management. Technical graduate, M.E. Experience in belting, office furniture and hardware lines. Uniformly successful in increasing output and decreasing costs. Desires permanent connection at a salary commensurate with training and ability.—G-256.

EXECUTIVE, ENGINEER or ASSISTANT, familiar with large and small construction, maintenance, operations, tests and inspections, competent to give or carry out orders, meet emergencies and to handle men. Location anywhere. Reply through the Society.—G-257.

TECHNICAL GRADUATE, 1911, E.E. and M.E., Junior Member, desires to make a change to position in the engineering department of company engaged in the design or construction of power plants or with a consulting engineer. Location in or near New York preferred. —G-258.

TEACHER in the Department of Mechanical Engineering or Physics in a technical school or university. Junior Member, E.E., M.E., Sc.D., with some commercial experience and five years teaching experience — G-259.

ASSISTANT EXECUTIVE, large manufacturing corporation, in accounting or operating department, portion of duties to consist of increasing output and lowering costs through intensive management methods; age 31; technical graduate; past seven years in industrial management work, as employe of noted efficiency engineer, later connected with large corporation as special investigator and manager of plant. Seeking connection with company that is aggressive, successful and broad-policied. Initial salary secondary consideration.—G-260.

MECHANICAL ENGINEER, technical graduate in mechanical and electrical engineering, Junior Member, at present employed, desires to become identified with manufacturing or industrial plant in responsible position. Thirteen years varied experience in designing, constructing and operating steam and industrial plants; piping layouts, structural designs, thermal investigations of power plants, handling men, etc. An efficient executive now in charge of steam plants and of construction

work for large company. Prefers Eastern location or New York City. Salary to start $175-$200.—G-261.

ASSISTANT TO EXECUTIVE OR EXPERIMENTAL ENGINEER. Junior Member, 28, Stevens 1911 graduate, good experience in power plant, field and office. Last three years in successful executive and experimental work. Possesses initiative, good personality, unusual mathematical ability. Open for engagement with concern where energy and ability will win advancement.—G-262.

GRADUATE M.E. with engineering and commercial practice; familiar with modern methods of organization and the management of industrial corporations and manufacturing establishments. Experienced in the design, manufacture and sale of various products based on cost analyses; also in the increase of efficiency through sanitation safety provisions and proper recognition of the human element.—G-263.

CHIEF ENGINEER, Member, successful designer of automatic machinery, 2 years experience, desires charge of maintenance and operation of industrial plants. At present employed in executive position. Salary $4000.—G-264.

REPRESENTATIVE; engineer having own offices in Dayton, Ohio, desires to add additional representation for manufacturers in connection with his consulting practice. Will be glad to correspond with any manufacturer for that purpose.—G-265.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

American Wood Preservers' Association. Report of Proceedings. 12th annual meeting. *Baltimore, 1916.* Gift of Association.

Automobile Ignition, Starting, and Lighting, Charles B. Hayward. *Chicago, American Technical Society, 1916.* Gift of Publishers.

This volume is written for the use of practical men, and therefore has much elementary matter. Its treatment of the subject is quite thorough. W. P. C.

Development of the New Bedford Water Supplies. By R. C. P. Coggeshall. (Old Dartmouth Historical Sketches, no. 42.) *New Bedford, 1915.* Gift of A.S.M.E.

Electrical Railways. By H. M. Hobart. Being the "James Forrest" Lecture, 1915, delivered at the Institution of Civil Engineers *London, 1915.* Gift of C. W. Rice.

English and American Tool Builders. By Joseph Wickham Roe. New Haven, Yale University Press, 1916. Price $3.00. Gift of Publishers.

"Well informed persons are aware of the part which machinery in general has had on modern industrial life. But the profound influence which machine tools have had on that development is scarcely realized, even by tool builders themselves."

This opening sentence in Professor Roe's book indicates the object for which it has been written, to show in detail the history of the machine tool, and record the incidents in the lives of machine tool makers.

The book is one of peculiar interest to mechanical engineers, and is replete with information. W. P. C.

Industrial Leadership. By H. L. Gantt. New Haven, Yale University Press, 1916. Price $1.00. Gift of Publishers.

Lectures given before the Senior Class at Sheffield Scientific School of Yale University in 1915.

The lectures, five in number, are devoted to the higher principles of scientific management, especially as to the importance of vocational training. W. P. C.

Public Cotton Warehouses, Grain Elevator and Terminal of the Board of Commissioners of the Port of New Orleans. May 1, 1916. Gift of New Orleans Public Cotton Warehouses.

Schwei. Ingenieur und Architektenverein. Jahresheft 1915 und Mitgliederverzeichnis. *Zurckh, 1916.* Gift of Schwei. Ingenieur und Architektenverein.

Scientific Management and Labor, Robert Franklin Hoxie. *New York, D. Appleton & Co., 1915.* Gift of Publishers.

The United States Commission on Industrial Relations empowered the author to make an investigation on scientific management in its relations to labor.

In the present work, a critical examination is made of the claims of the proponents and opponents of scientific management, and, as is to be expected, the decision, so far as any decision has been indicated, is a compromise. W. P. C.

Second Pan American Scientific Congress. The Final Act and Interpretative Commentary Thereon. *Washington, 1916.* Gift of Second Pan American Scientific Congress.

The Technical Production of Hydrogen and its Industrial Application. H. L. Barnitz. *New York, 1916.* Gift of author.

"What is an Engineer?" "Scientific Research in America," A. A. Noyes. *Pasadena, 1915.* Gift of Throop College of Technology.

EXCHANGES

Liverpool Engineering Society. Transactions, vol. XXXVI. *Liverpool, 1915.*

Society of Naval Architects and Marine Engineers. Transactions, vol. XXIII, 1915. *New York, 1915.*

TRADE CATALOGUES

The Colorado Culvert & Flume Co. *Pueblo, Colo.* Catalogue 16-A. Metal Flumes and other irrigation supplies.

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. *May, 1916.*

International Motor Co. *New York, N. Y.* Mack Motor Trucks. Model "AC," 3½, 5½, 7½ tons.

Leeds & Northrup Co. *Philadelphia, Pa.* Bulletin 875. Potentiometer system of pyrometry.

New London Ship & Engine Co. *Groton, Conn.* The Neseco News. *April, 1916.*

Shepard Electric Crane & Hoist Co. *Montour Falls, N. Y.* Bulletin no. 60. Monorail hoist types.

Texas Co. *New York, N. Y.* Lubrication. *May, 1916.*

Taill Indicator Co. *Corry, Pa.* The indicator book. *1916.* Gift of Geo. H. Gibson Co.

Valley Iron Works Co. *Appleton, Wis.* The Beater. *May-June, 1916.*

Walworth Mfg. Co. *Boston, Mass.* Walworth Log. *May-June, 1916.*

Wiedeke, Gustav & Co. *Dayton, Ohio.* Catalogue no. 48. Ideal Tube expanders; Ideal tube cutters. *1915.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

Die Abwasser. Ihre beseitigung und reinigung, J. E. Mayer. *Leipzig, 1915.*

Administrative Report of the State Geologist of Virginia Geological Survey, 1914-15. *Charlottesville, 1916.*

Aeroplane. A Concise Scientific Study, A. Fage. ed. 2. *London, 1915.*

American Association of University Professors. Report of the Committee of Inquiry on Conditions at the University of Utah. *July, 1915.* Gift of Association.

American Manufacturers Export Association. Year Book, 1915. *New York, 1915.* Gift of Association.

The Analysis of Permissible Explosives. U. S. Bureau of Mines. Bulletin 96. *Washington, 1916.*

The Anthracite Coal Fields of Pennsylvania, and Their Exhaustion. *Harrisburg, 1881.*

Appletons' New Spanish-English and English-Spanish Dictionary, Arturo Cuyás. *New York, 1916.*

The Athenaeum Subject Index to Periodicals, 1915. Science and Technology. *London, 1916.*

The Automobile. vol. 1-3, 8-13. *New York, 1899-1905.*

Bibliographie der Wünschelrute, Carl v. Klinckowstroem. *München, 1911.*

Bibliographie der Wünschelrute seit 1910 und Nachträge (1610-1909), Der Begriff des Erfolges bei Arbeiten von Wünschelrutengängern, Carl von Klinckowstroem und R. Weyrauch. *Stuttgart, 1912.*

Bibliography of the Chemical Influence of Light, A. Tuckerman. *Washington City, 1891.*

Birds of North and Middle America. Bulletin no. 50, U. S. National Museum. *Washington, 1916.*

British Locomotives, C. J. B. Cooke. *London, 1893.*

Case for the Shorter Work Day. Supreme Court of the United States. Brief for defendant in error. vol. 1-2. *New York, 1915.* Gift of National Consumers' League.

Catechism of Central Station Gas Engineering in the United States. *New York.*

Centrifugal Fans, J. H. Kinealy. *New York, 1905.*

Die Chemie der Kohle, F. W. Hinrichsen & S. Taczak. ed. 3. *Leipzig, 1916.*

Chemische Technologie, Fr. Heusler. *Leipzig, 1905.*

Civil Engineers' Cost Book, T. E. Coleman. ed. 2. *London, 1916.*

Coal Distillation, Gasification and By-Products, J. E. Christopher. *Wigan, 1915.*

Coal Mine Fatalities in the United States, 1870-1914. U. S. Bureau of Mines, Bulletin 115. *Washington, 1916.*

Coal Mine Fatalities in the United States, 1915. List of Permissible explosives, lamps and motors tested prior to January 1, 1916. *Washington, 1916.*

Constitutions of Pennsylvania, Constitution of the United States. *Harrisburg, 1916.*

Construction of Improved Ordnance, Daniel Treadwell. *Cambridge, 1862.*

Description of the Laboratories of the Mines Branch of the Department of Mines, Ottawa. Canada, Department of Mines. Bulletin no. 13. *Ottawa, 1916.*

Directory of the Iron and Steel Works of the United States and Canada, 1916. ed. 18. *New York, 1916.*

Effects of Atmospheres Deficient in Oxygen on Small Animals and on Men. U. S. Bureau of Mines. Technical Paper 122. *Washington, 1915.*

Die Eisenbahn Werkstätten der Gegenwart. Bd. I, pt. 2. ed. 2. *Wiesbaden, 1916.*

Electrical Conductivity and Ionization Constants of Organic Compounds, Heyward Scudder. *London, 1914.*

Electrical Engineering First Course, E. J. Berg and W. L. Upson. *New York, 1916.*

The Electron Theory, E. E. Fournier. ed. 3. *London, 1909.*

Engineers' Club. Constitution, Rules, Officers and Members. 1916. *New York, 1916.* Gift of Club.

The Engineers Club of St. Louis. Yearbook, 1916. *St. Louis, Mo.*

Les Explosifs, Henry Le Chatelier. *Paris, 1915.*

Federal Reserve Act. The National Bank Act. 1812-1914. *New York.* Gift of National City Bank.

Feldspars of the New England and North Appalachian States. U. S. Bureau of Mines. Bulletin 92. *Washington, 1916.*

The Flotation Process. Compiled and edited by T. A. Rickard. *San Francisco, 1916.*

Foundryman's Reference Book, J. F. Bowe. *Pittsfield.*

Franklin Institute Report of Second and Seventh Annual Exhibition. *Philadelphia, 1825, 1831.*

Galvanizing and Tinning, W. T. Flanders. *New York, 1916.*

Geology and Ore Deposits of Rossland, British Columbia. Memoir 77. Canada. Dept. of Mines. *Ottawa, 1915.*

Geology of Field Map-Area, B.C. and Alberta. Memoir 55. Canada. Dept. of Mines. *Ottawa, 1914.*

Good Roads Year Book, 1916. *Washington, 1916.*

Handbook of Formulas and Tables for Engineers. Compiled by Clarence A. Peirce & W. B. Carver. *New York, 1914.*

Handbuch der Radiologie, Erich Marx. Band III. *Leipzig, 1916.*

Die Hygiene des Wassers, Aug. Gärtner. *Braunschweig, 1915.*

Industries des Poils et Fourrures Cheveux et Plumes, J. G. Beltzer. *Paris, 1912.*

Information Annual, 1915. *New York, 1916.*

International Engineering Congress, 1915. vol. 10—Naval Architecture and Marine Engineering. *San Francisco, 1915.*

International Engineering Congress. vol. 11, Waterways and Irrigation. *San Francisco, 1915.*

Jahrbuch der Gastechnik, 1914, H. Strache. *München, 1915.*

Japanese Society of Naval Architects. Journal, vol. xviii. *Tokyo, 1916.* Gift of Society.

Kraftwagen Betrieb mit Inlands Brennstoffen, Freiherrn v. Löw. *Wiesbaden, 1916.*

Land and Marine Diesel Engines, Giorgio Supino. Translated by A. G. Bremner and James Richardson. *London, 1915.*

Learned Societies and Printing Clubs of the United Kingdom, A. Hume. *London, 1853.*

Limes and Cements, E. A. Dancaster. *London, 1916.*

Manual del Costruttore Navale, Giuseppe Rossi. *Milano, 1915.*

Marine Steam Turbine. A practical description of the Parsons and Curtis Marine Steam Turbines, J. W. M. Sothern. ed. 4. *London, 1916.*

Maintenance of Way and Structures, W. C. Williard. *New York, 1915.*

Mayor's Committee on Unemployment. Report, January, 1916. *New York, 1916.* Gift of Committee.

McGraw Central Station List, April, 1916. *New York, 1916.*

Memorial on the Upward Forces of Fluids, and Their Applicability to Several Arts, Sciences and Public Improvements, E. C. Genet. *Albany, 1825.*

Military Aeroplanes, G. C. Loening. ed. 2. *Boston, 1916.*

Miners' Nystagmus. U. S. Bureau of Mines, Bulletin no. 93. *Washington, 1916.*

Modern Guns and Gunnery, 1910, H. A. Bethell. *Woolwich, 1910.*

National Banks of the United States. Their Organization, Management and Supervision, 1812-1910. *New York.* Gift of National City Bank.

Naval Percussion Locks and Primers, Particularly Those of the United States, J. A. Dahlgren. *Philadelphia, 1853.*

New Castle County Highways, Report on. Prepared for a special committee of the Chamber of Commerce, Wilmington, Delaware, Arthur H. Blanchard, H. G. Shirley and G. W. Tillson. *April, 1916.* Gift of Arthur H. Blanchard.

New International Encyclopaedia. ed. 2. vols. 19, 20. *New York, 1916.*

New York State Public Service Commission for the First District. Report, 1914, vol. II. *New York, 1915.*

New York Times Index. January-March, 1916. *New York, 1916.*

Ohio Mining Journal. nos. 26, 27, 1897-98. *Columbus, 1899.* Gift of Ohio State University.

Oil and Gas Map of Southwestern Pennsylvania, 1915. *Harrisburg, 1916.*

Oil, Paint & Drug Reporter. Green Book for Buyers. April, 1916. *New York, 1916.* Gift of Oil, Paint & Drug Reporter.

Ore Deposits of the Beaverdell Map-Area. Memoir 79, Canada. Dept. of Mines. *Ottawa, 1915.*

Overhead Conductor Electric Railway Co. Description of J. R. Finney system. *Pittsburgh, 1887.*

Packing House and Cold Storage Construction, H. P. Henschien. *Chicago, 1915.*

Pennsylvania. Bureau of Engineering. 1st Annual Report, 1914. *Harrisburg, 1915.*

Pennsylvania. Department of Agriculture. 20th Annual Report, 1914. *Harrisburg, 1915.*

——— Linseed Oil Report, 1915. (Bulletin 274.) *Harrisburg, 1916.*

——— List of Fertilizer and Lime Manufacturers and Importers. Bulletin. *Harrisburg, 1916.*

Pennsylvania. Department of Labor and Industry. 2d Annual Report, 1914, part 1. *Harrisburg, 1915.*

Photo-Electricity. The Liberation of Electrons by Light, H. S. Allen. *London, 1913.*

Physical Geography of Wisconsin. Bulletin no. 36. Wisconsin Geological & Natural History Survey. *Madison, 1916.*

A Practical Guide for Russian Consular Officers and All Persons Having Relations with Russia, A. Heyking. ed. 2. *London, 1916.*

Practical Shaft Sinking, Francis Donaldson. *New York, 1910.*

Die Prüfung von Stampasphalt und Anderen Strassendekten mit Bituminösen Bindemitteln, Hugo Schmidt and Paul Herrmann. *Berlin, 1915.*

Public Utilities Reports. 1916 A. *Rochester, 1916.*

Relativity and the Electron Theory, E. Cunningham. *London, 1915.*

Report on the Iron of Dodge and Washington Counties, State of Wisconsin, Jas. G. Percival. *Milwaukee, 1855.*

Report on Past Experimental Work on Cutting Tools, Dempster Smith. *Manchester, 1915.*

Results of Observations Made at the United States Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1913 and 1914. *Washington, 1916.*

Results of Observations Made at the United States Coast and Geodetic Survey Magnetic Observatory Near Tucson, Arizona, 1913 and 1914. *Washington, 1916.*

The Rise of Rail Power in War and Conquest, 1833-1914, E. A. Pratt. *London, 1915.*

Sand Test for Determining the Strength of Detonators. U. S. Bureau of Mines. Technical Paper 125. *Washington, 1916.*

Seed Report, 1915. Pennsylvania. Department of Agriculture, Bureau of Chemistry. *Harrisburg, 1916.*

Sewer Gas and Its Dangers, G. P. Brown. *Chicago, 1881.*

Straight Line Engineering Diagrams, Manifold & Poole. *San Francisco, 1911.*

Study and Review of the Problem of Passenger Transportation in Philadelphia by a Unified System of Lines. March 29, 1916. Gift of Department of City Transit.

Surface Water Supply of Virginia. Virginia Geological Survey. Bulletin no. X. *Charlottesville, 1916.*

Text Book of Paper Making, C. F. Cross and E. J. Bevan. ed. 4. *London, 1916.*

Transvaal Chamber of Mines. Address delivered by W. H. Dawe, at annual meeting held March 27, 1916. *Johannesburg, 1916.* Gift of Transvaal Chamber of Mines.

Tunungwant Coal Field, McKean County, Pa. Reports on the Geology of, D. D. Owen & B. Needham. *Buffalo.*

United States National Museum. Proceedings. vol. 49. *Washington, 1916.*

Value for Rate Making, Henry Floy. *New York, 1916.*

Versuche aus der Wärmelehre, Gustav Looser. ed. 4. *Braunschweig, 1915.*

Waldwick Mines, Report of J. W. Foster. *Boston, 1866.*

GIFT OF HILL PUBLISHING COMPANY

A collection of state reports, mining companies reports, and various pamphlets.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

OFFICERS AND COUNCIL, 1916

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American Society for Testing Materials Modification Briggs Standard for Pipe Threads
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Conference Committee on Electrical Engineering Standards
Henry G. Stott, *Chairman;* Albert F. Ganz, Carl Schwartz

Conference Committee of National Engineering Societies
Charles W. Baker, Arthur M. Greene, Jr., D. S. Jacobus

Conference Committee to Determine Cost of Electric Power
D. C. Jackson, A. H. Kruesi, R. J. S. Pigott, John A. Stevens, B. F. Wood

Conservation
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Engineer Reserve Corps
William H. Wiley, *Chairman;* W. F. M. Goss, H. A. Gillis, Alex. C. Humphreys, Wilfred Lewis

Engineering Foundation
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Note—Numbers in parentheses indicate number of years the member has yet to serve

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Frank H. Clark, Fred J. Miller

Filter Standardization
George W. Fuller, *Chairman;* Jas. C. Boyd, Arthur M. Crane, Philip N. Engel, Martin F. Newman, Wm. Schwanhausser

Increase of Membership
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ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY.

AIR CRAFT BALLISTICS.
TERMINAL VELOCITY OF FALLING BODIES.
BALLISTIC COEFFICIENT.
CONCRETE AGGREGATES WITH LIMESTONE SCREENINGS.
ALLOYS, HEAT TREATMENT.
ALLOYS, STEEL AND COPPER COMPARED.
BALSA WOOD AS INSULATION MATERIAL.
PORTLAND CEMENT, CHEMICAL CONSTITUTION.
BAG-HOUSE.
STRAINERS, LOSS OF HEAD IN.
ORIFICES, LOSS OF HEAD IN.
SAND, LOSS OF HEAD IN.
OIL, FLOW THROUGH PIPES.
OIL, PHYSICAL CONSTANTS.
PRIME MOVERS IN THE OIL FIELD.
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STRICKLAND DOUBLE-ACTING FOUR-STROKE CYCLE ENGINE.
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WIRE ROPE, LUBRICATION.
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WATER LEVEL INDICATORS FOR BOILERS.
FLOW OF HEAT IN METAL SHEETS.
FLOW OF HEAT IN METALS, INDICATING MATERIALS.
FLOW OF HEAT, SOLIDS TO AIR.
WATER IN COAL.

In nothing, perhaps, are the tendencies of modern engineering more evident than in the present methods of viewing materials of construction. Cement was cement to the engineer of yesterday, but the Geophysical Laboratory of the Carnegie Institution in Washington, as told by George A. Rankin in an abstract in this issue, has just carried out an extensive and thorough chemical and optical investigation of the constituent parts of portland cement, and discovered which of these constituents increase or decrease its strength and why, and incidentally shows how a better clinker can be ultimately produced. George H. Ruhling emphasizes the same idea in *The Michigan Technic* by maintaining that "it will always pay to screen aggregates and find out the proper combination whereby the densest concrete may be had." This is particularly significant, as not so long ago American engineering was accused of being excessively conducted along cut-and-try methods. From present indications it is permissible to look forward into a not distant future to the day when the American engineer will, perhaps in a higher degree than his European colleague, know exactly why and how he achieves those results of which the high quality has been already almost universally acknowledged.

THIS MONTH'S ARTICLES

In the abstract on air craft ballistics the meaning of terminal velocity of bodies falling from a high altitude is fully explained.

A general discussion of the heat treatment of alloys is presented from a paper by L. Grenet in a French publication. Among other things it contains an interesting comparison between steel and copper alloys.

The thermal properties of balsa wood are discussed by R. C. Carpenter, Mem.Am.Soc.M.E., who also compares the coefficient of heat transmission in his own equation with the specific conductivity *e* of insulating materials of the Bureau of Standards.

The new bag-house at the Midvale Smelter is described by L. S. Austin.

From an English publication is abstracted a report on extensive tests on the relation of viscosity of oil to the rate of flow through pipes carried out at the National Physical Laboratory under the direction of Dr. R. T. Glazebrook. These tests have shown clearly that the ordinary laws of viscous flow hold so long as the velocity of flow is below critical velocity and that above that figure the flow becomes turbulent.

The use of internal combustion engines for pumping and in the oil field is discussed in two articles, the first by C. R. Knowles and the other by F. G. Rappoport. In the same section is given an illustrated description of the Strickland double-acting engine, which, while working on a four-stroke cycle, gives a power impulse every revolution in each cylinder.

A statement is taken from an English publication that a new steel has been invented in England which contains none of the usual rare metals and is still a high-speed tool-steel from every point of view.

Studies of instruments for measuring radiant energy are reported from a publication of the Bureau of Standards. Such instruments are becoming increasingly important partly because they may be used as pyrometers in certain lines, and also in connection with investigations of heating systems.

A brief abstract is given of a paper on spur-gearing, read by D. Adamson, Mem.Am.Soc.M.E., before the Institution of Mechanical Engineers. Among other things the writer mentions the case of a pair of machine cut bevel wheels transmitting 1500 h.p. with a pitch line velocity of 3000 ft. per minute.

The high precision of screws used in munition work prompted apparently an investigation by the National Physical Laboratory of England on errors of screws, in which is particularly emphasized the influence of an error in one of the fundamental elements of a screw thread on the other fundamental elements, and the maximum admissible error in any of the fundamental dimensions.

Aeronautics

Air Craft Ballistics

The article treats primarily of methods for determining the successive stages in the ascent and descent of projectiles fired vertically, the application being primarily to firing against air craft; but as the article involves considerations applicable to other problems it is of general engineering interest.

The author gives two diagrams, one showing the vertical heights attained by projectiles as a function of their initial velocity, and another the striking velocity of falling bodies.

He emphasizes the fact that in the case of falling bodies air resistance introduces a complex disturbance, since acceleration in the rate of fall is restricted to the initial stages of travel where the force of gravity is greater than the resistance of the air; then a state of equilibrium is established and the body continues to move at a constant velocity known as *terminal velocity.* In fact, a falling body may attain its terminal velocity at a considerable height from the ground, and thereafter, instead of an increase of velocity, there will be a slight decrease, due to the increase of resistance as denser layers of air are traversed. The terminal velocity is a function of the ballistic coefficient C, which is to be determined experimentally and is in turn a function of the weight and design of the falling body. With $C = 1.0$ the earth is struck at a velocity of 188 ft. per second, no matter whether the dropping height be 2000 or 12,000 ft. (*Arms and Explosives,* vol. 24, no. 284, p. 67, May 1, 1916, 3 pp., 2 figs. *pe*).

Engineering Materials

Laboratory Tests on Concrete Aggregates, George H. Ruhling

The author made tests to determine the physical properties of concrete aggregates. In his work in Seneca County, Ohio, he found it to be the opinion of many engineers in that locality that the screenings from limestone should not be used for fine aggregate in concrete because it was alleged that the screenings contained too much fine material. Hence, the local specifications stipulated that all fine aggregate should be not less than 50 per cent lake or clean bank sand, this stipulation being always a source of argument between the contractors and the engineer for the county.

The writer made a series of tests to determine the best aggregate and found that, in the first place, it will always pay to screen aggregates and find out the proper combination whereby the densest concrete may be had, and, second, that concrete of stone screenings, if properly proportioned and with the stone screenings well graded, will make just as strong and probably stronger concrete than ordinary lake sand (*The Michigan Technic,* vol. 29, no. 2, p. 114, May, 1916, 7 pp., 8 figs. *c*).

General Considerations on Heat Treatment of Alloys, L. Grenet

The paper presents a general discussion on the heat treatment of alloys. Because of lack of space, only the conclusions can be presented here.

Within the limits of the present investigation, various types of steel may be considered as systems consisting of two independent components, a ferrous component (pure or nearly pure iron) and a carbide. The ferrous component is malleable and has the ability to resist tensile stresses; it endows with these properties the phases α and γ which contain a large proportion of it. The carbide component is hard and brittle and forms (almost entirely) the phase τ_1 or cementite. This component τ_1 affects probably the mechanical properties of steel through its dissemination through it and through contact action between it and the phases α and γ, which latter are alone malleable. The influence of the phase τ_1 or cementite is more direct in the matter of resistance to wear or scratching than in tensile stresses.

The copper alloys may be considered as being formed of a cuprous compound, which in the case of binary alloys is pure copper, and the alloying compound. The cuprous compound plays the same part as the ferrous compound in steels, and the alloying compound the part of the carbide in steel.

Steel has the peculiar property that all of its phases may or may not be magnetic and the rapid variations of magnetism as a function of temperature are usually accompanied by rapid variations of the law which connects the other properties of steel with temperature, but as long as the phase does not change these transformations are almost entirely reversible, and the temperature at which they occur does not have to be considered except for the purpose of heat treatment of steel.

From the point of view of heat treatment the only difference between steels and alloys which we have to bear in mind is that the phase α of steels is derived from the transformation of the solid phase γ, however small may be the carbon content, while the phase α of copper alloys can be derived from the transformation of a solid phase γ only when the proportion of the metal allied to copper is sufficiently large.

The hardening by tempering bound by the conditions of transformation of the solid phase γ into the solid phase α is observable up to the limit of pure iron, but not up to the limit of pure copper alloys. But in all cases where it is possible to carry through this transformation with a change of phase while in the solid state, the phenomenon of tempering of alloys is identical to that of tempering steels. The tempering of a solid metal which on cooling undergoes a transformation with a change of phase does not differ from the tempering in a chill mold of a melted alloy, except by the greater intensity of the effect of tempering and the ability to carry through this operation without simultaneous deformation of the piece.

The hardness of an alloy is determined by the "heat history" of the phases of which it is composed. (*Généralités sur les traitements thermiques des alliages,* L. Grenet, *Bulletin et Comptes rendus mensuels de la Société de l'Industrie Minérale,* October-December 1915, 81 pp., 21 figs. *etA*).

The Properties of Balsa Wood, R. C. Carpenter

Balsa wood, which grows extensively in the Central American and northern South American states, is the lightest wood known, and has been used quite extensively for life preservers and fenders of life boats and rafts. It appears also that it has important insulation qualities for heat. Only the latter will be discussed here.

The Bureau of Standards, Washington, D. C., has determined the specific conductivity, c, of Balsa wood, and found it to vary from 0.394 to 0.403 B.t.u. per sq. ft. per in. of thickness per deg. fahr. of difference in temperature between the surfaces for untreated wood, and from 0.424 to 0.383 B.t.u. for treated wood. Table 1 gives the results of the writer's investigation of heat transmission by determining the quantity of ice which melted in boxes made of Balsa wood and

other materials under known differences of temperature measured inside and outside. The results were reduced to B.t.u.'s transmitted per sq. ft. of mean surface between the outside and inside surfaces of each box, per degree of difference of temperature of the air inside and outside, per hour of time, which correspond to the "coefficient" of heat transmission k in the equation

$$H = k\ (T - T')$$

in which T = the temperature of the air on the entering side and T' = the temperature of the air on the discharge side, while H = the heat transmitted. The coefficient, k, differs from the specific conductivity, e, of the Bureau of Standards as it is dependent on the surface as well as the conduction capacity for heat transmission.

The author discusses in detail the relation between the specific conductivity, e, of the Bureau of Standards and the coefficient of heat transmission, k, of the above equation, and derives the following equation from which the relations between k and e can be computed provided the values of a_1 and a_0 are known:

$$\frac{1}{k} = \frac{1}{a_1} + \frac{1}{a_0} + \frac{x}{e}$$

In this equation x = thickness of the insulating material, a_1 coefficient of surface flow entering the body, and a_0 coefficient of surface flow leaving the body. This equation applies only to a single thickness without air space. It may be applied also, with proper modifications, to other cases.

A table is given showing comparative values of the coefficient k obtained by computation and by test (melted ice in a zinc box inside a balsa box). As computed from the Bureau of Standards tests, it is 5.98, and 5.80 as determined by ice melting experiments in Sibley College. (*Proceedings of the American Society of Civil Engineers,* vol. 42, no. 5, p. 649, May, 1916, 31 pp., 16 figs. *de*).

TABLE 1—HEAT TRANSMISSION EXPERIMENTS IN SIBLEY COLLEGE

Tests Made by Melting Ice

No. of Test.	Thickness of wood, in inches.	British Thermal Units Per Square Foot Per Degree of Difference of Temperature of Air.		Kind of Material
		Per hour k.	Per 24 hrs. k[1].	
1	2	0.121	2.90	Balsa wood, treated.
2	2	0.120	2.89	Balsa wood, treated.
3	2	0.122	2.93	Balsa wood, untreated.
4	2	0.192	4.61	White pine.
5	2	0.102	2.45	Nonpareil cork, extra.
6	2	0.122	2.93	Balsa, single boards, treated.
7	2	0.121	2.90	Balsa, double boards, at right angles.
8	2	0.1194	2.67	Armstrong, XX-cork blocks.
9	3	0.191	2.18	Balsa wood, treated.
10	2	0.1194	2.87	Balsa wood, treated.
11	1	0.199	4.78	Balsa wood, treated.
..	1/16	0.660	15.82	Bare zinc, 1/16 in. thick.

k coefficient of heat transmission per degree Fahrenheit of difference of temperature of air near the sides, per square foot, per inch of thickness per hour.

k[1] 24 k.

Portland Cement, George A. Rankin

Discussion of the basic conditions affecting the physical properties of portland cement; the discussion is partly historical and partly from the point of view of the chemical constitution of the material.

Portland cement is made up of a number of chemical compounds, of which there is but one which in itself possesses all the properties of a desirable portland cement. This compound, tricalcic silicate, makes up only about 35 per cent of an average portland cement. It would appear, therefore, that one method of increasing the strength and durability of portland cement would be to increase the percentage of tricalcic silicate.

Portland cement consists of three fundamental oxides, lime, alumina and silica, and the relatively small admixture of other oxides exerts at most a wholly secondary influence; indeed good portland cement can be made from the above three pure oxides in the proper proportions. While ordinary chemical methods enable us to ascertain the aggregate proportion of each oxide present, they yield no information as to the manner in which these oxides are combined with one another, in other words, as to the substances which actually are present in the clinker and are responsible for its characteristic properties. It is very important to know this because until we know what the substances actually are we cannot hope to improve the quality of the material except by cut-and-try methods.

At the same time cement clinker is a mixture of substances of very similar properties and is besides exceedingly fine grained, which renders quantitative determinations of the constituents quite difficult. The method of investigation adopted by the writer begins with the isolation and determination of all the possible compounds of lime, alumina and silica which one may expect to find in portland cement clinker; next he proceeds to establish their relations at high temperatures and to ascertain their optical characteristics, which constitute the most convenient and satisfactory criterion of the identity of the several substances.

The characteristic properties of the several solid substances containing only lime, alumina and silica which are likely to occur in portland cement have been determined at the Geophysical Laboratory of the Carnegie Institution in Washington in the course of an investigation of all compounds formed when any mixture of these oxides is heated to a high temperature. This investigation is facilitated by the fact that in American-made portland cements the relative proportions of these oxides vary only between comparatively narrow limits, lime 60 to 64, alumina 5 to 9, silica 19 to 25 per cent. The author describes in detail the apparatus and methods of experimentation used. It has been found that the data can be interpreted most readily if they are plotted in three dimensions; the concentration (composition) of each mixture is represented by a point within an equilateral triangle on the horizontal plane; the magnitude of the corresponding temperature by the distance above the plane. In this way a model was obtained with a series of surfaces representing the melting temperatures of all products obtained when any mixture of the three oxides is heated progressively to higher and higher temperatures. The model resembles a relief map of a mountainous region. Each mountain peak is the melting point of a pure component or of a pure compound. The mountain slopes represent the melting temperatures of a component or compound in ternary mixtures; the points where the rivers

in the valleys meet to form a lake are the lowest melting temperatures known as eutectic points.

The author gives a diagram from which can be seen the behavior of the crystalline substances separating from a melt composed only of the three fundamental oxides in such proportions as to produce a good portland cement. In the actual manufacture of portland cement the necessary compounds are formed by burning at a temperature much below that required for complete melting. If, however, the cement clinker is not perfectly burned there will be present besides the three compounds before mentioned two others, namely, CaO and the compound $5CaO.Al_2O_3$. It has been found possible to determine the characteristic optical properties of each of the compounds and to show their various crystals. Microscopic investigation of commercial portland cement clinker shows it to be made up largely (over 90 per cent) of the three compounds tricalcic silicate, dicalcic silicate and tricalcic aluminate. It would appear, therefore, that the value of portland cement as a cementing material when mixed with water is due largely to one or more of these compounds. The author investigates their formation when portland cement is burned. The rapidity with which the reactions go to completion is governed by the temperature and by the amount of the flux formed at that temperature, the melting temperature of the flux necessary for the production of the clinker being materially lowered by the presence of small amounts of impurities. The author worked out a table which gives the constituents of portland cement present between certain definite temperature intervals during the burning of the clinker. The table applies equally to commercial portland cement and cement made up of the three fundamental oxides only. The components of portland cement are lime, alumina and silica and its constituent substances are definite compounds of these oxides. If the raw material for pure cement is perfectly burned at a temperature of 1650 deg. cent., the clinker obtained will consist of the three compounds, dicalcic silicate, tricalcic silicate and tricalcic aluminate. In the actual manufacture of portland cement, however, the clinker is not always perfectly burned, that is, the raw materials are not always ground fine enough or heated to a sufficiently high temperature so that the chemical reactions are completed. With the present knowledge of the nature of the chemical reactions it is, however, possible to state which of the constituents will not be completely formed. When commercial clinker is not perfectly burned there is less tricalcic silicate and more dicalcic silicate, while lime will be present as an individual constituent, the exact percentage of the material depending upon how near to completion the reaction

$$(CaO + 2CaO.SiO_2 = 3\,CaO.SiO_2)$$

has been carried. The importance of this is evident in view of the influence of lime on the physical properties of portland cement. Only cements in which the lime is entirely combined are sound and of good strength.

From the experiments made it appears that of the three compounds which take part in the setting and hardening of portland cement, tricalcic silicate is the best cementing constituent and that it is the only one of the three which when mixed with water will set and harden within a reasonable time to form a mass comparable to portland cement in hardness and strength. The dicalcic silicate requires too long to set and harden in order to be in itself a valuable cementing material. The tricalcic aluminate sets and hardens rapidly but is rather soluble in water and is not particularly durable or strong. The author comes, therefore, to the conclusion that the compound tricalcic silicate is *the* essential constituent of portland cement, and the higher its percentage the better the cement.

When tricalcic silicate is mixed with water to form a mortar, a gelatinous material is formed, composed of hydrous lime and silica. Whether the lime and silica continue to be chemically combined or whether the gelatinous material is colloidal is still a matter of some uncertainty, although it would appear that this material is colloidal. The author tries to establish that gelatinous silica is the most essential constituent of a cement mortar, but confesses that it is only a speculation.

The average portland cement of today contains about 30 to 35 per cent tricalcic silicate, a proportion which closely approaches the maximum possible yield with the present percentage of flux. With the finer grinding of the raw materials, burning for a longer period and at an increased temperature, a higher percentage of tricalcic silicate may be obtained but only at a materially higher cost of production. The writer hopes, however, that a study of other systems may establish the economic possibility of producing a cement containing a high percentage of tricalcic silicate. He thinks that an insight might be gained by substituting some substance, such as Fe_2O_3, for Al_2O_3, and then investigating the equilibrium relations of the new system. He comes to the final conclusion that in order to determine the most economic process for producing tricalcic silicate in the higher percentages it will be necessary to study the rate of formation of this compound in a series of mixtures of various substances, this in turn necessitating the determination of the equilibrium relations of tricalcic silicate at high temperatures in such mixtures. (*Journal of The Franklin Institute,* vol. 181, no. 6, p. 747, June 1916, 38 pp., 16 figs. *etA*).

Firing

New Bag-House, L. S. Austin

Description of a new bag-house at the Midvale Smelter. The bag-house was designed to take out the dust from any five out of six furnaces at a time, before the gases pass to the stack, these five taking the air from a blower of 175 cu. ft. per revolution at 160 r.p.m. or, allowing for 5 per cent of slip, 26,600 cu. ft. per minute. The temperature of this air, entering the blower at 40 deg. fahr., would be 200 deg. fahr. at the top of the charge with a volume, because of expansion by one third, of 35,470 ft. Allowing for the other furnace and for a leakage through the furnace top covers as well as for additional air admitted to lower the temperature at the bag-house to 150 deg. fahr., a fan capacity of 60,000 cu. ft. was needed. The main mechanical features appear in Fig 1 showing position of inlet damper and air feeder. From the fan, gases enter the flue *A* by a 7-ft. pipe. The adjoining main chamber, which consists of the dust chamber *D* and the bag chamber *C*, is divided transversely into five compartments or bays; each bay has an admission and an exhaust pipe, both controlled by disc valves. By adjusting these valves, any bay may be shut off and an exhaust connection opened, thus collapsing the bags and so loosening the flue dust that has accumulated on them. The exhaust pipe is branched into the exhaust main *X*, this leading back to the "trail" on the exhaust side of the fan. Once during a shift the valves are operated and after each shake a five-minute interval is allowed in order to give the dust an opportunity to fall into the lower chamber. Once in several days the bags are given a "hand-shake" to clean them more thoroughly.

The bottom of the dust chamber is inclined at 50 deg. When the bag-house was started, these grades were much flatter and the dust was expected to form its own slope, but it tended to arch over the feed screw and harden there so that the steeper slope of sheet steel had to be used.

As the gases seep through the bags they flow along the flue *D* which continues at a grade of nearly 5 in. per foot to the base of a brick-lined stack 210 ft. high by 16½ ft. inside diameter. In the flue *D*, deflectors are placed to turn the gases leaving the dust chamber into the direction of the flow. The velocity of the gases here is 9 ft. per second, while at the stack the flow is nearly 5 ft. per second.

The cost of the bag-house was $200,000, not including the stack (*Mining and Scientific Press*, vol. 112, no. 21, p. 746, May 20, 1916, 3 pp., 3 figs. *d*).

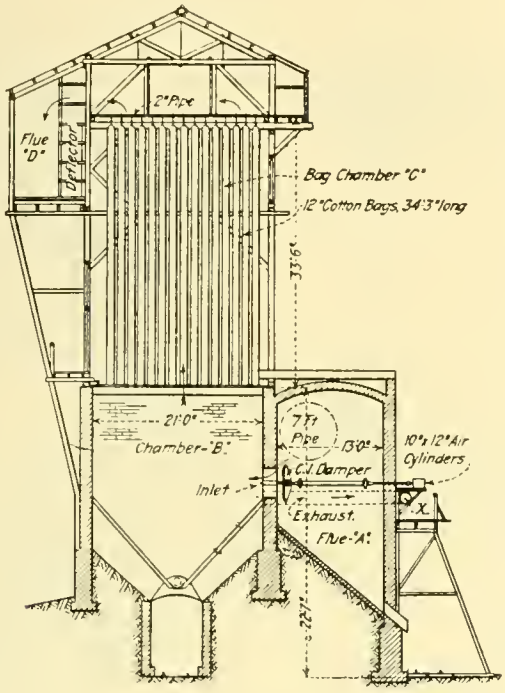


Fig. 1 Section of Baghouse Showing Position of Inlet Damper and Air Feeder

Hydraulics

Tests of Loss of Head in Strainers, Orifices and Sand, Langdon Pearse

The data given in the paper are derived from experiments made by W. W. DeBerard and the author in 1908 during filtration investigations for the Peoples Water Company of Oakland, California. The article describes in detail the testing device used and the methods of operation. The tests were made with the orifices or strainers submerged. The data are presented in the form of tables and curves.

The tests of orifices indicate a coefficient of discharge ranging from 0.62 to 0.85 as a function of the ratio d/t, where d = diameter of orifices and t = thickness of plate. With a very few exceptions the coefficient of discharge C varied but little for the range of head tried on any one orifice. Similar tests were made for loss of head in strainers and sand and fairly consistent results were obtained for the coefficients of discharge for each type. (*Journal of the American Water Works Association*, vol. 3, no. 2, p. 504, June 1916, 11 pp., 7 figs. *e*).

The Viscosity of Oils in Relation to the Rate of Flow through Pipes, Dr. R. T. Glazebrook, W. F. Higgins, and J. R. Pannell

The paper presents data of tests undertaken by the National Physical Laboratory at the request of the British Admiralty. The object of these tests was to investigate the loss of flow of oil in drawn steel pipes of varying sizes with a view to determining how far the pressure difference required to produce a given flow could be calculated from a knowledge of the dimensions of the pipe and of the viscosity of the oil. The experiments were made on the flow of four oils in pipes of 3, 4 and 5 in. diameter.

Further tests were made for the purpose of determining the densities and viscosities of the oils used at various temperatures and the measurement of their flash points. Tests were also made on mixtures of various oils, with special regard to the permanence of the mixtures. Among other things it has been found that Mexican oil is apparently subject to a change in viscosity with time: the viscosity increases if the oil is kept at a low temperature, but is reduced again by short exposure to high temperature.

As regards the loss of flow it was found that the ordinary loss of viscous flow held so long as the velocity of flow was less than the critical velocity which is given by the equation

$$\frac{\rho V d}{\eta} = 2500$$

where V is the velocity of flow in feet per second, d = the diameter of the pipe in feet, ρ = the density in pounds per cu. ft., η = the viscosity coefficient, in foot-pound-second units. It has been found that in all such cases the flow is stream-line in character and the pressure drop is given by

$$\frac{P}{V} = \frac{2\rho}{gd^2}\left(AT - \frac{B}{T}\right)$$

where P is the pressure-difference in lb. per sq. in. and per ft. run, and g is the acceleration due to gravity in feet-second units. A and B are constants of instruments given by special equations in the original articles, and T is the time of flow in seconds observed in the viscosimeter experiments, at temperature t.

For values of velocity greater than 2500 ft. per second the flow is turbulent and the known relation for turbulent flow can be applied when the condition of surface roughness of the pipe is known.

In the discussion which followed one of the speakers pointed out that the experiments were made with a drawn pipe and that the presence of joints which usually occur at distances of 20 or 30 ft. apart, might materially affect the results.

The second part of the investigation, covering the physical constants of the oil, is of great interest, but cannot be abstracted because of lack of space. In an appendix is described the manometer used in the experiments. It is a modification of the pressure gage as designed by Dr. A. P. Chattock. (*Journal of the Institution of Petroleum Technologists and Record of Transactions*, vol. 2, part 5, p. 45, December, 1915, 38 pp., 14 figs. *eA*).

Internal Combustion Engineering

The Internal Combustion Engine in the Oil Field. F. G. Rappoport

Discussion of various sources of power to be used in oil fields.

The author compares oil fired internal combustion engines with gas engines, steam power and electricity in their application to oil fields. The paper is written on the basis of practice in the Caucasian oil fields, Russia.

Besides its ready adaptation to a piecemeal system of development, the great advantage of steam power is its elasticity and flexibility in readily and quickly responding to the intermittent power requirements for which the character of oil field work calls. In boring, changes of speed are constantly required at short notice. In baling, likewise, a constantly changing speed is required. On the other hand, steam power is inefficient and uneconomical.

Electric power has the important advantage of the economies of the central power station with an efficient steam plant, high pressure steam, etc. In the application of the power, however, the constant-speed electric motor lacks the flexibility of the steam engine. Further, it can be applied only to well-established fields or fields which are very conveniently located to existing plants.

The crude oil engine, especially of the medium compression type, has the following advantages: (1) Minimum fuel consumption per unit of power; (2) can be installed in all stages of oil field development on a large or small scale; (3) occupies a minimum of space in proportion to the power developed; and (4) is clean and safe and, with good supervision, comparatively cheap to maintain. The disadvantage of the present method of using oil engines on a large scale in the oil field is, in the first place, the decentralization of the power plant. The plant is installed in separate scattered units at each well, which means increased danger from fire, increased supervision and labor. The total power laid down must be equal to the maximum power and the reduction effected in centralized plants by equalization of peak loads is unobtainable.

The chief practical difficulty in the use of oil motors on oil fields is their constant speed. For example, in drilling, the regulation of the number of blows per minute is important in rock of varying hardness. The freeing of a column of casing which has become fast may require momentary increase of power applied without delay, and the oil engine cannot provide that instantaneous variation of speed necessary in such cases.

In the Baku fields an attempt is made to return to centralization by using one high-power engine to drive several wells, and this principle is being still further extended by the use of wire rope transmission to cover long distances. The author shows diagrammatically the advantage of such centralization. One 150-h.p. motor centralized is sufficient to drive four wells, whereas by installing a motor on each well about 200 h.p. would have been needed.

The oil engine, however, has created a large and important sphere of its own by facilitating profitable operation of a large class of wells which, owing to their small yield, could not have been profitably exploited by either steam or electricity.

The next form of internal combustion engine is that utilizing gas, natural and artificial. The gas engine is simpler in construction, cheaper, and possesses greater flexibility. A drawback to its extended use is the uncertainty of the supply of gas.

The author describes and classifies modified types of what is known as convertible engines, i.e., those which can be alternately used on either liquid or gas fuel (*Journal of the Institution of Petroleum Technologists and Record of Transactions*, vol. 1, part 4, p. 195, June 1915, 33 pp., 21 figs. *cd*).

Strickland Double-Acting Four-Stroke Cycle Engine

Description of the Strickland engine, which, working on a four-stroke cycle, gives a power impulse every revolution in each cylinder. As shown in Fig. 2, there is a two-diameter piston with the usual combustion space at the top of the cylinder. Midway of the cylinder length is an annular space left when the piston is at the top dead center, and this forms a secondary combustion chamber. The action is as follows: As the piston descends under the impulse of a charge in the upper combustion chamber, the lower part of the piston is

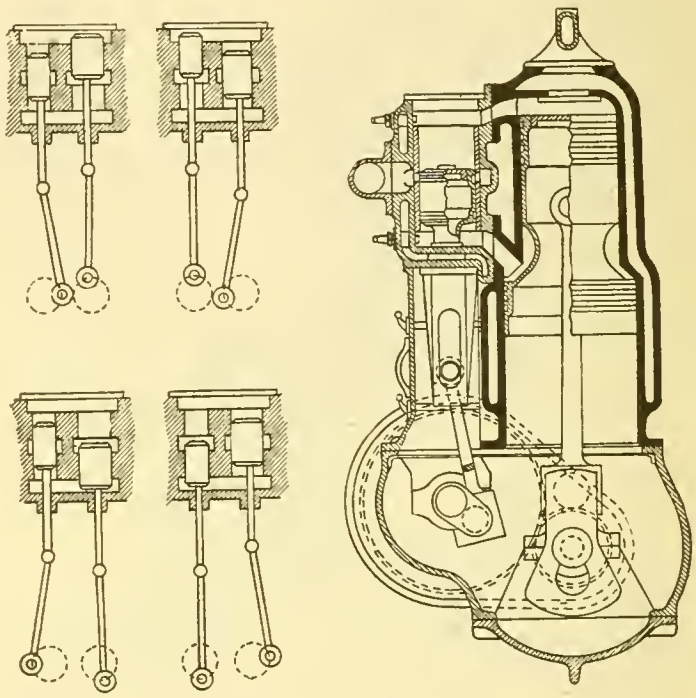


Fig. 2 Strickland Double-Acting Four-Stroke Cycle Engine

drawing in gas from the carburetor. On the reversal, at the bottom of the stroke the upper piston commences its exhaust stroke and the lower part rises on the compression stroke. In the next stroke, firing and expansion take place in the lower part and intake on the upper piston. For the last stroke the upper part is compressing, while the lower is exhausting.

Had poppet valves been used, a mechanism to control the intake and exhaust would necessarily have proven to be somewhat complicated. Therefore, the inventor uses a single pair of double-acting piston valves to control both the upper and the lower cycles. These are shown on the left of the engine in the illustration. The valves are operated from a second crank shaft driven by the gear from the main crank shaft.

The inventor lays particular stress on two points in connection with his design. The first is that the effect of the piston valves is to extend the indicator diagram, thus making for increased thermal efficiency. This is said to be so because the piston valves are near the top of their stroke during suction and descend during the firing stroke, thus having the

effect of making the cylinder bigger during the expansion stroke than it is during the suction stroke. The other claim is that for a given power output the space occupied is much smaller than with a four-stroke cycle engine of equivalent power.

The article does not state whether such an engine has been actually constructed, and gives no data of any tests of an engine. Neither does it state in which sizes such an engine is supposed to be most efficient (Four-Cycle Engine—Two-Stroke Effect, *The Automobile,* vol. 34, no. 22, p. 974, June 1, 1916, 2 pp., 3 figs. *d*).

The Use of Oil Engines for Pumping, C. R. Knowles

The use of oil engines instead of gasoline engines has been due to increased consumption of water necessitating larger pumps and heavier power, together with the increase in the cost of gasoline. This has been done in many cases by converting the existing gasoline equipment to kerosene and distillate engines by the additions of the proper attachments. A series of efficiency fuel tests with distillate, alcohol, kerosene, gasoline and motor spirits were made, pumping against a total head of 61 ft.

It was found that distillate is the most economical of the fuels used. The power obtained from the use of kerosene was practically the same as from distillate, the only difference being in the price of the two fuels.

Another series of tests with a 12 h.p. 4-cycle engine showed that the engine consumed the same amount of 39 deg. distillate per h.p.-hr. as gasoline. The article also reports data of tests with the semi-Diesel engine. (*Journal of the American Water Works Association,* vol. 3, no. 2, p. 356, 8 pp., *cg*).

Lubrication

Lubrication Requirements for Wire Rope, George R. Rowland

Data on lubrication of wire ropes secured from one of the largest rope manufacturers in this country as well as by the company with which the writer is connected.

The latter has made measurements on a 3500-h.p. twin tandem reversing engine, which showed that there were 319 sq. ft. of actual frictional surfaces to be lubricated, which shows that every foot of wire rope is a moving part subject to friction, and to secure its proper efficiency and service it must be given the same attention in the way of lubrication as any other mechanical device.

Because of the demand on the part of purchasers that the manufacturers give a guarantee to the life and performance of the ropes, the question of efficiency in lubrication has assumed a considerable importance. A careful investigation of the ropes used in all classes of service has shown that no two manufacturers are using the same grade of rope lubricant and that the materials most commonly used contain tar, graphite and other fillers in large proportions. Such materials have the effect of only partially protecting the external parts of the rope and at low temperatures will crack and peel. This has the effect of permitting the deteriorating elements to attack the internal parts of the rope, and instances are known of ropes suddenly breaking while the visible wires show no sign of deterioration, it being invariably found upon examination that the internal wires have perished by corrosion.

Ordinary black oil or what is known as "waste oil" are worthless as rope lubricants. A still worse practice is that of giving the ropes an external coating or slushing by the manufacturer. An efficient wire rope lubricant must be free from any material that will attack the constituent parts of the rope, must remain soft and pliable under all atmospheric conditions, must not be subjected to evaporation, must be insoluble in water and must be unaffected by water heavily charged with chemicals such as exist in some operating conditions. Further, it must be of such a nature that it will enter between the wires in the strand and between strands to the core of the rope when the rope has been put into service, preserving the core as well as the metal which surrounds it. In addition, it should be equally efficient as a lubricant for sheave wheels, drums, pulleys and other bearings over which the rope passes.

Too little attention has been given to the initial lubrication of wire ropes, particularly as regards proper saturation of the hemp center. The method of application of lubricant in service is not always correct. The proper way to apply the lubricant is to use a split box of sufficient dimensions to permit of its holding about 25 lb. of the lubricant to be used, constructed with a hole in the center large enough to permit of the passage of the largest rope to be coated. The lubricant should be thoroughly liquefied in a metal condenser, and after it is poured into the split box the rope should be permitted to pass slowly through the box. (From *Lubrication,* through *The Blast Furnace and Steel Plant,* vol. 50, no. 6, p. 286, June, 1916, 2 pp. *p*).

Machine Parts

Oval Flanges for Steam, Air, Water and Other Pipes, Fairfax

In the British Standard flanges for pipes and fittings for use under steam and water pressure are all circular. There are, however, still a great many uses for oval flanges under certain conditions. For example, for lower pressures, say air pressure below 100 lb. per sq. in., and for exhaust piping or piping where pressures are used below that of the atmosphere, oval flanges will be used, just as they will for very light pressures where brass fittings of copper pipes are essential. The article gives a list of oval brass or brazing metal flanges suitable for copper pipes, valve, cock, etc., working under a vacuum or for use up to a gage pressure of 15 lb. per square inch (Table 2A) and a list of oval flanges suitable for use on wrought iron pipes, brass or cast iron valves, cocks, and pipes working under gage pressures above 15 and up to 100 lb. per sq. in. (Table B).

Under certain peculiar conditions oval flanges are also used for much higher pressures such as in connection with hydraulic pressure pipes and fittings, from 700 to 900 lb. per sq. in., and even as high as 1200 lb. per sq. in. The writer gives two tables for these ranges of pressure. The article is not finished (*Mechanical World,* vol. 59, no. 1534, p. 253, May 26, 1916, 2 pp., *gp*).

Machine Shop

New High-Speed Steels

The difficulties connected with the supply of tungsten and other rare metals used in the manufacture of high-speed steel led to intensified metallurgical research, and it is stated that Darwin and Milner of Sheffield, England, have discovered an alloy substitute for high-speed steel which contains neither tungsten, molybdenum, cobalt nor vanadium, and which, it is

said, can be cast in iron or sand molds suitable for grinding to tool shapes with an emery grinder without forging, hardening or heat treatment of any kind. It is further claimed that the material possesses the thermal stability which enables it to cut to a red heat. Actual cutting tests were made with a tool prepared from 1.25 in. square bar on a round bar of high tensile steel containing 0.32 carbon, 0.07 silicon, 0.59 manganese, 0.024 sulphur, 0.012 phosphorus, 1.26 chromium and 3.28 nickel. Quarter-inch cuts were taken at speeds of about 50 ft. and cuts of 1/64 in. at speeds 150 ft. with, it is said, very satisfactory results. Particulars of the composition of the alloy are at present withheld though patent rights were secured in October, last year (*Mechanical Engineer*, vol. 37, no. 957, p. 394, May 26, 1916, 1 p. *d*).

Jig and Fixture Details, R. F. Pohle

The article presents data on details of jigs and fixtures, together with tables embodying the practice of the General Electric Company works at Lynn, Mass. It covers the subjects of jig stop pins, spring pins, hinge pins, clamps and straps, latches and swing bolts (*Machinery*, vol. 22, no. 10, p. 839, June 1916, 3 pp., *dp*).

Measuring Instruments

Simplified Condensation Hygrometer, Charles Margot

Description of a condensation hygrometer which is a modification of the one described by Crova in 1883 for use especially in measuring the moisture in air in places of difficult access.

As shown in Fig. 3, it consists essentially of an exterior cylindrical casing or cooling chamber, *E*, 8 cm. in diameter and 2 cm. deep. On the side towards the observer, this chamber is closed by a thin disc of nickeled brass, perfectly flat and polished. The other face has a small opening, closed by a glass, which permits the level of the ether to be seen. The second chamber, truncated in shape, is screwed on the first chamber and is closed by a glass, which permits the seeing of the condensation of the vapor on the nickel plated surface. It has three auxiliary apparatus: (1) Part *C*, which, by means of suitable tubing, is placed into communication with the air, the hygrometric state of which has to be measured; (2) *D* is connected by a rubber tube with the tube *B*, the end of which is immersed into ether; (3) *T* is used to hold the thermometer. Air is taken in through *A* by means of a water jet or some other kind of suction device. It passes first the cooling chamber where the condensation is effected, and then bubbles through the ether. The observer follows the course of condensation and can see the slightest trace of dew appear and disappear on the central part of the polished disc. As the deposits of dew appear first in the center of the disc, while the parts nearer the rims remain clear, it is easy to make observations. It is advisable to place the apparatus on a solid cast-iron foundation with an intervening wooden support, and not on a metal support, so as to avoid the conduction of heat to the apparatus. As the first chamber is quite large, there is no danger of the air circulating at a velocity too great to allow time to take the temperature of the cooling disc. A series of tests have shown that the same precision is obtained whether the two chambers are located in series or separately (*Modèle simplifié d'hygromètre à condensation*, Charles Margot, *Archives des Sciences Physiques et Naturelles*, vol. 41 (Quatrieme periode), no. 3, p. 222, March 15, 1916, 4 pp., 1 fig. *de*).

Studies of Instruments for Measuring Radiant Energy in Absolute Value, W. W. Coblenz and W. B. Emerson

One of the real needs in the measurement of radiant energy is a reliable radiometer which evaluates the observations in absolute measure. Such an instrument should be a primary one, capable of measuring radiant energy directly. Actually, however, there is no such primary instrument, although there are several apparently trustworthy methods for making measurements of radiation in absolute value. The U. S. Bureau of Standards has, therefore, undertaken to prepare standards of radiation and to study various instruments used in making absolute measurements of radiation. The present paper reports on the results obtained with one of these instruments,

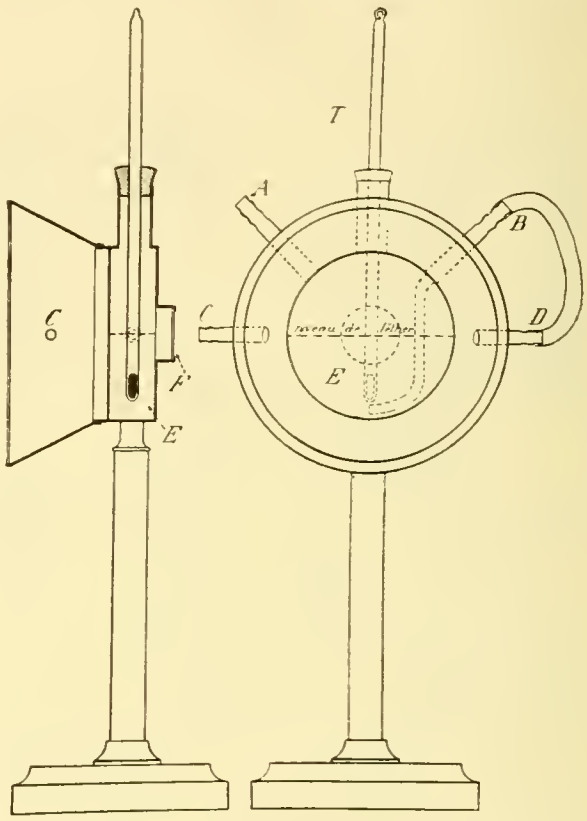


Fig. 3 Modified Crova Condensation Hygrometer
Niveau de l'éther—level of ether

and also presents the evaluation of the coefficient or the so-called Stefan-Bolzmann constant of total radiation of a uniformly heated cavity (black body).

In a previous communication from the Bureau the results of a study of the so-called Radiobalance were given, which showed that while this instrument has many good points it did not appear to be sufficiently reliable for a primary instrument.

The present paper describes in detail the apparatus used in the present series of tests, and the method of making observations and reduction of data.

While it is difficult to estimate the accuracy attained in the final results, it is important to note that the value of the radiation constant is based upon observation with a far greater number of receivers than were hitherto employed, the receivers being differently prepared and operated under various conditions as to width and thickness of the metal strip, distance between potential terminals, kind and thickness of the

absorbing layer, etc. The data are presented in the form of tables.

On the whole, it was found that the device described in the paper may be used as an instrument of precision because of its quickness of action, freedom of surrounding conditions, high sensitivity and simplicity of operation. It can be much simplified and then used as a radiation pyrometer. In practice it is advisable to calibrate the receiver by exposing it to a black body heated to about 1000 deg. cent. when it is desired to make the refined radiation measurements. A complete radiometric outfit, including the radiator, has been placed in an evacuated inclosure for the purpose of making in the future radiation measurements in absolute value at certain fixed temperature points as defined by the melting points of metals such as gold, silver, palladium and platinum. In this manner it is hoped to eliminate the effect of atmospheric absorption, and to otherwise improve the reliability of the measurements.

The loss of energy by diffused reflection from the blackened surface of the receiver was investigated and it was found that there was but little difference in the reflecting power of the different surfaces examined. (*U. S. Bureau of Standards, Scientific Papers,* No. 261, p. 504, March 4, 1916, 47 pp., 6 figs. *e.*)

Mechanics

Spur Gearing, Daniel Adamson

Paper read before the Institution of Mechanical Engineers on May 19 last. It discusses the design of spur gearing, the materials used and the mechanical properties of the finished gears. Among other things it presents interesting historical data on the development of various views on the mechanics of spur gears and a chronological list of references.

Because of the fact that Lasche's investigation, originally printed in the *Zeitschrift* of the German Society of Engineers, has never been translated into English and is not easily accessible, the author gives an extended abstract of it. Lasche investigated the variation in the amount of sliding at different parts of the tooth faces and flanks and from this developed his "wear characteristic." This wear characteristic is dependent upon the contact pressure and the amount of sliding between contiguous teeth. Lasche has also shown the importance, as affecting the working of gear teeth, of the relation between theoretical arc of contact and circumferential pitch, called for convenience "duration of contact" and usually expressed in terms of circumferential pitch. When the theoretical arc of contact exceeds unity, the duty will be distributed between the different teeth in contact at a time when the rate of wear would otherwise be at its highest value.

The factors to be considered when estimating suitable proportions to resist wear are: P = pressure to be transmitted at pitch line, N = number of revolutions per minute, e = estimated number of teeth in contact, and b = breadth of teeth. A table of actual examples from practice and experiment is given in Lasche's paper to enable a suitable value to be placed upon PN/eb according to the conditions of the working.

As to variations in stresses due to irregularities in pitch, Lasche gives calculations of a typical example from practice, showing that while at moderate speeds this is not serious, yet as the excess load due to irregularities will increase as the square of the velocity at higher peripheral speeds, trouble is experienced that cannot be accounted for by calculations based upon the transmitted load alone.

Lasche strongly advises the separation of revolving masses, as, for example, armatures of motors, from adjoining masses such as the large gear wheels of the second motion, by some elastic medium such as a length of shaft or a flexible coupling, so as to allow slight variations in angular velocity due to unavoidable errors in gear cutting to take place without giving rise to destructive loads between the teeth.

The writer attaches great importance to the selection of the best material for gears. He calls attention to the fact that while heat treatment may be quite feasible with large masses such as armor plates and gun tubes, where the value of each piece makes it possible to maintain an expensive laboratory and staff to check the processes and the results, this is not so convenient in ordinary machine shops. He foresees stricter requirements as to the constituents of steel used for gearing.

TABLE 2A VACUUM TO 15 LB. PER SQ. IN. GAGE PRESSURE

Nominal Size: Bore of Pipe	A	B	C	D	E	F	G	H	J	K
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1/2	3	1 3/4	2 1/8	3/8	5/16	1/2	1	7/16	5/16	5/32
3/4	3 3/4	2	2 5/8	1/2	3/8	5/8	1 1/4	9/16	3/8	5/32
1	4	2 1/4	2 7/8	1/2	7/16	3/4	1 1/2	9/16	7/16	5/32
1 1/4	4 3/4	2 5/8	3 7/16	5/8	1/2	13/16	1 7/8	11/16	1/2	3/16
1 1/2	5 1/4	3 1/8	3 7/8	5/8	1/2	7/8	2 1/4	11/16	1/2	3/16
1 3/4	5 1/2	3 1/2	4 1/8	5/8	9/16	15/16	2 1/2	11/16	9/16	3/16
2	6	3 7/8	4 1/2	5/8	9/16	1	2 7/8	11/16	9/16	7/32

TABLE B ABOVE 15 TO 100 LB. PER SQ. IN. GAGE PRESSURE

Nominal Size: B. S. Pipe Thread.	A	B	C	D	E	F	G	H	Cast Iron		Brass	
									J	K	J	K
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1/2	3 3/4	2	2 5/8	1/2	1/2	7/8	1 3/8	9/16	1/2	5/16	3/8	5/32
3/4	4	2 1/4	2 7/8	1/2	5/8	1	1 5/8	9/16	5/8	5/16	7/16	5/32
1	4 3/4	2 5/8	3 7/16	5/8	3/4	1 1/8	1 7/8	11/16	3/4	5/16	1/2	5/32
1 1/4	5 1/4	3 1/8	3 7/8	5/8	7/8	1 1/4	2 1/4	11/16	7/8	3/8	1/2	3/16
1 1/2	5 1/2	3 1/2	4 1/8	5/8	1	1 3/8	2 1/2	11/16	1	3/8	9/16	3/16
1 3/4	6	3 7/8	4 1/2	5/8	1 1/8	1 1/2	2 7/8	11/16	1 1/8	3/8	9/16	3/16
2	6 3/4	4 3/8	5	3/4	1 1/8	1 5/8	3 1/8	7/8	1 1/8	7/16	5/8	7/32
2 1/2	7 1/2	5 1/4	5 3/4	3/4	1 1/4	1 3/4	3 7/8	7/8	1 1/4	7/16	3/4	1/4

As to the allowable working stresses, the author cites the work of E. R. Walker (1868), F. Reuleaux and Wilfred Lewis (1892), as well as the paper of Marx in the *Transactions of The American Society of Mechanical Engineers,* vol. 34.

In the matter of maximum speeds, the author holds that a velocity of 2500 ft. per min. is quite feasible, as shown by actual examples which he cites. In fact, an example has come to his notice in private correspondence of a pair of machine cut bevel wheels, ratio 3 to 1, transmitting 1500 h.p., pitch line velocity 3000 ft. per min., load 1570 lb. per in. of width. In the matter of durability, the author cites an investigation by Dr. Otto Schaefer, who gives a table showing the variation in loading according to the total number of revolutions

estimated to be made by a wheel before wear has so weakened the teeth as to bring the stress due to bending up to a predetermined maximum.

Dr. Schaefer gives the formula: $W = P \times F \times K$, where W = safe working load in lb., P = circular pitch in in., F = width of face in in., and K is a variable dependent upon the material used and the circumstances of the drive. The author gives a table for K converted into British units from the data in Dr. Schaefer's article (*Institution of Mechanical Engineers,* Advance Paper E, 37 pp., 17 figs., *htA*).

Errors of Screws

The present article forms part of a pamphlet entitled "Notes on Screw Gauges" and published for the National Physical Laboratory, of Teddington, England.

A screw is defined by the profile of the thread as exhibited by a section cut through the axis of the screw. The Whitworth thread has seven elements, error in any one of which may be sufficient to cause a gage to reject work which ought to pass. These elements are: Full or major diameter; core or minor diameter; effective or pitch diameter; pitch; angle; form at crest; form at root. The most important, and likewise most difficult to control, are the pitch and the effective

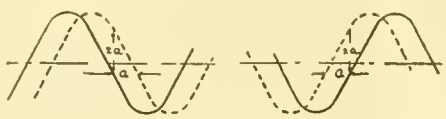


Fig. 4 Ring and Plug Screw of Similar Thread Form But Slightly Different Pitch

diameter. With the exception of the radii at the crest and root of the thread, which may be ill-formed without affecting the accuracy of other dimensions, an error in any one of the elements of a screw thread is necessarily associated with some corresponding error in one or more of the remaining elements. The most important case of this is found in the close association of pitch and effective diameter errors.

Suppose the full and dotted outlines in Fig. 4 to represent a ring and a plug screw of similar thread form, but of slightly different pitch. Let the maximum relative displacement of any thread in the length engaged be $2a$. Then the extreme threads will be displaced axially by $+a$ and $-a$ respectively. The diagram shows that in this case the parts will not go together unless the axial displacement is accompanied by a radial displacement which, allowing for the angle of the thread, is about equal to $2a$. This is doubled on the diameter so that as a rough rule it may be taken that any error in pitch has to be compensated by an error of twice the amount in effective diameter.

The errors in all the different elements should be such that their combined effects do not produce a shape lying outside the specified maximum limits in the section of the screw which is to be gaged. Hence, considering a gage correct in all respects except effective diameter and pitch, we see that if the limit of tolerance on effective diameter be 0.0006 in., that on pitch between any two points on the length of thread engaged must not exceed 0.0003 in. either short or long.

There are two kinds of error in pitch. First, there may be a progressive error increasing with the length of the screw, or there may be a variable error of either regular or irregular kind, or both may occur together. If the variable error is repeated at regular intervals, it is called periodic error and is usually due to play or to faulty adjustment of the lead screw of the lathe. If the lathe has a lead screw of ¼-in. pitch, there will be alternating lengthening and shortening in the pitch of a screw cut by it every ¼ in. run of the screw whatever be the actual pitch cut. When the pitch error is of variable character, a somewhat wider error than the limit of tolerance may be allowed, provided this is compensated by a corresponding error in effective diameter, and in such a way that the combined effect is to give an equivalent effective diameter lying within the limits of tolerance allowed (*Notes on Screw Gauges,* pamphlet, published by W. F. Parott, The Causeway, Teddington, Middlesex, England, abstracted from reprint in *Mechanical World,* vol. 59, no. 1531, p. 206, May 5, 1916, 2 pp., 6 figs., article not finished. *p*).

Rectangular Pressure Vessels, H. J. Vander Eb

The paper is an abstract from an article in *The Locomotive* for April, 1915, and discusses methods of calculation of proper plate thickness of rectangular or square vessels, and of the pressure that can safely be allowed in such a square vessel of a given thickness of material.

The author derives certain formulæ, the notation of which will be seen from Fig. 5. If S represents the direct stress in the inner skin of the material and P the internal pressure, then

$$S = P \frac{R_1^2 + R^2}{R_1^2 - R^2} \qquad [1]$$

As regards the tendency of the square vessel to become cylindrical, we may consider the curved corners as short curved beams; in a length of vessel of 1 in. there will be two groups of four beams, namely four straight ones and four curved ones, the straight beams being the sides of the structure. Because of the fact that the four side and corner beams form one continuous structure but bend in opposite directions from one another, it follows that for elastic deflections the shortening of the inner fibres of one set of beams is equalized by a corresponding elongation in the inner fibres of the other set of beams; this may be expressed by saying that with regard to the total inner surface of a square vessel, the sum of all elongation equals the sum of all contraction in that surface, so long as the elastic limit of the material of the vessel is not exceeded by the attendant fibre stresses. The following formulæ give the total unit fibre stress in the metal of the inner skin of the curved beam (S_1) and the maximum unit stress in the straight beam (S_2) respectively.

$$S_1 = P \left(\frac{R_1^2 + R^2}{R_1^2 - R^2} + \frac{l^3}{5.02\, t^2 r} \right) \qquad [2]$$

$$S_2 = P \left(\frac{3l^2}{4t^2} + \frac{D}{2t} \right) \qquad [3]$$

where P is internal pressure and the remainder of the notation is as in Fig. 5.

The article also gives information as to the distances of the neutral surface to the concave side of the curved beams, of importance because the fibre stresses in the metal of the concave side of the beams vary inversely as these distances.

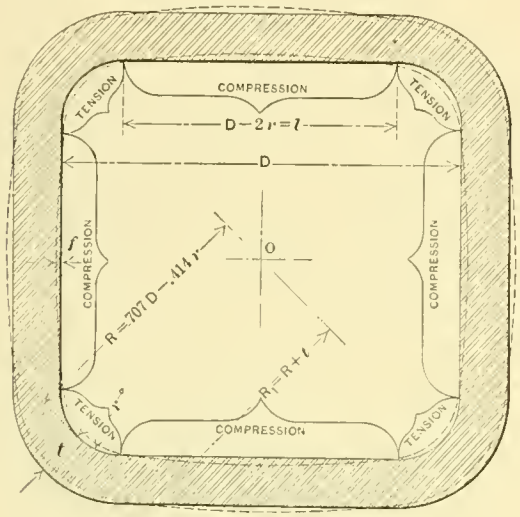
The allowable pressure on the vessel should always be based on the weakest part, i. e., whichever of the beams is found stressed the highest. These formulae take also into account the all important radius of the corner fillet. (*Machinery,* vol. 22, no. 10, p. 861, June 1916, 2 pp., 3 figs. *t*).

Presses

Pressure Developed by Friction Screw Presses, F. J. W. Sparkuhl

The article describes the operation of the type of presses more commonly known in this country as percussion or spindle presses, and gives formulæ for the calculations of pressure developed by them.

It gives formulæ for calculating the coefficient of efficiency of the screw during the actual embossing action, the total energy stored up in the fly-wheel of the press, the amount of work required for raising the reciprocating parts, the pressure developed, and finally the velocity of the screw. The paper, among other things, is illustrated by a diagram showing the amount of energy stored up in the fly-wheel at different points in cycle, and gives a fully worked-out example showing the application of the formulæ presented in the article (*Machinery*, vol. 22, no. 10, p. 846, June 1916, 4 pp., 4 figs. *dm*).



Machinery

Fig. 5 Notation Used in Formulae of Stresses in Rectangular Pressure Vessels

Railway Engineering

Goff's Electro-Pneumatic Brake System

Description of the Goff electro-pneumatic brake system as applied to street cars or steam railroad service.

Although no triple valves are required, the brake is automatic. The brake may be applied or released in full or graduated on or off with any desired pressure. Accidental bursting of the air hose or brake pipe does not interfere with the application or the release of brakes.

In the device, an ordinary electro-magnet is used to control the flow of compressed air from the auxiliary reservoir to the brake cylinder and another to control the flow from the brake cylinder to the atmosphere when a release is desired. The system differs from the usual electrically controlled brake in that the application magnets are energized when the brake is applied, and when these magnets are de-energized by a movement of the brake valve on the locomotive or by rupture in the brake pipe, the magnet valves will admit compressed air to the brake cylinder applying the brake. The magnet valve controlling the flow of air from the brake cylinder is normally closed with the magnet de-energized, and when a release of brakes is desired the release circuit is closed at the control switch, energizing the release magnet and drawing the exhaust valve away from its seat, opening the brake cylinder to the atmosphere. It is stated that this brake system will be set up and be in operation at the Master Mechanics' Convention at Atlantic City this year. (*Railway and Locomotive Engineering*, vol. 29, no. 6, p. 199, June 1916, 2 pp., 2 figs. *d*.)

French Hospital Trains

The paper describes the French system of trains for transporting the wounded from the battle line to the hospitals in the rear, where proper care can be taken of them. Among other things is described a new method of carrying the wounded in the trains.

Some of the disadvantages of using third-class passenger coaches of the corridor type for the transportation of the wounded lay in the facts that they are rather heavy, and in addition had to be cleared of their old transverse seats and provided instead with iron cots. Besides this, the use of beds for the transportation of the badly wounded is objectionable in itself, because the men have to be moved from the stretchers to be placed in the coach, and again from the coach to be transferred to the hospital, which means loss of time and suffering for the men.

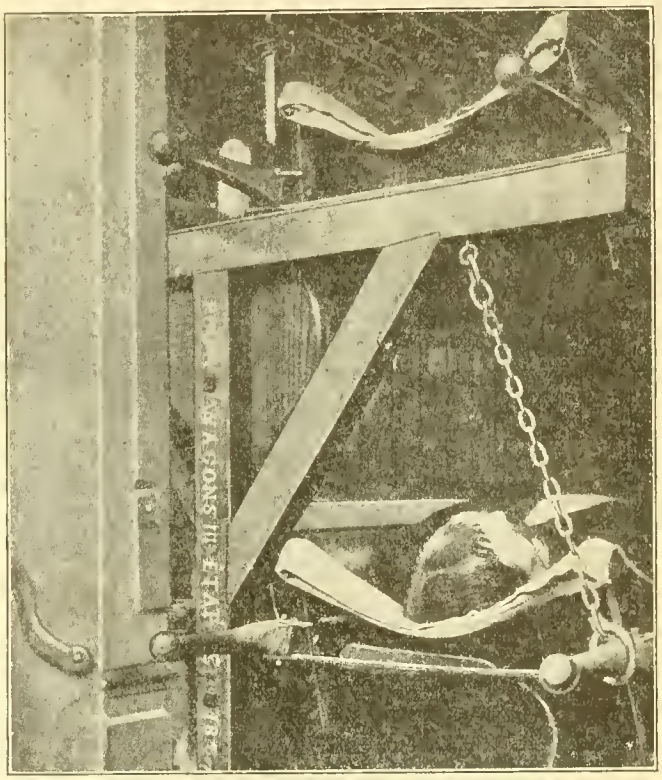


Fig. 6 Beltzer Frame Support for Stretchers

Dr. H. L. Beltzer last spring devised a frame support for stretchers (Fig. 6) which is both simple and practical and makes it possible to utilize any English or continental passenger car without a single change in the seating arrangement, without injuring the car and without installing in it a single bed. When the stretcher is placed in the frame its handles are fitted into a set of iron rings, each held by a spring which takes up any kind of shock. When the train arrives at its destination there is no shifting of the wounded man when he is loaded into an ambulance, as the stretcher goes with him right to the hospital. In other words, the device means that

a man can be carried from the battle field to a hospital hundreds of miles away without a change of bed. (How French Hospital Trains Help to Save the Wounded, *The Railway Gazette*, vol. 24, no. 18, p. 501, May 5, 1916, 4 pp., 6 figs. *d*).

The Strength and Wear of Locomotive Tires, E. L. Ahrons

A brief historical discussion of the strength of locomotive tires covering mainly European practice.

As to the actual wear of locomtive tires, the author refers to the papers by A. J. Hill in the *Proceedings of the Institution of Civil Engineers*, 1895, and G. Hughes in the *Proceedings of the Institution of Mechanical Engineers*, 1909. The writer has attempted to obtain a proportionate figure for the wear of tires which takes into account mileage obtained from a wear of 1/32 in., tensile strength, diameter, and weight on the wheels. A number of tires from different classes of passenger engines (with brakes on the wheels) which have been taken off when worn out were selected. Specimens had been taken from the worn tires and the tensile strength, both with and across the grain, were ascertained. The total mileage and the wear being known, the number of miles run per 1/32 in. of total wear including re-turning is given. To this mileage 4 per cent is added for single engines, 3 per cent for four-wheel coupled engines and 2 per cent for six-wheel coupled engines to allow for ordinary and imperceptible slipping. A weight of 15 tons on the pair of wheels was taken as standard. The results obtained are given in several tables. In certain cases, namely, the 6 ft. coupled engine, the tensile strength of the tires is extremely low, but in spite of this these tires run a large mileage. The chemical analysis of these two tires showed only a trace of carbon, although they were of Bessemer steel; in fact, one of the tires was iron with an added mixture of manganese (0.259 per cent carbon trace) (*The Engineer*, vol. 121, no. 3151, p. 411, May 19, 1916, 2 pp., *et*).

Refrigeration

A Theory of Cooling Towers Compared with Results in Practice, B. H. Coffey and George A. Horne

This paper is a continuation of the one published in the *A.S.R.E. Journal*, November, 1914, and January, 1915.

As a result of the previous year's experience, the writers arrived at the conclusion that certain apparent inconsistencies in the results would be smoothed out by taking, if possible, all readings at the site. Arrangements had been made to have installed a standard anemometer upon the tower so as to obtain a continuous record of wind velocity. Likewise, arrangements were made to have at the site a recording wet and dry bulb thermometer to check the records from the Arsenal Station, Central Park, New York, so as to eliminate discrepancies believed to be of considerable magnitude, due to difference in wet bulb temperatures at the two localities.

No complete theory underlying the operation of cooling towers is presented in the papers, the writers stating that their data are not yet complete enough for such an undertaking. They arrive, however, at the following conclusions: Considering the difference between the final water temperature and the wet bulb temperature or approach to the wet bulb as a measure of tower efficiency, the degree of approach is affected by four variables, (1) the cooling range or number of degrees of heat extracted in the tower; (2) the position of the wet bulb in the thermometric scale—a wet bulb temperature that is high on the thermometric scale can be more closely approached than one at a lower temperature level; (3) the ratio by weight of air to water in contact throughout the cooling process; (4) the ratio of exposed water surface to the weight of water cooled in unit time. Any consistent theory must, therefore, be capable of expressing the effect of these variables upon the terminal temperature, which, as well as the wet bulb temperature, is the wet bulb approach. The writers give several plates containing characteristic curves derived from this theory, which show the effect of these variables on the cooling water, but, as they state, they have not yet succeeded in developing general formulæ for determining these curves for the variables. In order to compare the theories with practice, curves of the theoretical results were prepared, referring to wet bulb approach as a standard in which the effect of the selected variable is shown through a wide range. Such curves are drawn, for example, with the wet bulb or wind velocity as variables.

Curves from experimental data were drawn, and they still show obvious inconsistencies and discrepancies, due, probably, to the impossibility of expressing with the recording instruments the exact conditions that exist.

A large section of the paper is devoted to the determination of the constant θ, which is the total heat loss per hour per square foot of surface per mercury-inch difference of pressure between the values of the function ω at the cooling surface and at the wet bulb, this difference in the value of ω being the measure of the total heat loss from the cooling surface to the atmosphere.

To evaluate the constant θ it is necessary to determine the weight of water evaporated in known time from a known superficial area under a known difference of pressure expressed in mercury inches. The writers state the conditions which have to be satisfactory in order to obtain correct values, and give a table representing the summary of evaporation tests made to determine this constant. The mean value of θ from the eleven experiments made is 652.5 B.t.u., and the maximum departure of any single experiment from this mean is 4 per cent, which the writers think justifies the belief that a fairly close approximation of the true value has been obtained. The evaluation of the constant θ makes it possible to apply the theory in its present form to any tower employing film cooling surface exclusively, as with this form of surface the wetting in contact with the atmosphere can be accurately calculated. (*A.S.R.E. Journal*, vol. 2, no. 6, page 5, May, 1916, 27 pp., 7 figs. *etA*).

Ammonia Condenser Data, Henry Torrance

A brief and interesting paper reporting tests on a double pipe ammonia condenser of the injector type (continuation of previous tests which showed that in a double pipe condenser it does not matter whether the ammonia runs up-hill or down-hill, water to run counter-current, and that "flooding" makes no gain).

In the present series of tests there was inserted a gate valve on the fourth run of pipe from the bottom, so that when closed the gas first passed through three runs of pipe at the bottom and was first cooled by waste water; after which it entered the top of the coil and ran down-hill as usual. Thus arranged, the coil became like a condenser of the ordinary type. In Fig. 1 are plotted the weights of ammonia condensed as indicated.

As regards the theory of condensation, the author states: In a condenser where vapor is condensed, the vapor should

touch the pipe surface; in a brine cooler where liquid is evaporated, the liquid should touch the pipe surface; a condenser should run empty as far as possible; a brine cooler should run flooded as far as possible.

The author presents the data of his tests in the form of a table where *the results shown appear a little better with the valve closed* considering that the surface was reduced.

In the discussion which followed, V. R. H. Greene, who cooperated with the writer of the paper, spoke of the use of baffle plates on the side of the cast-iron shell to receive the liquid as fast as condensed and take it away. These tests have been described in a previous paper before the same society. He gave further data as to the method by which the relative velocity of the vapor in the pipes had been ascertained.

F. L. Fairbanks spoke of his own tests to establish the comparative efficiency of the flooded type condenser on one hand, and the older, or dry, type on the other. A condenser which he had designed and had been experimenting with was of the jet type in which the principles of the jet steam condenser were utilized. The jet condenser for ammonia was designed for a capacity of 1000 tons in 24 hours, and was only 24 in. in diameter and 6 ft. high over all. The cool anhydrous ammonia from the liquid coolers was pumped to the liquid jet in the condenser by a large pump driven by steam, making it possible to spray through a special nozzle into the gas coming from the compressors. 1 to 600 gal. per minute of the liquid. The gas and liquid were then brought more intimately into contact with each other by a series of baffles, and the resultant condensate flowed by gravity through liquid coolers which brought it down to within 3 to 5 deg. of the temperature of the condensing water. From the liquid cooler it flowed by gravity to the ammonia pump and thence to the jet of the condenser again.

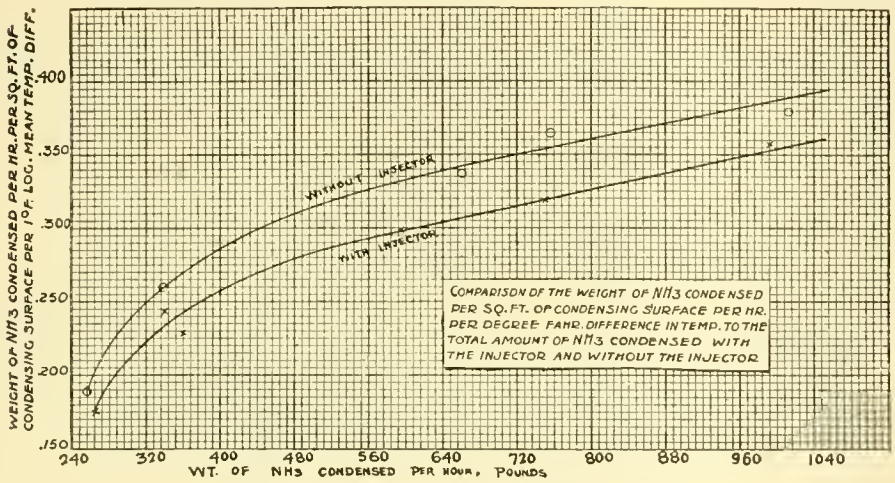


Fig. 7 Ammonia Condenser Data

The gas flowing to the condenser under testing conditions averaged about 175 deg. and the thermometers indicated that with a small amount of liquid spray the superheat disappeared instantly or, at least, in the 18 in. distance between the thermometers. When the amount of liquid was increased to the maximum, the only result in every case was to raise the condenser pressure from 5 to 10 lb. in addition to the pressure shown when condensing by the normal method without the liquid jet.

The speaker believed that the *introduction of the liquid into a condensing gas under certain conditions retards rather than facilitates condensation,* and consequently raises the condenser pressure. In his opinion such conditions are present in the flooded type of condenser, which may account for the contention by Mr. Torrance that it is more efficient without the liquid jet than with it.

As stated in the concluding remarks of the author, it has been claimed that the flooded condenser is the greatest improvement made in the refrigerating industry in recent years. These tests, however, raise the question whether this is true. (*A.S.R.E. Journal,* vol. 2, no. 6, p. 33, May, 1916. 17 pp., 3 figs. *ecd*).

Safety Engineering

Gasoline, Chamois and Sparks, Arthur D. Ewell

In the press, occasional allusions have appeared to the danger of filtering gasoline through chamois in cold weather. It was stated that the " friction " of the gasoline passing through the chamois produces opposite charges of static electricity in gasoline and chamois which occasionally results in sparks igniting the gasoline vapor and producing disastrous explosions.

Tests were made in the physical laboratory of the Worcester Polytechnic Institute with insulated chamois in the form of a funnel properly connected to a Braun electrometer. Different samples of gasoline were used at different heights of fall and under different weather conditions. Under proper normal conditions the potentials observed were always less than 20 volts, although on very cold days with high falls resulting in considerable splashing, potential differences of several hundred volts were sometimes found.

The author concludes that the passage of gasoline through chamois does not give rise to potential differences sufficient to produce sparks, and that the sparks and ignition reported may have been due to discharge from fur coats or clothing to the metal of funnel or car (*The Journal of the Worcester Polytechnic Institute,* vol. 19, no. 4, p. 315, May, 1916, 3 pp., 1 fig. *e*).

Gasoline Fires Caused by Sparks When Filling Tanks, Herbert Chase

The author, chief engineer for the Automobile Club of America, discusses the possibility of fires created by frictional electricity generated by the passage of gasoline through a chamois or through other non-conducting material. He states that the U. S. Bureau of Standards at Washington has been conducting an investigation along this line, but has made as yet only a preliminary report, which establishes, however, that electricity is generated by the passage of gasoline, and under certain circumstances may be sufficient to cause a spark, which, again accompanied by certain conditions, may result in igniting gasoline vapor. The fact that accidents have not occurred more frequently is, in the opinion of the writer, presumably because, first, the heat of the spark is not always sufficient to ignite an explosive mixture, even though this mixture exists in the region where the spark occurs, and second, the proportion of air to gasoline vapor is most frequently not such that ignition can occur.

To eliminate entirely the possibility of fire when filling a gasoline tank, it is simply necessary to "ground," that is, to connect with the earth, the funnel or nozzle on the surface of which the charge is apt to accumulate. As a rule, most of the danger can be entirely averted by simply keeping the funnel or filling nozzle in metal contact with the tank being filled. The writer cites several cases of fire caused by sparks. (*Motor Travel,* vol. 8, no. 1, p. 37, June 1916, 2 pp., p.)

Steel Belts from the Point of View of Safety of Operation, Willemann

The article discusses the comparative dangers of leather and steel belts.

That steel belts may be used to advantage under certain conditions there is scarcely any doubt; but whether they are more or less dangerous than leather belts, especially in transmissions between two floors, is still a mooted question. Assuming now that two belts, one a leather one and the other a steel one, run as shown in Fig. 8A. Let both break on the lower side. What will happen? The leather belt, because of its weight and flexibility, will let its free end fall down. Then, as the pulley is still running, the belt will continue to move and its ends will describe an extended arc. This throwing apart of the ends of the belt can become a source of very considerable danger for the man on the lower floor, especially if the belt fastening is at one of the ends of the broken belt, which is very likely to happen, because that is where belts usually break. In Fig. B the leather belt is shown broken in its tension or upper side. In this case the entire belt is thrown violently away from its pulleys and may easily become entangled in the running machinery.

As to the steel belt, it may be assumed that its weight is only about one-eighth that of a leather belt designed for an equivalent transmission of power; hence the centrifugal force of a steel belt is correspondingly smaller. The instant the belt breaks the tension necessary for the transmission of power is lost, the belt has a tendency to occupy a position in a plane, becomes free of the rotating pulley and falls flat. It is, therefore, unlikely that a steel belt can do any harm if broken. The likelihood of a steel belt inflicting bad cuts is overestimated and can be reduced by rounding its edges. The contact with the running steel belt may become dangerous if the belt runs at a very high speed, but contact with a leather belt is likewise dangerous, and both should be protected by proper guards.

Perforated steel belts have the additional advantage that one can see at a glance that the belt is running.

Because of its lack of stretching, it is practically impossible to put on a steel belt while the shaft is running, which automatically eliminates one of the sources of accidents in belt operation, and also limits the field of application of steel belts to operations where it is not necessary to shift the belt very often. For this reason steel belts are not adapted for use on step pulleys. Besides, as the steps on the pulleys are seldom in precise correspondence with each other, the steel belt, because of its lack of ability to stretch, is inadaptable for this kind of work. In engine lathe work, where men are accustomed to shifting the belts from one pulley to another by hand, a steel belt would not do at all. The author concludes that the steel belt is no more dangerous than the leather belt, and he calls attention to a statement made in 1911 in a German periodical showing the very small number of accidents due to steel belt operation (*Stahlbänder und ihre angebliche Gefährlichkeit,* Willemann, *Dinglers polytechnisches Journal,* vol. 331, no. 6, p. 94, March 18, 1916, 1 p., 2 figs. *p*).

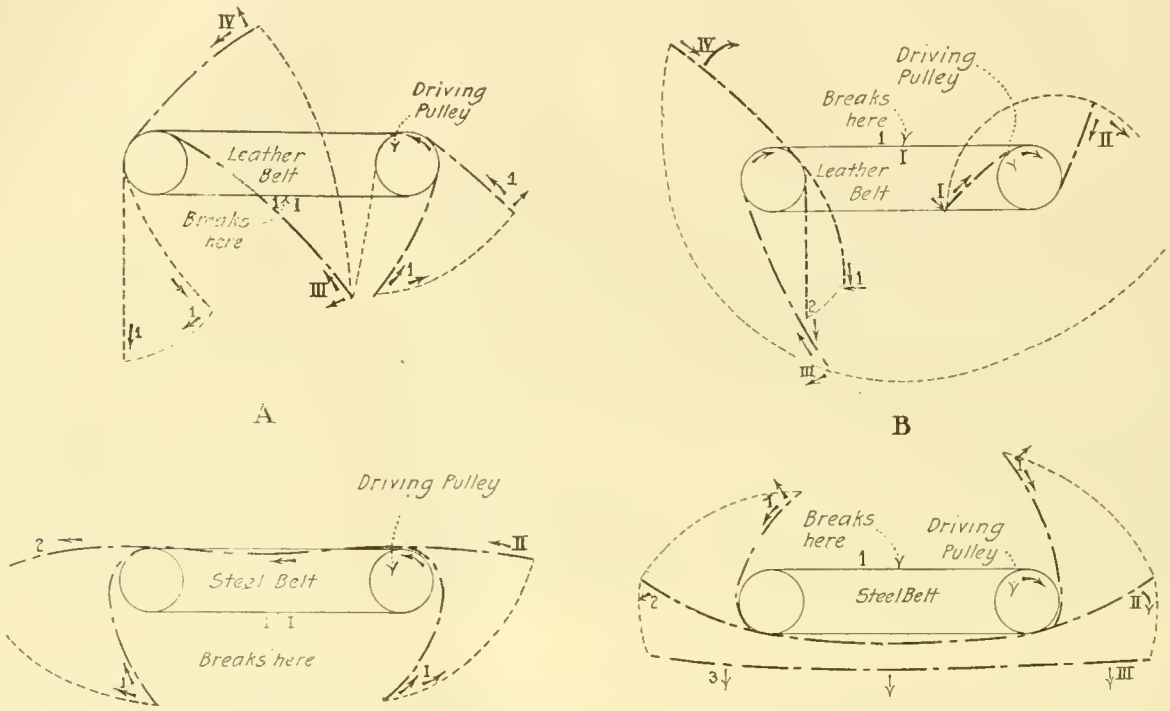


Fig. 8 Diagrams Showing the Difference in the Way of Rupture of Steel and Leather Belting

Steam Engineering

Results of the Hall of Records Test

The article presents a summary of the report of the Bureau of Municipal Research, giving a comparison of the estimates

of the interested parties as to the results which would occur should the Hall of Records (which forms part of the municipal buildings in New York City) make its own current instead of purchasing it from the New York Edison Company.

The report of the Bureau of Municipal Research was compiled under the direction of Professors Carpenter and Lucke, and disagrees with both the city engineers and the engineers of the Edison Company. Because of the nature of the matter, only the two tables giving the three estimates by all the parties interested are here reproduced, the reader being referred for details to the original report. (*The Isolated Plant,* vol. 8, no. 4, p. 4, April, 1916, 3 pp., *ec*).

TABLE 3 RESULTS OF THE HALL OF RECORDS TEST

Estimated Reduction in Plant Operating Cost

	Estimated by the City	Estimated by the Edison Co.	Estimated by the Bureau of Municipal Research
Coal	$3,296	$6,151	$4,125
Labor	2,944	10,282	4,683
Supplies for operation	400	1,576	326
Repair material	550	.....	624
Ash removal	260	692	373
Gas lighting	65	65	65
Total	$7,515	$18,766	$10,196

TABLE B

	City Estimate	Edison Estimate	Bureau Estimate
Cost of current equivalent to that used during test	$21,015	$21,015	$21,015
Saving by shutting down engines	7,515	18,766	10,196
Effect on City of Edison Service	$13,500 (loss)	$ 2,249 (loss)	$10,819 (loss)

Hoblitt Steamer System

Description of a steam engine system for truck use, said to consist of a new steam generator, a new oil boiler and a new hydraulic transmission (invented by Enoch Rector).

The essential part of the generator is a long double cone-shaped plug, part of which projects into the combustion chamber under the generator, and part reaches through the crown sheet or bottom plate of the boiler, through the water and about 2 in. above the level of the water. Numbers of these plugs are inserted through the crown sheet, as many being used as practicable. Their function is a double one,—making complete combustion possible by presenting a heated surface for the burning gases and conducting the heat of combustion directly into the water. They are really modified "legs" on the crown sheet, but carried through to the other side. The inventor claims that in the ordinary boiler the crown sheet cools down that portion of the burning gases that comes directly in contact with it, so that the combustion is not perfect in the thin layer of gas next to the comparatively cool metal. The lower ends of the plugs, however, are designed to reach high temperatures and become quite hot in actual practice, and it is against this quite hot metal that the burning gases impinge and complete their combustion uncooled.

It is stated that tests conducted by Prof. Harry L. Parr, of Columbia University, showed in the exhaust gases ½ of 1 per cent of carbon monoxide and from 11.5 to 14 per cent carbon dioxide. (No complete results of the tests are published) (*Automobile Topics,* vol. 42, no. 3, page 239, May 271, *d*).

New Water Level Indicators, B. Grey

The question of water level indicators is attracting considerable attention in Germany, especially in connection with what corresponds to the Safety First movement in America. Several improved water level indicators patented recently are described in the present article.

Otto Voss has patented a device shown in Fig. 9, the essential characteristics of which are a movable water container with a counterweight located below the water level in the boiler, and further, a scale arranged in such a way that the part corresponding to the low water state in the boiler responds to smaller differences of level than that corresponding to the high water state.

The vessel *b* is suspended in the usual manner and has its lower end connected with the water space of the boiler and

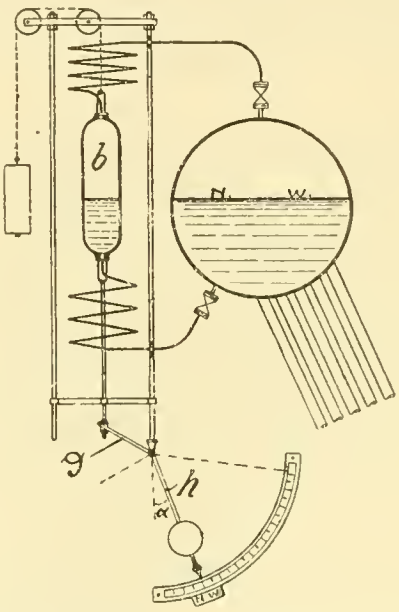


Fig. 9 Voss Water Level Indicator for Steam Boilers

its upper end with the steam space. Hence as the water level varies in the boiler, there occurs a similar variation in the vessel *b*, which latter is provided with a rod pressing against the lever *g*. As the amount of water in the vessel *b* varies, the latter moves either up or down in accordance with the variation of relative weight of the vessel and the counterweight. As it moves it causes the motion of the arm *h* of the lever *g* with its counterweight at the other end and in this way the pointer moves over the scale. The section of the scale which corresponds to the lowest water level takes care of the smallest angle of deflection α of the lever; since the moment of torsion produced by the load on the lever varies as the sine of the angle of deflection, the deflection of the lever for the same amount of variation of level will be greater for the smaller angles than for the larger angles, which makes the apparatus more sensitive for indicating variations at low level than at high level, which is as it should be. The sensitiveness of the apparatus is still more increased through the fact that the changes in volume of the liquid in the vessel *b* are actually greater than the changes in level in the boiler because of the sinking of the vessel with the increase of the weight of water in it (*Neue Dampfkesselwasserstandszeiger,* B. Grey, *Sozial-Technik,* vol. 15, no. 5, p. 45, March 1, 1916, 3 pp., 3 figs. *d*).

Thermodynamics

Experiments on the Flow of Heat in Metal Sheets, Sidney Skinner

The paper describes a method for showing to a class of students the conductivity of heat along a metal bar. The usual method is to place the bar under a specially prepared paper which changes color with heat, but this is not satisfactory because paper is too poor a conductor and the color effect has no definite edge. The author, therefore, devised a different method, namely, placing over the bar a thin layer of tin. As the tin melts it forms a sharp edge which constitutes an equi-temperature line corresponding to its melting point of 227 deg. cent. Inside this sharp line other equi-temperature regions are shown by the oxidation colors of the tin, each oxidation color seemingly corresponding to a definite temperature. When the melted tin solidifies the crystals arrange themselves differently than in the original plate, and the equi-temperature line may be very sharply developed by washing the surface with a mixture of bleaching powder and hydrochloric acid.

The author made a series of tests to compare the flow of heat in a sheet of metal cut with a tongue protruding from one edge and the flow of electricity from the tongue into a plate. It is an electrical law that if a plate be cut along a line of flow, no change will take place in the equi-potential lines in the portions which are formed by the cut. The author made a similar experiment with the flow of heat in a tinned sheet by cutting a longitudinal opening along the tongue and through the sheet in the direction of flow. The flow of heat was studied separately in the two portions, and on putting them together the equi-temperature line was the same as in the uncut sheet.

Another problem examined was the flow of heat into a circular disc and out from a circular disc, around the corner of an L-shaped strip, and into the vanes of an air-cooled cylinder. The results were found to be closely analogous to the flow of electricity in similarly shaped conductors. In the discussion which followed, Dr. R. S. Willows said that a similar method had already been used by Voigt to compare the thermal conductivity of different metals. He used an organic substance which melted about 41 deg. cent., and gave a very sharp line on resolidification.

Experiments involving the use of indicating paints are described in "Light, Visible and Invisible," by Prof. S. P. Thompson (*The Physical Society of London, Proceedings,* vol. 28, part 3, p. 119, April 15, 1916, 5 pp., 3 figs. *e*).

Flow of Heat from Solids to Air, E. E. Snyder, C. S. Robinson and W. K. Lewis

The investigation was undertaken to determine whether the coefficient of heat transferred from solids to air is proportional to the square root of the gas velocity (J. W. Richards) or to the cube root of the velocity (Irwin Langmuir). A complete description of a method of testing is given.

The writer came to the conclusion that the value of the coefficient of heat transferred, K, up to the temperature employed is independent of the temperature and is a function of the velocity alone. He derived an equation

$$K = \frac{39.6V}{V + 3.67}$$

where K is the coefficient of heat transferred from solid to air in B.t.u. per square foot of heating surface per degree fahrenheit difference in temperature per hour, and V is the lb. of air per second flowing through each square foot of section, the section being taken at right angles to both heating surface and direction of flow of the air. The expression is apparently independent of temperature up to 750 deg. fahr. (*The Journal of Industrial and Engineering Chemistry,* vol. 8, no. 6, p. 515, June 1916, 2 pp., 2 figs. *et*).

Varia

Some Properties of the Water in Coal, Horace C. Porter and O. C. Ralston

The paper deals with the manner in which water may be held in coal and how its properties and those of the coal are affected by the condition in which it is held. The author considers as problematical the condition in which the so-called "water of combination" exists in coal. In the true chemical sense the water is probably not "combined," that is, united with another substance in definite proportions as determined by its relative molecular weight and the number of molecules. The behavior of coal with respect to moisture resembles so strongly that of many substances known to be colloidal that there can be no doubt of the colloidal nature of part of the coal substance.

Different kinds of coal contain in the air-dried condition widely different percentages of water. Part of the water in coal is held more tenaciously than free water by forces due to colloidal conditions which in a practical way are manifested in the following features: (1) The impossibility of drying coal completely in an atmosphere not absolutely dry; (2) the extremely hygroscopic character of dry coal; (3) large changes in the moisture content and therefore in the weight of some kinds of coal by changes in the humidity of the atmosphere; (4) more rapid drying out of moisture from the mature Appalachian coals than from the younger, more hygroscopic coals of the Middle West and West. These factors depend on the fact that part of the water in coal has a vapor pressure below normal.

The development of heat by wetting coal is dependent on the same explanation as that of the lowering of vapor pressure; namely, the densified condition of the water in the colloidal state, and consequently will vary in different coals. The fact that the size of the coal or its fineness of division makes little difference in the heat of wetting is probably to be explained by assuming that each particle of the dried coal acts as a sponge. Water is drawn into the pores of the larger pieces with nearly the same facility as it is into those of very small particles. Heat may be produced by two processes, the mere penetration of the liquid into minute capillaries and the formation of a colloidal condition possibly more readily entered into by water than by other liquids.

The free extraneous water adhering to broken coal may vary between very wide limits as affected by the fineness of division and the kind of coal. (Department of the Interior, Bureau of Mines, *Technical Paper 113*, Washington, 1916, 28 pp., 3 figs., *et.*)

An investigation made in a number of British boiler plants in four different industries, cotton mills, woolen mills, paper mills, and dyeing, bleaching and calico-printing works, has shown that sixteen paper mills are giving remarkably good results—an average of 76.65 per cent efficiency. Fourteen cotton mills are slightly better than the average, with 65.11 per cent efficiency, while the woolen mills and the dyeing industries were found below the average in efficiency.

SELECTED TITLES OF ENGINEERING ARTICLES

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Air-Craft Ballistics. Arms and Explosives, vol. 24, no. 284, May 1, 1916, 2 pp. (See abstract.)

A Study Concerning the Best Proportion for a Stream-Line Body, F. W. Lanchester. Engineering, vol. 101, no. 2629, May 19, 1916, 1 p., 5 figs.

The University of Michigan Course in Aeronautics. Aerial Age Weekly, vol. 3, no. 12, June 5, 1916, 1 p.

AIR MACHINERY

Commercial Methods of Testing Air Compressors, H. Addison. Mechanical World, vol. 59, no. 1533, May 19, 1916, 1 p., 3 figs.

ENGINEERING MATERIALS

The Properties of Balsa Wood, R. C. Carpenter. Proceedings of the American Society of Civil Engineers, vol. 42, no. 5, May 1916, 22½ pp., 16 figs. (See abstract.)

The Efficiencies of Tool Steels, J. O. Arnold. Engineering, vol. 101, no. 2628, May 12, 1916, ⅓ p.

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DYNAMIC BALANCE

An Elementary Explanation of the Phenomenon of Unbalance in Rotary Parts, and a Description of a New Machine with which Dynamic Balance can be Obtained Easily and Accurately

BY N. W. AKIMOFF,[1] PHILADELPHIA, PA.

IN this paper is described a machine devised by the author for correcting the condition of dynamic unbalance. The description is preceded by an explanation of the phenomenon of dynamic unbalance, made as elementary as possible by carefully excluding all references to products of inertia, momental ellipsoids, free and forced oscillations, etc. The subject of dynamic balance is not an involved one, and the author feels it is time it were placed on a purely rational basis.

For the general reader, a knowledge of the subject of dynamics of rotation as treated in Worthington's *Dynamics of Rotation* will suffice. To those who would like to develop a mathematical theory of the machine described, the author would recommend a study of Routh's *Dynamics*. Those interested in reciprocating balance are no doubt familiar with Dalby's well-known publication on the subject, and with Sharp's recent and extremely valuable *Balancing of Engines;* neither of these touches, however, in any way upon the subject of *dynamic balance* proper, in the sense in which it is generally understood and in which it will be considered in the present paper.

The balancing of reciprocating parts is purely a matter of calculations and of design; but the balancing of rotating parts, aside from the design, is a matter of trial and adjustment, because of its accidental nature.

In a theoretically perfect rotating body, symmetrical and made of homogeneous material, there cannot be any question of running balance,—such a condition would be understood as a matter of course. But we know that in practice nearly all bodies rotating at high speeds show a certain amount of unbalance. The immediate consequences of this unbalance are vibrations in automobiles and turbines; defective commutation in electrical machinery; undue wear and strain on bearings; defective products in the cases of grinding disks for steel balls, woodworking machinery, etc.

As is well known to all, an unbalanced condition of a rotating body may be due to two distinct causes: lack of static balance, and lack of dynamic balance.

By static balance is understood the condition when the center of mass of the body lies somewhere on the axis of rotation. Such a condition is easily obtained on one of the static balancing machines of the knife-edge or of the roller type. In order to place the body into static balance, it is sufficient to drill one hole or to add one weight, although either of these might be split up into one or more components whenever desirable, all of which does not present any special difficulties.

[1] Dynamic Balancing Machine Company, Philadelphia, Pa.

SYNOPSIS

An unbalanced condition of a body rotating at a relatively high speed, such as an armature, an automobile crankshaft, a ventilating fan, etc., may be due either to lack of static balance or lack of dynamic balance.

An indication of static unbalance may be obtained with a static balancing machine. Correcting for such unbalance involves drilling one hole or adding one weight to bring the center of the mass of the body on the axis of rotation.

In a statically balanced body, however, two masses on opposite sides of the axis of rotation, located axially at a distance from each other, form, on rotation, a couple which develops vibrations, as is noted in defective commutators in electrical machinery, etc. The machine described in the paper furnishes a means for determining easily and correctly the magnitude and plane of the couple.

The principle of the Akimoff machine is the establishing of another couple which, while maintaining the static balance, counteracts the couple which produces dynamic unbalance. The magnitude and plane of this couple indicates the correction to be applied to the body under test to produce perfect dynamic balance.

A rigid horizontal beam, such as a lathe bed, is hinged at one end and supported by a spring at the other. The body to be tested, already in perfect static balance, is rotatively supported on the beam. If dynamically unbalanced, the body will, on rotation, cause the beam to vibrate in a vertical plane. The object of the spring is to amplify the vibrations.

A so-called squirrel cage, disposed at the underside of the beam, is rotated in unison with the body being tested. This squirrel cage consists of two circular discs carrying an even number of rods arranged slidably in the two discs and parallel to the axis of rotation of the cages. When the ends of the rods are in one plane, the cage is in both static and dynamic balance, but if two opposite rods are displaced the dynamic balance is destroyed and the couple produced will itself cause vibration of the beam.

One pair of rods in the squirrel cage would suffice if the relative position of the rods could be altered through the transmission device, but for convenience three or four pairs are employed, and even then it is sometimes necessary to change the angular position of the cage so that the balancing can be done by one pair of rods and not two.

In making a test of a body the cage is adjusted so that the vibrations produced in the beam by the body are damped out by those set up by the squirrel cage. An arrangement whereby the rods of the cage may be adjusted axially while the cage is in rotation is provided and by utilizing this arrangement the rods are shifted until the desired effect is produced.

After the magnitude and plane of the unbalancing couple in the body under test is obtained, it is an easy matter to furnish directions for the workman to follow in removing the necessary material to secure dynamic balance. If a number of bodies of the same kind are to be tested the matter of giving instructions for correcting each piece is further simplified.

The paper was followed by an interesting discussion, which is here reproduced, with the author's closure. In the discussion the lag of unbalance in rotating bodies was considered other forms of balancing machines in present use were described, and points of criticism of the author's machine were raised, to which he replied. The whole account forms an authoritative presentation of the principles and modern practice of balancing of rotating parts of machines.

Presented at the Spring Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New Orleans, La., April, 1916. Pamphlet copies without discussion may be obtained; price 5 cents to members, 10 cents to non-members.

Now, by dynamic balance is understood the condition when there is no so-called *centrifugal couple* in any axial plane. In a statically balanced body, Fig. 1, a centrifugal couple can only be due to *two* masses, m and n, on opposite sides of the shaft and located at a certain distance, c, axially, from each other. Such masses may be, for instance, the centers of gravity of corresponding congested regions. At any rate, in view of the static balance, (1) such masses must be in some axial plane, and (2) the products of each mass and its respective distance from the axis of rotation must be equal.

Such a couple is in general numerically equal to a certain coefficient multiplied by radius times weight times axial distance, that is, equal to $k.m.r.c.$, where k involves the speed as well as other numerical constants. Now we shall choose the unit of speed in such a manner that k can be made equal to

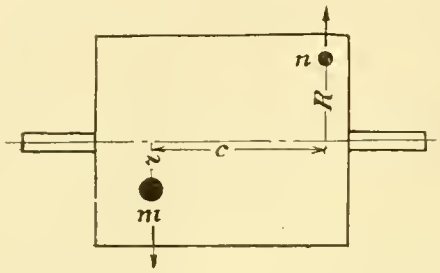

Fig. 1 Centrifugal Couple in Statically Balanced Body

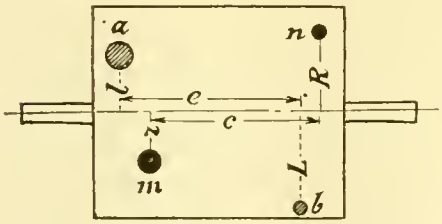

Fig. 3 Couple Counteracting Centrifugal Couple

unity, so that the centrifugal couple is equal to $m.r.c.$ or $n.R.c.$ (since $mr = nR$).

Since the effect of a couple can only be counteracted by that of another couple, it will be seen that any effort to balance such a body as in Fig. 1 by adding *one* weight, or drilling *one* hole, cannot fail to make matters worse. Such a method not only does not take care of the centrifugal couple, but also distorts the static balance.

It seems to be a "natural feeling" that the way to correct unbalance is to drill a hole at the "high spot."—the point where the marking tool touches the body. Indeed, it appears that various devices have been designed and are now on the market precisely for marking such "high spots," after which judicious removal of metal is supposed to secure the desired condition of balance. These devices are based upon the so-called floating bearing principle, Fig. 2, that is, are provided with bearings yielding in the horizontal plane to emphasize the running of the body out of true. Of course, all such devices can only serve to indicate that the body is out of balance; they can give neither the true axial plane of the disturbing centrifugal couple, nor the numerical value of it. Also, drilling in any one place, as has just been seen, cannot secure dynamic balance, but can only distort the static balance.

It appears likewise that an attempt has been made to balance round disks, wheels, pulleys, etc., by pivoting them on one point and by marking the "high side." It is extremely difficult to ascertain just what is the underlying idea of such apparatus, as rotation of bodies on a fixed axis and rotation about a fixed point are two entirely separate chapters of dynamics, the latter much more difficult than the former, and the deductions of one apply in no way to the other. The same remark applies to the method consisting of rotating a body suspended on a flexible shaft (wire rope) and observing the high spots in this manner. All such attempts to ascertain the dynamic unbalance are perfectly irrational.

What it is absolutely necessary to know, in a statically balanced body, is:

a the exact location of the axial plane of the disturbing centrifugal couple

b the exact numerical value of the disturbing couple

c the sign of the couple, i.e., the direction of the vector representing the couple.

Indeed, with the axial plane of the disturbing couple known, attention can be limited to that plane; and what is done on one side of the shaft will be repeated on the other side so

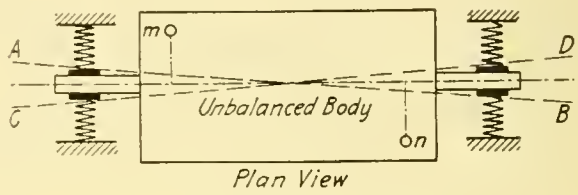

Fig. 2 Floating Bearing Principle

as to preserve the static balance. Furthermore, with the numerical value of the couple $m.r.c$ (Fig. 3) known, all that has to be done to secure dynamic balance is to introduce an opposing couple, $a.l.e.$, of the same magnitude. Of course, this counteracting couple can be introduced in a variety of ways, small holes drilled on a large radius and far apart axially being equivalent to larger holes located on smaller radii and nearer to each other axially.

It will be seen from the above that a machine to deserve the name of dynamic balancing machine absolutely must indicate the plane of unbalance, as well as the numerical value and sign of the unbalancing couple. The author claims to have produced such a machine, of which the following is a brief description.

A rigid horizontal beam, such as a lathe bed, Fig. 4, is hinged at one end and supported by a spring at the other. The body to be tested, already in perfect static balance, is rotatively supported on the beam.

If dynamically unbalanced, the body will, when rotated, cause the beam to vibrate in a vertical plane, with a period of oscillation equal to the period of rotation of the body. In other words, if the speed of the unbalanced body is, say, 315 r.p.m., the beam will vibrate at the rate of 315 complete oscillations per minute, quite regardless of the characteristics of the spring (except possibly at the very beginning of the motion).

Now imagine a second body, exactly similar in every respect to the first, also in perfect static balance but dynam-

ically unbalanced to precisely the same extent as the first body, temporarily associated with the same beam, say suspended under it.

If these two bodies are oppositely located as to balance and run precisely at the same speed (synchronously), then the unbalancing or disturbing couples will cancel out, and the beam will have no tendency to vibrate, no matter how badly unbalanced, individually, are the two bodies. This is the fundamental principle of the machine,—to determine unbalance by determining the unbalance necessary to neutralize its effect.

In the actual machine, instead of the second body being an exact image of the original unbalanced body, it is a so-called squirrel cage, and this is rotated in unison with the article to be tested. The cage, Fig. 5, consists of two or more circular disks, carrying an even number of rods (usually six or eight) arranged slidably in the disks. The rods are accurately made

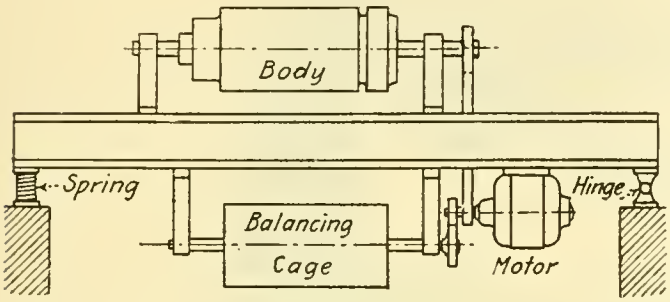

Fig. 4 Principle of Dynamic Balancing Machine

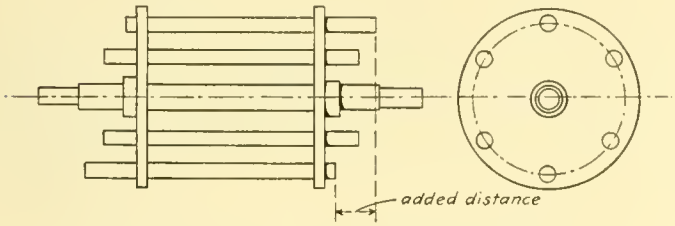

Fig. 5 Construction of Squirrel Cage

and their common weight is known; therefore, any displacement of one of the rods with respect to the one exactly opposite will not affect the static balance, originally perfect, of the cage, but will introduce a certain centrifugal couple, according to the relative displacement or *added distance*.

For instance, suppose that the unbalanced body is a special fan, Fig. 6, and that the unbalance is due to two excess weights, grossly exaggerated in the figure. This will result in a centrifugal couple, and to counteract it, the cage will have to be put into a state of dynamic unbalance, as shown by the relative displacement of the rods and as measured by the added distance.

Thus the cage has means for indicating the exact amount of unbalance which has been put into it in order to reproduce with the opposite sign the exact unbalance of the article being tested. For instance, the displacement or added distance of 15/16 in. may represent (for a certain speed) a couple of, say, 129 oz-in. The plane of unbalance is easily established by the location of the two rods, the moving of which into a new position stops the vibrations; and the value of the couple is immediately given by the added distance.

It should be clearly understood that the centrifugal couple due to the body acts upon the beam in a simple harmonic manner, that is, according to the law of sines; but so does the effect of the balancing cage. In other words, when the axial plane of unbalance is vertical, the effect of unbalance on the hinged beam is the greatest, as also is the effect of the correcting element, the cage.

When the plane of unbalance is horizontal, and to this is proportional the free period of the small oscillation of the beam, that of the correcting element is likewise horizontal, since the cage and the body rotate in unison, and neither is in any manner felt by the beam, which does not respond visibly to any but vertical efforts or the vertical components of other couples.

So far as the spring (Fig. 4) is concerned, its object is to intensify the amplitude of the vibrations, although an unbalanced body will always cause the whole bed to vibrate with a frequency corresponding to the speed of the body (on this principle is based the well-known vibrating tachometer).

However, there is an additional advantage in the use of the spring, as it is always possible to select the characteristics

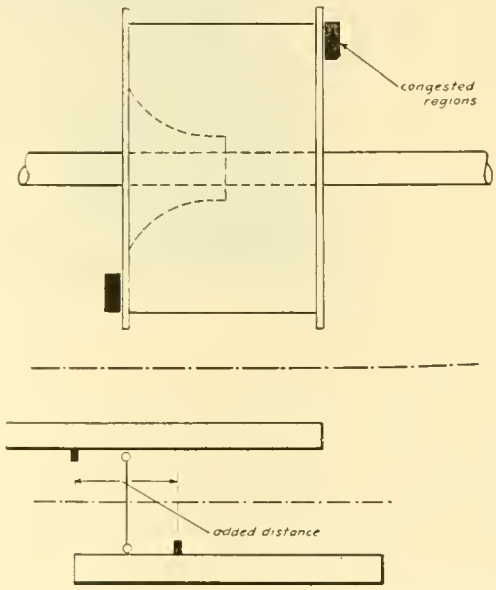

Fig. 6 Dynamic Unbalance in Special Fan

of this so that, under its load, its free period of oscillation will correspond exactly to the rate at which it is desired to run the test. Such a synchronism has a large magnifying effect, so that even a slight unbalance results in a considerable amplitude of oscillation. The natural period of oscillation of the spring is calculated from

$$T = 2\pi\sqrt{M\,U_d}$$

where

T = period in sec. of one complete (double) oscillation
M = mass by which spring is actually loaded
U_d = unit deflection, ft. per lb. load
$\pi = 3.1416$.

The details of construction of the cage would not be of any material interest in the present discussion, but the main feature is that the rods can be adjusted axially while the cage is in rotation, the speed of the cage never being higher than 400 r.p.m. or so.

With regard to the proper speed at which to balance a body, the author submits the following considerations: Unless the body itself is elastic or is mounted on a flimsy shaft, the body balanced at any speed will run true at any other speed. If the shaft is not strong enough, no balancing machine can

make it stronger. If the windings of a rotor seek to find their places under a certain speed and temperature, they should be allowed to do so, after which balancing can be done. In the "high spot" method, in which azimuth (commonly known as lag or lead) depends upon the speed itself, it is of course of considerable importance to watch the speed; but in the rational method here proposed the best speed is determined only by the characteristics of the spring, Fig. 4.

Fig. 7 illustrates a dynamic balancing machine arranged for testing armatures weighing up to 2000 lb., previously placed in perfect static balance. The information furnished by the machine is simply the relative displacement (added distance) of one of the pairs of rods of the squirrel cage.

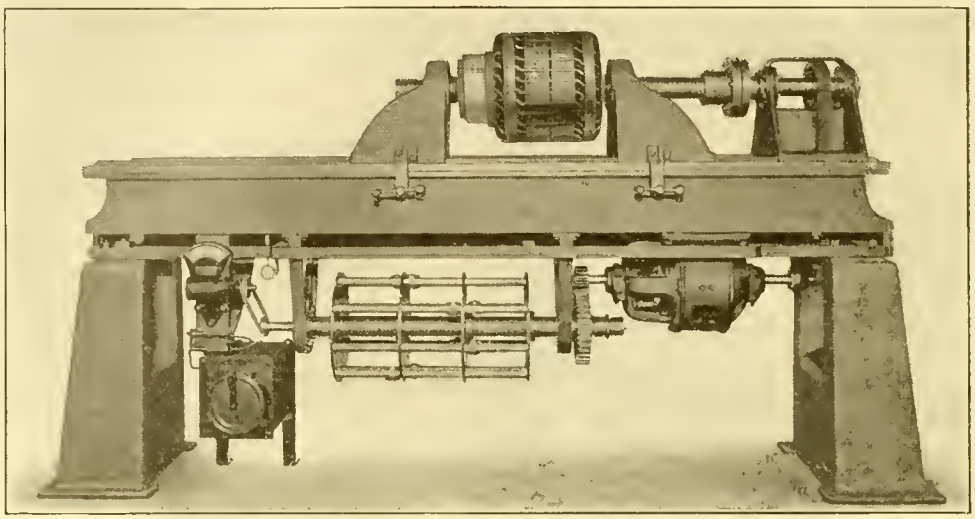

FIG. 7 DYNAMIC BALANCING MACHINE, TESTING ARMATURE

The paper also shows the machine arranged for testing automobile crankshafts, in which case, by referring to a set of specially prepared tables, similar to the one shown in Fig. 8, the operator can pick out readily the necessary directions as to how to remove a certain amount of metal from one of the cranks, and how to drill the flange in order to secure perfect dynamic balance.

An application of the machine for testing special blowers is also shown. If all such fans are of the same size, the directions in this case are also given in a very easy form.

CONCLUSION

It is not necessary to dwell on the extreme importance of testing a body for unbalance in its natural position and upon its own bearings. This machine, in its very conception, is adapted for testing under such conditions. The shaft in Fig. 8 has been tested in its own crank case.

The importance of static balance cannot be overestimated. Fortunately such a condition can be readily secured.

Theoretically, one pair of rods in the squirrel cage, Fig. 5, of the machine would suffice, since the relative position of the rods to the body being tested can be altered readily through the transmission (chain drive shown in Fig. 4). For convenience, however, it is best to have three or four pairs of rods, and even then it is sometimes necessary to change the angular position of the cage so that the balancing can be done by one pair of rods, and not two, as often happens at the beginning of a test.

DISCUSSION

MR. HALSEY DISCUSSES THE LAG OF UNBALANCE OF REVOLVING BODIES

F. A. HALSEY (written). For some years students and practitioners of the art of balancing have known that the high spot of a revolving unbalanced body is not truly radial with the heavy spot, but that it lags behind it by an indeterminate angle when the heavy spot is high, as it runs ahead of the light spot when it is high. This has been attributed to various causes—friction and inertia especially—though it has not been shown how these causes could produce this effect. Along with this go two other unexplained phenomena—the reversal of the body from the position in which the heavy spot is high to that in which the light spot is high and the failure of the shaft to break with indefinite increase of speed as previous analysis indicates that it should do.

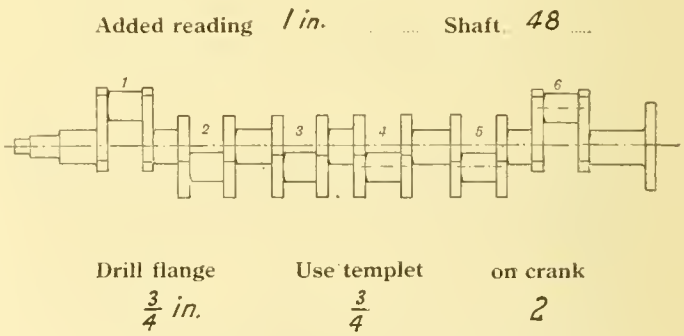

FIG. 8 DIRECTIONS FOR BALANCING SHAFT

It is the object of this discussion to explain the lag and to at least indicate an explanation of the other phenomena.

Fig. 9*a* represents two balls of the same diameter but of unequal weights (the heavier ball being indicated by the heavier shading) mounted on a light cross arm and a flexible shaft running in constrained bearings. The center of figure C_f is also the center of rotation, the center of gravity being at C_g. If the system be set in revolution the centrifugal force of the heavier ball will exceed that of the lighter, the result being the springing of the shaft as indicated in Fig. *b*, the heavier ball

being high and the centers of figure and of rotation taking the positions C_f and C_r. This statement is, however, true in a general sense only. Observation shows that the highest spot lags behind the heavy side by an angle which increases with the speed. To the best of my knowledge this is a recent discovery.[1] Observation further shows that at sufficiently high speeds (that is, above the critical speed) the action is reversed, the light side running high in constrained rotation at such speeds, as it does in free rotation at all speeds, while the lag, measured from the light high side, becomes a lead.[2] This action has long been known, as have the conditions under which it is possible, but I am not aware of any satisfying explanation of the reason for the reversal by which the heavy side, which is high at low speeds, becomes low at high speeds. The two phenomena—lag and reversal—are apparently connected, the former as the cause of the latter.

Before explaining the phenomena—so far as they can be explained—it is necessary to show the conditions under which a constrained body may rotate with its light side high.

Assuming the shaft to be sufficiently flexible and the speed sufficiently high, it is clear that, could the system be placed in the position of Fig. *c*, the centrifugal force and the elastic resistance of the shaft would be exerted in opposite directions and hence would balance, the light side being the high side. What, however, is the explanation of the change of position? Why should a body rotating under the conditions of Fig. *b* change itself to the conditions of Fig. *c*?

Contemplation of Fig. *b* would lead one to expect the opposite tendency, for the higher the speed, the greater the centrifugal force and the more the shaft should deflect in the direction of Fig. *b*, with no discoverable tendency for the direction of flexure to invert itself to the condition of Fig. *c* at the critical, or any other, speed. While, then, we are now in position to understand why the light side should continue to run high, provided it were once placed in that position when running at a sufficiently high speed, we have found no explanation of the manner in which it gets into that position nor have we found any forces at work tending to place it there.

The reversal is due to the lag and it takes place when the lag equals 90 deg. The cause of the lag must, therefore, first be explained. It is due to resistance to rotation which is felt by all rotating parts of actual mechanism—that being what they are for. There are two fundamentally different conditions to be noted, first that of a body driven from the center and experiencing resistance at the periphery, as the armature of an electric generator, and second a body driven at the periphery and experiencing resistance at the center, as the armature of an electric motor.

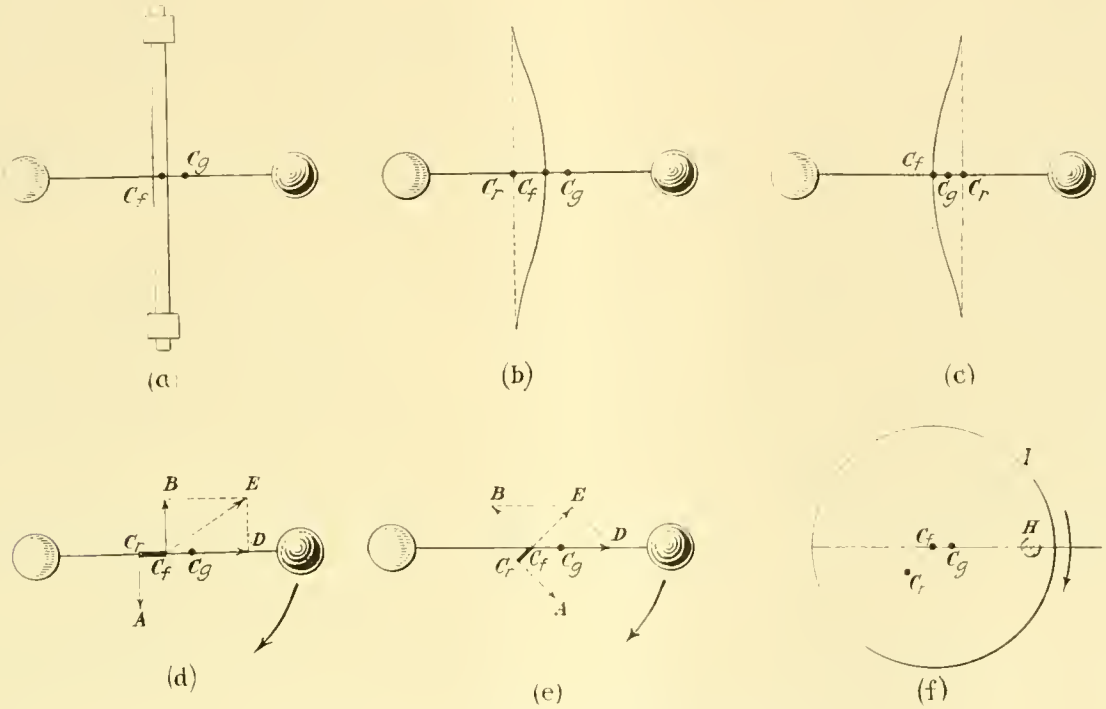

Fig. 9 Lag of Unbalance of Revolving Bodies

Consider the system of Fig. *b*, redrawing it in plan as in Fig. *d*, and consider the effect of the resistance of the air, which is always present, even if we have no other.

The centers of rotation, of figure and of gravity, are indicated as before by the letters C_r, C_f and C_g, while the arm of the elongated crank, due to the spring of the shaft, is shown by the heavy line from C_r to C_f. The direction of rotation being that of the arrow, the resistance of the air exerts a reacting couple, one component of which, C_rA, exerts a pressure on the bearings and may be neglected, while the other, C_fB, exerts a tangential pressure on the crankpin. The centrifugal force C_fD, is exerted as shown, the resultant of the tangential pressure and the centrifugal force being C_fE. Now the deflection of the shaft which forms the elongated crank is due to the applied forces and the direction of the crank must be that of the resultant C_fE. Redrawing Fig. *d* to show this condition, remembering that the reacting force due to air resistance is tangential, we get Fig. *e*, the direction of the crank being plainly at an angle with the line connecting the balls. The highest spot being radially an extension of the crank, we have

[1] The first publication of it to come under my eye was in an article by E. R. Douglass, published in the "American Machinist" for Feb. 22, 1906. It is interesting to know that it was this article that directed the attention of C. H. Norton to the subject and ultimately led to the design of his balancing machine.

[2] The action, as is well known, is utilized in the De Laval steam turbine in which, by the use of a flexible shaft, the critical speed is brought below the operating speed of the turbine.

at once a satisfactory explanation of the lag. This is, perhaps, plainer from Fig. *f*, in which a disk with a heavy spot at *H* is substituted for the pair of balls. Plainly, the highest spot is at *I* radial with the crank and lagging behind the heavy spot.

Fig. *e* requires, however, another correction to make it strictly accurate. With the crank at an angle with the connecting bar, the centrifugal force will no longer act lengthwise of the bar, but on a radius through C_r and C_g. This changes the form of the parallelogram of forces, but it does not alter the tendency of the air resistance to produce the lag.

Experiment shows the lag to increase with the speed (because, in a balancing machine, the air resistance increases with the speed) and the speed at which the angle of lag equals 90 deg. is the critical speed at which the change takes place, and at higher speeds the light side runs high.

To put it in another way, instead of a simple progressive increase of the centrifugal force with increase of speed, as has been assumed, there is also a progressive change of direction of the resultant which ultimately puts the body over to the position in which the light side is high and before the force becomes so great as to break the shaft.

Proof that the lag is due primarily to the tangential force and not to speed is found in the experience of the General Electric Co., which finds, when balancing rotors of steam turbines, that, the speed remaining unchanged, the lag differs with the direction of rotation. With most bodies the air resistance is the same for both directions of rotation, the only method of changing the resistance being by changing the speed. In steam turbines, however, the shape of the buckets causes the resistance to change with the direction of rotation, and, with this condition introduced, we find the lag to change without change of speed but with change of force.

In a steam turbine or an electric motor, the forces C_rA and C_rB, sketched in Figs. *d* and *e*, are reversed, the impulse being applied at the periphery while the resistance due to the load is applied at the shaft. In such machines, therefore, it would appear that the high side should *lead* the heavy spot instead of lagging behind it. I am not aware that observations have been made to cover this point or, indeed, that the inference has before been pointed out, but the observations deserve making. In the balancing machine, to which our observations have been limited, the body under test is always driven from the center, the opposite condition having escaped observation.

While the action described is clear, the analysis, nevertheless, is incomplete. It is obvious that the turning force must be adequate to produce the result, and it is also obvious that the speed and the flexibility of the shaft must concurrently be such as to make the maintenance of the reversed condition possible. Moreover, linked with the flexibility of the shaft and the speed, is the eccentricity of the center of gravity. It will be apparent from a moment's consideration of Fig. *c*, that the greater the distance between C_r and C_g, the higher will be the speed at which, with a given flexibility of shaft, the conditions of the illustration can be maintained. I am not aware of any analysis covering these points, nor have I been able to carry one to a conclusion. The nature of the forces involved would lead one to expect more fruitful results from experimental than from analytical investigation.

It is, however, necessary to assume that the condition of Fig. *c* is more stable than that of Fig. *b*. Were it otherwise a force sufficient to produce the change from Fig. *b* to Fig. *c* would also produce a change back again, resulting in repeated alternation between the two positions, which does not, in fact, take place. There would thus seem to be no doubt of the superior stability of Fig. *c*, although I am not aware of any explanation of the fact.

MR. LORING BELIEVES BALANCE CAN BE OBTAINED IN THREE SHOTS. CRITICIZES SPEED OF BALANCE

E. J. Loring (written). I would define a body as dynamically balanced when its unconstrained axis of rotation is concentric with its journals.

The method proposed assumes perfect static balance, but dynamic balance conditions are far more sensitive because a slight static unbalance is greatly magnified at high speed. I do not agree that static balance is easily obtained. On the contrary unbalance always persists to some degree and must be provided for in the dynamic balancing operation. A body dynamically unbalanced does not usually show high spots diametrically opposite at the two ends, as it would if a simple couple were acting.

The wire rope suspension is not irrational. It supports the shaft with far less constraint than any rigid bearing, transforms a "rigid shaft" construction to "flexible shaft" conditions, and leaves the rotating body more nearly free to rotate on its own principal axis in space.

When provision is made for attaching balancing weights in two well-separated planes between the bearings of a two-bearing shaft, it is possible to determine the position and amount of added weight required in the nearer plane to each bearing in not more than three "shots," and with this information for each balancing plane the proper weight and position for each plane to clear both bearings simultaneously may be found by a simple calculation.

A slow-speed test is by no means conclusive; a body in dynamic balance at 400 r.p.m. may be dangerously far from balance at 3000 r.p.m. When corrected for 400 r.p.m. it is safer than when only statically balanced, but its balance is never fully proven at less than its full speed.

I would be interested to know how the correct plane of displaced rods is picked out from the behavior of the beam and the rotating body. Is it by a definite rule or by selection and trial?

MR. HODGKINSON SEES OBJECTION TO AKIMOFF MACHINE IN NECESSITY FOR STATIC BALANCE FIRST

F. Hodgkinson (written). It seems to me that the author's device is open to the objection that the member to be dynamically balanced must be put in perfect static balance before being balanced by the means described. In the case of heavy revolving bodies this is quite difficult, and is not to be satisfactorily attained by the usual method of rolling the body on ways or the like. Therefore, it seems to me that a machine for dynamic balancing should also render possible the elimination of errors in static balance.

Mr. Akimoff points out that he is enabled to move the rods of his balancing machine axially while the cage is in rotation, but withholds his method for accomplishing this and the details of the cage.

It would seem evident that the spring support at one end of his frame should have a natural period of oscillation equal to the period of revolution of the body being balanced. This of course would mean a different spring for every different weight of body applied, which would require some calculation in advance of doing the work, where there is a great variety of things to be balanced.

The author speaks disparagingly of the older method of securing dynamic balance, that is, running the body at a reasonably high speed and marking the shaft and determining the "high spots." He says they can only serve to indicate the body is out of balance. As a matter of fact, a very well organized system of adding weights may be employed which renders both the static and dynamic balancing of the body a simple operation. One of the hardships of the matter, however, is that the adding of weights or drilling, as the case may be, must be done more or less piecemeal, and the time occupied by speeding up and shutting down occasions a rather severe loss.

In stating that the static balance is not easily obtained, I referred particularly to bodies such as revolving fields of great weight where to mount these on ways, giving them a rolling balance, is unsatisfactory because, in spite of the surfaces being hardened and made as level as possible, the journals will sink into the ways to a slight degree, so extreme sensitiveness cannot be obtained because of the field having to run up hill.

It has been frequently found, in the case of very large fields, that an approximate static balance may be obtained by smearing the bearing surface and journals well with a heavy cylinder oil, dropping the field into the bearings and quickly removing the chains, that the friction would be so low that the field would respond to an error in static balance better than the previously described method of rolling on ways. Of course the field must not be allowed to stand more than a fraction of a minute, or until the oil film has been squeezed out, for then of course the friction becomes very material.

So far as steam turbines are concerned, it has not been the practice of the company with which I am associated to resort to dynamic balancing except in a few extreme cases. Turbines generally are comprised of a drum or quill to which are attached the spindle ends and journals. This drum has secured to it a certain number of disks or rings. Generally the speed of the drum is low, so that ordinarily static balancing, that is rolling on ways, is sufficient. Further, the disks or rings are short in their axial length as compared with their diameters, and a careful static balancing of these is found to be all sufficient. For balancing these disks and rings, a special static balancing machine was devised many years ago and has been in continual use. Inasmuch as this paper is confined to the subject of "dynamic balancing" its description is out of place. To those interested, a fair description of it is found in U. S. Patent No. 710,148, September 30, 1902. I might further add that with this machine a disk weighing 4000 or 5000 lb. may be given a static balance within an error of half an ounce.

SYSTEM EMPLOYED BY WESTINGHOUSE COMPANIES

I stated previously that there is an organized system available for balancing bodies which Mr. Akimoff disparages, and which he has illustrated in Fig. 2. It may perhaps be of interest to describe this system, although the description is rather more of instruction to a mechanic than technical data for the records of the Society.

The bearings being mounted on springs as described is not really a necessity. The bearings employed for large turbine rotors have enough clearance and oil film thickness to give sufficient amplitude of vibration to determine the "high spots," although in building a balancing machine, I would prefer to mount the bearings on springs, or their equivalent, but taking care that the natural period of oscillation of the bearings and the rotary masses be higher than that of the running speed to be employed in balancing. It does not matter at what speed the balancing is done, any more than it would with the machine Mr. Akimoff describes. It is only necessary to run it fast enough so that the vibration due to error in the balancing is well in evidence. It is necessary, however, that marks be applied to the shaft always at the same speed, because the angle between the error in the balance and the mark on the shaft will vary with different speeds. It is invariably found that the error in balance will be a number of angular degrees behind the mark, this angle becoming less with the speed, and greater with more rigid shafts. Inasmuch as it is the centrifugal couple which is to be eliminated and the bodies are of such proportions, that is, great relative axial length, and the balancing at each end must be done independently and as in the case of Mr. Akimoff's machine, it is impossible to eliminate centrifugal couples such as he illustrates. It is found in practice that it is undesirable to work on more than one end at a time, and the end should be first selected which is most out of balance, this to be judged by the degree of eccentricity of the path of the shaft rather than the shaking of pedestals, bedplates, and such. Having marked the shaft at each end, a mark is made which may be used for future reference, and a temporary weight is added, as judgment would dictate, some degrees behind the mark. On the machine again being speeded up, it may be found that the balance may be better, but the position of the mark has changed. If this is so, an additional weight should be added, or the original weight have its angular position moved so as to maintain the mark in its original position, continuing the operation, one end or the other, whichever has the most eccentric path. This process is carried on, and if the mark is maintained in the original position, it will be found finally that a weight added will throw this mark 180 deg. away from its original position, when the weights are then slightly in excess of that required for perfect balance, and only require to be slightly reduced.

By such means both error in static balance and in centrifugal couple are simultaneously eliminated. Balancing frequently has to be performed in the field—when it is successfully carried out in its own bearings and with no knowledge as to the condition of static balance. Plainly, should the marks appear at each end on opposite sides of the shaft, and the body run with similar eccentricity at each end, it would be inferred that the body was in static balance, only requiring the correction of the centrifugal couple.

Generally speaking, it is the practice of the Westinghouse companies to employ this method for all larger revolving fields, as well as for the occasional times when a turbine rotor may need dynamic balancing because some element of it is, due to some error, out of static balance. For small generator rotors, a Norton balancing machine is successfully employed and an addition to the companies' balancing equipment is about to be made of one of the machines the author describes.

MR. FAIRFIELD DESCRIBES THE NORTON BALANCE INDICATING MACHINE

Howard P. Fairfield (written). The necessity for providing some means for indicating a running balance was perhaps first realized a generation or two ago when woodworking machines having rotating cutter heads, and threshing machines for grain, were placed on the market. In the case of wood planing machines the cylinders upon which the knives or cutters were mounted were given a rotative speed, and in the case

of the threshing machines the teeth which beat the grain from the straw were attached to a cylindrical drum which was made to rotate at a considerable speed. The first attempt at solving this question with which I am familiar was by placing the piece to be tested in a pair of boxes that were hung from the ceiling by a wire. The part being tested was then rotated at speed, and its action noted and indicated by the operator, who made the necessary weight change to give the required effect.

One of the most extended investigations of the problem of balancing rotating bodies that has ever been conducted was carried on by Charles H. Norton, Mem.Am.Soc.M.E., who later developed his well-known Balance Indicating Machine, which indicates running balance only, no attention being given to questions of standing balance. It is believed this was the first machine to provide a means by which the workman could locate the position of the error of balance with any degree of

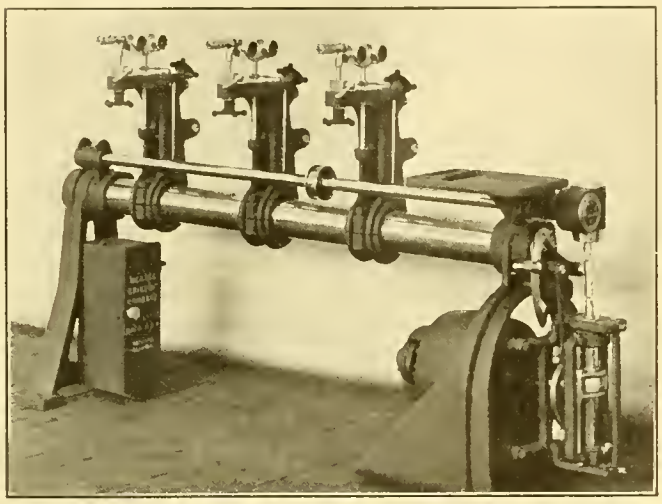

Fig. 10 Norton Balance Indicating Machine

accuracy, which be accomplished by providing means for reversing the direction of rotation, thus eliminating the guesswork in indicating due to the lag.

Mr. Norton's machine, as shown by Fig. 10, consists of a round steel supporting bar, which may vary in length as conditions warrant, supported by two floor stands. By means of a disk friction drive, connected with suitable gearing, an electric motor gives rotation to the smaller pulley-carrying shaft seen immediately above the supporting bar. The upper works consist of two or more upright frames carrying vertical pendulums. The pendulums are seated at their lower ends in suitable sockets, and on their upper ends are provided with a small table upon which are mounted light anti-friction rollers. Opposite the rollers are placed marking pointers. Connected with the vertical pendulums and fulcrumed to the sides of the uprights are the vibrators which indicate the unbalance of the rotating part. The piece to be indicated is mounted on rollers upon the top of the inverted pendulums.

If, when rotated at any speed, the piece being indicated is not in running balance, the vibrating indicators will show as they do in Fig. 11, where they indicate that the piece is out of running balance at each end. When the piece is in running balance, these indicators are perfectly still.

Unless the piece to be indicated is so slender as to spring appreciably, it makes no especial difference, of course, at what speed it is indicated; however, in practice, I believe it customary to indicate the work when it is being rotated above the so-called "critical speed."

Fig. 12 well shows diagrammatically the action of the vibrating indicator as the piece approaches, reaches and passes beyond the critical speed.

Fig. 13 shows a shaft that has been "marked" when rotated below the critical speed. Below this speed the indicated spots are behind the exact heavy spot, whatever the direction of rotation. Rotating the piece in two directions and locating arrow heads in the length center of the two marks indicates the exact heavy spot, as centered equidistant from the arrow points.

Fig. 14 shows a shaft rotated above the critical speed marked and arrowed as above, the arrow heads in each case flying in the direction of rotation.

In using this machine the following points have been noted: When the piece is rotated below the critical speed, the operator marks the heavier side, above the critical speed the lighter side. When marked on the heavier side, the marks lag or are behind the exact heavy spot when the direction of rotation for each mark is considered.

When marking on the lighter side, the marks lead the exact light spot. When marking on the heavier side, the arrows point toward each other. When marking on the lighter side,

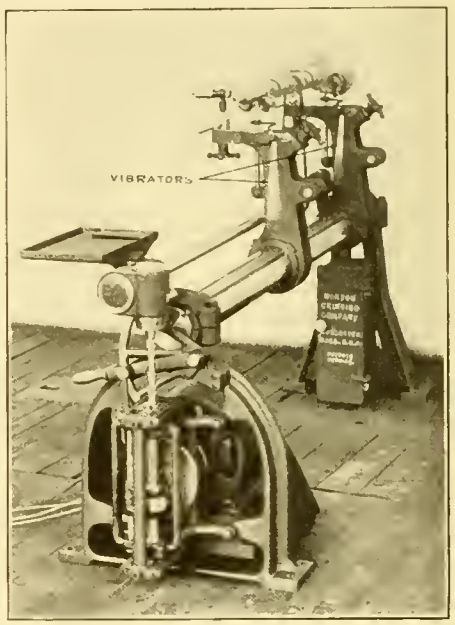

Fig. 11 Norton Machine Indicating Running Unbalance

the arrows point away from each other. The true heavy spot lies midway between the points of the arrows.

In closing this description, it may be well to take note of several practical points that have been well proven in practice:

a That while a body placed in static balance may be decidedly out of running balance, one that is placed in running balance must also be in static balance

b Exact symmetry of form must not be taken to mean that the machine part is in running balance

c A machine part put in running balance at any speed is certainly in running balance at any other speed if it is not distorted from its true axial condition. This fact renders it possible, therefore, to rotate the part which is being tested at any speed desired which does not distort or spring it.

It will be admitted, I think, by all users of speed machinery that all rotating parts should be placed in exact running balance if the machine is to quietly perform its functions.

MR. HYMANS CONSIDERS AUTHOR HAS FOUND COMPLETE AND PRACTICAL SOLUTION OF PROBLEM

F. Hymans (written). In addition to the detrimental effects of an unbalanced rotating body enumerated in this paper, loss of power in causing and maintaining vibrations of the structure supporting the body should be mentioned. This loss has been demonstrated by Sommerfeld (Z. d. V. d. Ing., 1902) in experiments with a small electric motor which carried on its shaft an eccentric weight. Placing the motor on a table, it was found that at 310 r.p.m. the table began to execute horizontal vibrations. In an endeavor to increase the motor speed the voltage impressed on the armature was raised. It was found, however, that the voltage could be considerably increased without causing any increase in the speed of the motor and the increased power consumption was absorbed in maintaining the vibrations of the table.

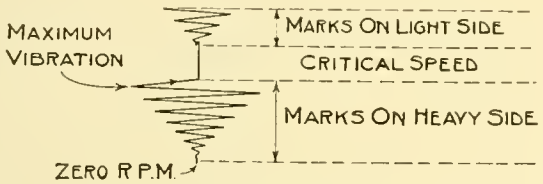

Fig. 12 Action of Vibrator Passing Critical Speed

By perfect balance of a body rotating freely around a horizontal axis is understood the condition when there is no bearing pressure, save that due to the body's weight. If it were possible therefore to measure directly the bearing pressure and its direction relative to the body, we should have the simplest form of a balancing machine and be in a position to determine the corrections necessary to bring about perfect balance. Unfortunately, however, direct measurement of forces is rarely possible.

It is not impossible to determine the corrective means for static as well as dynamic balance simultaneously on one and the same machine. However, the problem is considerably simplified if a static balance is first secured, as in a body so balanced the resultant of the centrifugal forces to which its particles are subject is a couple only, instead of a couple and a force, as in a body entirely unbalanced.

Considering more in particular the balancing machines of the vibrating type, we can broadly divide them in two classes, namely:

First, machines in which the vibrations excited by the centrifugal couple are directly employed to determine its plane of action, as is the case with nearly all balancing machines existing heretofore. (See also description of the Lavaczeck machine in The Journal, March, 1916.) *Second,* machines in which the vibrations are merely employed to indicate lack of balance, of which class Mr. Akimoff's machine is to date the sole example.

Referring to the first mentioned class, the position of the plane of unbalance is always determined by observing the position of the body at the instant of maximum amplitude of the oscillations. When the body is rotated at a sufficiently low speed, so that the period of rotation is very large as compared with the period of free vibration of the system, the oscillations of the machine will be in phase with the exciting forces, and it is a simple matter to determine accurately the plane and even the magnitude of the centrifugal couple. A machine so arranged would, however, not be sensitive enough for the purpose.

On the other hand when the body is rotated at a speed at which the period of free vibration of the system is no longer negligible as compared with the period of rotation, there is a phase difference, due to mechanical friction and damping forces, between exciting forces and oscillations. As the amount of this phase difference is uncertain, the plane of unbalance can only be determined approximately. In addition the oscillations can no longer be employed to calculate the magnitude of the centrifugal couple.

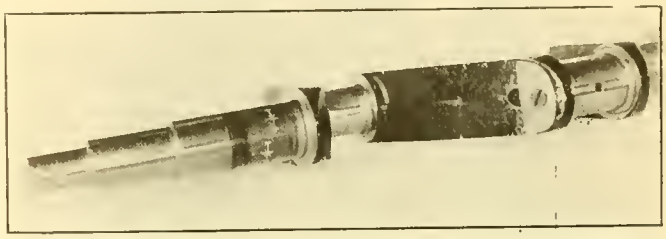

Fig. 13 Piece Marked on Norton Machine Below Critical Speed

Fig. 14 Piece Marked on Norton Machine Above Critical Speed

In the Akimoff machine it is quite immaterial if there is phase difference between oscillations and exciting forces. As described, an additional couple is introduced, which can be so adjusted in phase and magnitude, that the vibrations of the balancing machine vanish. The machine affords therefore at once the means to determine exactly both the plane and amount of unbalance. Disturbing influences such as "weakness" of the shaft of the rotating body can be practically wholly eliminated by selecting a spring of a flexibility which is large as compared with that of the shaft. In other words by the proper selection of the spring, the speed of rotation of the balancing machine can be made sufficiently low, that the transverse vibrations which the centrifugal couple tends to set up in the shaft of the rotating body will be practically of no effect on the beam of the balancing machine.

Looking at the matter from any angle, it must be conceded that Mr. Akimoff has found a complete and practical solution of the problem, and with the advent of a machine with which a perfect balance can be obtained easily and accurately, there should be no reason why a perfect balance should not become a standard requirement for nearly all classes of rotating machinery.

MR. RIDDELL COMPARES HORIZONTAL AND VERTICAL BALANCING MACHINES

JOHN RIDDELL (written). The use of balancing machines has now become universal, and the results are generally satisfactory, both as regards the quality of work produced as well as in the matter of economy. It becomes simply a matter of selecting the type of machine deemed most suitable for the particular kind of work to be done, and more particularly depending on the degree of perfection of balance desired.

It appears that present day balancing machines can be divided into two distinct classes: *First*, with vertical rotor suspended from an overhead drive by a cable or a flexible shaft. Such a machine is shown in Fig. 15. *Second*, with horizontal

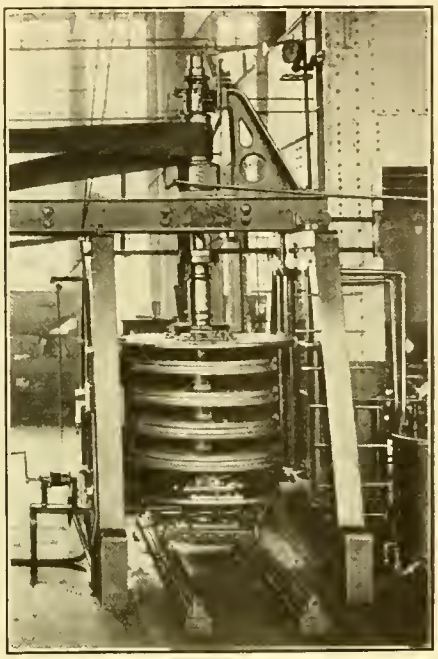

FIG. 15 TYPICAL VERTICAL BALANCING MACHINE

rotor running either in ordinary bearings or on rollers carried in suitable holders that can rock against springs or buffers of some description,—in other words, bearings that possess some degree of flexibility. A horizontal machine is shown in Fig. 16.

The writer's experience is that the vertical machine gives the most perfect balance, owing, no doubt, to the fact that there are no bearings to influence the running of the rotor, and also that the rotor, being suspended, can run out and show the amount "out" much more easily and to a greater degree than if supported in bearings.

The cost of balancing with the vertical machine is, at least for heavy work, somewhat greater than with the horizontal machine, partly on account of attaching the work to be balanced to the machine.

The vertical machine is so much more sensitive than the horizontal type that the very balancing operation becomes somewhat more delicate, and it is no doubt often the case that the refinement obtainable on a vertical machine is not needed for some kinds of work. In such cases, it is proper to use the horizontal machine. One thing should be remembered, however, and that is, that when it is desired to balance a rotor, the service speed of which is somewhere near its critical speed, it is much easier to do the balancing in the vertical than in the horizontal machine, owing to the fact that the rotor is suspended, and therefore not subject to bending during the operation.

It is the opinion of the writer that in order to give a body perfect dynamic balance, it is necessary to do this at a speed at least equal to the maximum speed at which it is to be operated in actual service, as it is quite possible to have an apparently perfect dynamic balance at one speed and then find that the balance shows imperfectly at higher speeds. Whereas, if a body is in perfect balance at its highest speed, it will also prove to be in perfect balance at all lower speeds.

I wish to say also that in my opinion it is a useless and wasteful practice, except in a very few specific cases, to give a body a static balance if a dynamic balance is to be finally produced.

MR. BRYSON RAISES SOME QUESTIONS REGARDING PRINCIPLES OF THE MACHINE

T. A. BRYSON[1] (written). The author explains that it is extremely difficult to ascertain the underlying idea of apparatus in which the axis of the body is pivoted at one point, and that the dynamics of the case is much more difficult of solution than that of a body having a fixed axis. Is not the action of the device shown similar to the former case since all axial motions of the body are transmitted to the hinged frame?

It would seem that much might be gained by providing for close adjustment of the axial plane of the balancing weights while the cage is in rotation, thus performing both operations without stopping to change the angular position of the cage.

Is the chain and gear drive free from vibrations which would affect the results?

THE AUTHOR REPLIES TO POINTS RAISED IN THE DISCUSSION

THE AUTHOR. In explanation of the several points brought up by those who have discussed my paper, I will review three of these discussions:

Mr. Loring. Unfortunately no explanation or reasons are given to justify the several assertions which comprise this discussion. I will consider each paragraph separately.

1 The definition of dynamic balance is objectionable because it involves a conception of higher order; if one knows what an unconstrained axis is, no definition of what constitutes dynamic balance is needed. Furthermore, an axis, being a straight line, cannot very well be *concentric* with anything. This, of course, may be only a *lapsus linguae;* but meant as a correction it is out of place.

2 Regardless of what the high spots show (in general they mean nothing at all), it was explained in the paper that the unbalance can only be due to a couple, provided that the body is in static balance; remove the couple and the body is in balance. This is actually being done every day in our shops, and by the users of these machines.

3 That the wire rope suspension is the most irrational of all methods that can be conceived follows from the fact that here we have the case of a so-called system with four degrees of freedom; in other words, there are four different ways in which such a system can oscillate, all confusing one another. There is absolutely no hope in this method.

4 So far as the possibility of placing a body in balance in two or three "shots" is concerned, I will merely ask this

[1] Fulton and 6th Streets, Troy, N. Y.

question: Who has ever said, or on what machine was it ever proved, that the body was really placed in balance? Is it because the operator himself said so? Is it because a machine, wrongly constructed upon a radically wrong idea, showed so? Is it not clear that it is absolutely impossible to secure any such result in three shots, except if the machine is so constructed that it shows balance where no balance exists?

5 Here are two examples showing that slow speed may be very conclusive indeed: 21-in. blowers are being balanced on our machine at 450 r.p.m., and operate at 800 to 1300 r.p.m. very satisfactorily; by older methods no such satisfaction could have been secured at all. Another rotor was balanced by us at 350 r.p.m. and ran very well at all speeds, including its highest speed of 2500 r.p.m. There is nothing unusual about this. Balance is balance; if the rotor is so constructed that it changes its shape with the speed, it should be thrown away, because it cannot be balanced at all. But of course supposed illusory balance may show one result for a low speed and another, quite different, for higher speeds.

Mr. Hodgkinson's discussion in defense of what he calls "older methods" contains a number of weak points, with which I shall deal separately.

1 There is no secret about the details of construction of the cage. It can be (and is being) made in a great many different manners, each of which yields the same result, and the description of all such types would take up much space, without being instructive or interesting. The main principle is that the rods can be displaced while the cage is in rotation.

2 To Mr. Hodgkinson "it seems evident that the spring support on one end should have a natural period or oscillation equal to the period of revolution of the body being balanced. This, of course, would mean a different spring for each different weight of body applied . . ." As a matter of fact, however, this is not only not evident, but it is not even so! By writing down the easy differential equation controlling this small oscillation, it will be seen that the free period depends not only on the weight but upon three other things, so that it is perfectly possible to imagine a great variety of different weights which would not necessitate any change whatsoever in the spring support. Full advantage is being taken of this fact in the arrangement of the machine, which is such that the operator has no calculations to make. This is a vital point that has been carefully considered in the design of my machine.

3 Mr. Hodgkinson does not seem to like my speaking "very disparagingly of older methods," but I must nevertheless go further and actually deny their very existence as methods. They are not methods at all. They never did or can give accurate results and there is a very definite logical reason why this is so: they are all concerned with what is known as *multiple degree of freedom*, the one-point (cone) suspension method involves freedom of two degrees; the floating bearing principle also involves two degrees; while the flexible rope suspension method involves no less than four degrees of freedom. All this means that the body being tested does not vibrate in just one way, from which some sort of an indication of value can be derived. Actually it vibrates in two or even in four entirely independent manners, each introducing new confusion into the already complicated motion. The machine described in the paper is to my knowledge the only one ever proposed involving but *one degree of freedom*, namely plane oscillations about the hinge; this is why balance shown on this machine is actually real, perfect balance.

4 Excessive confidence in the high spot methods, together with the hope that it is at all possible (which it is not) to balance "one end at a time," are precisely the reasons why it is necessary "frequently to perform balancing in the field." There is no necessity for doing this if real balance has first been secured in the shop.

5 Mr. Hodgkinson states that in the shops of the company by which he is employed, balance of small rotors is being "successfully" secured on a floating bearing machine. From all I heard and saw personally regarding this matter, his statement is entirely at variance with the facts.

Mr. Fairfield describes a typical floating bearing machine, which, however, has the fundamental error of a machine possessing two degrees of freedom. I have elsewhere advanced a few logical reasons showing why no machine with more than one degree of freedom can possibly secure dynamic balance. One of the features especially detrimental to the machine described by Mr. Fairfield is the belt drive. Since the bearings are of the flexible or yielding type, it is a most unwise plan to drive from an outside source of power, no matter where located. Another notion which should have been exploded long ago is that of the so-called *critical speed*. I am fully aware of the tremendous amount of brilliant work that has been done by the English and German mathematicians in connection with this delicate subject, but that particular critical speed is one thing, and the speed at which the floating bearing machine changes its spots, whatever they are, is another thing, the two having no connection whatsoever. In the floating bearing machine we have the influence of the yielding nature of the bearings and of the twofold freedom; but there is nothing critical about it and certainly nothing from which any sort of valuable information may be obtained in regard to balance or unbalance of the body. It is not clear what started this idea of critical speed, but inasmuch as it does not correspond to anything of value and is misleading, it should be dropped once and for all.

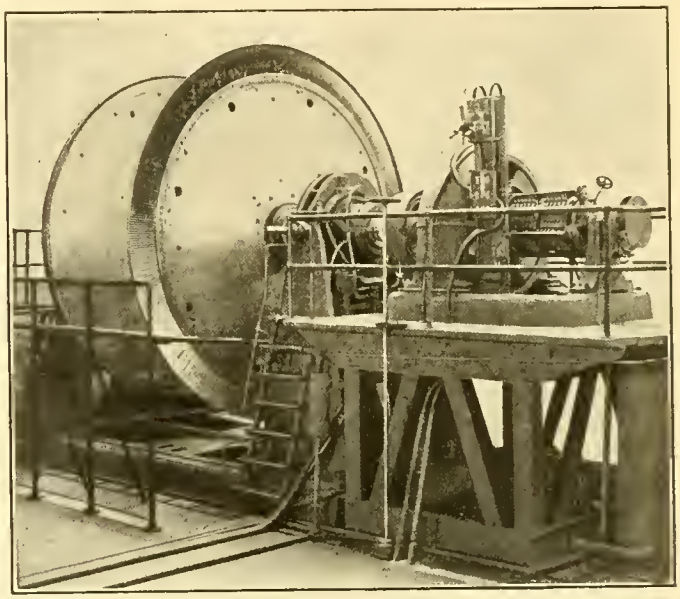

Fig. 16 Typical Horizontal Balancing Machine

In conclusion, the trouble with an understanding of what constitutes dynamic balance is that it is based on the presence (or absence) of certain quantities called "products of inertia" with which the practical man is in general quite unfamiliar. I did not wish to introduce the products of inertia in my paper and for this reason had to explain things by

something easier, the centrifugal couple, although this meant a much longer explanation. But I have seen some big practical men think the matter over and thoroughly digest the meaning of the expression *centrifugal couple*, after which, according to their own testimony the "thing came as clear as daylight" to them, which, however, is only too natural, because it is based upon common sense pure and simple; only it takes a little dynamics to put matter into an easy shape in which common sense can grasp the real meaning of this would-be elusive conception *dynamic balance*.

The principle of my machine has been worked out in a purely deductive, analytical way, and not by building up or by cut-and-try process. To begin with I had this problem in mind: how to tilt the momental ellipsoid so that its axis, the nearest to the axis of rotation, will be brought into absolute coincidence with the latter. This can easily be done by building the cage around the body, which is correct, although in the immense majority of cases, impractical. From this it was but one step to splitting up the body and the cage.

Inasmuch as we deal with couples, that is, moments, there was nothing else to do, except writing down the equation of the oscillation of the beam and working out the parts in detail. This did not require a single assumption or postulate, but was derived directly from elements of rigid dynamics.

In the matter of dynamic or running balance, Charles L. Clarke says, in effect, that since it is necessary only that the center of gravity of each elemental or narrow cross-section of a body shall lie in the axis of that body's rotation, in order for them to be in dynamic balance, this condition can be secured for them with practical accuracy, in the majority of cases of machine design, by the method of standing or static balancing of a sufficient number of sections in this manner before they are finally assembled, and thus assure the sought for dynamic balance of the body as a whole.

Static balancing has its practical limits, however, as many bodies are not separable into sections along the axis of rotation, or the shaft, if the body be one so mounted, for individual balancing, and hence must be balanced as a unit.

The balancing of machines having connected and oscillating and reciprocating members is a complicated compromise between purposely produced surplus dynamic effects of out-of-balance rotation of one body and the dynamic effects of other connected non-rotating but moving bodies. The balance at best is a rough one.—*General Electric Review*, July, 1916.

Concerning the strength of oxy-acetylene welds, S. W. Miller says that in the case of ordinary cast iron it is well known that the weld is stronger and less brittle than the original material, due to the finer grain resulting from the good quality which it is imperative that the welding rods shall have.

With steel the situation is very complicated owing to its many kinds and purposes of use and hence its many kinds of stresses.

Hardness and ductility are relative terms, and a weld in a very soft, ductile, low-carbon steel may be harder than the original material, while a weld made with the same welding wire in a much harder steel of higher carbon may be softer than the original material.

Microscopic examinations indicate that it is impossible to weld high carbon steel without burning it.

With steel of about 55,000 lb. tensile strength, a welded piece will usually locate in the weld, at a tensile strength of about 52,000 lb. The elongation may run as high as 20 per cent, that of the original material being, perhaps, 32 per cent, and the elastic limit will be about 33,000 lb. against 35,000 lb. for the original material.

Referring to welds in non-ferrous metals, Mr. Miller says that in a general way if the welds are carefully made with a good torch and proper materials the results will usually be satisfactory.—*Machinery*, vol. 22, no. 10, June 1916.

The Swedish State Railways have requested the king to propose a bill for an appropriation for the erection of a peat powder factory for use as a locomotive fuel. After a careful examination the railway directors state, according to a report transmitted by Ira N. Morris, American Minister at Stockholm, that they have found peat powder to be very efficient and practical for locomotives, with a fuel value compared with that of coal of about 2 to 3. Using the ratio given and calculating from the lowest estimate for the production of peat powder, the cost of the latter per ton would be $4.02 with a corresponding price of coal of $6.03 per ton.—*Railway Review*, June 24, 1916.

Condenser tube troubles prompted an investigation which was conducted by Prof. A. E. White in 1913 for the Edison Illuminating Company of Detroit. The results are presented in a paper read at the annual meeting of the American Society for Testing Materials, held at Atlantic City, June 30, 1916.

The purposes were to ascertain the reason for the splitting of brass condenser tubes in service; to determine the proper chemical composition, and the mechanical and heat treatments which should be given to the tubes; and to formulate such specifications as would be of material aid in their purchase. The specifications finally arrived at completely eliminated the troubles previously encountered.

To ascertain whether or not the splitting was due to impurities, chemical analyses were made, which showed that the proportion thereof was very small and evidently not the source of failure. This was later found to be due to defects in the making, particularly in the drawing and annealing. The composition of the material of the tubes, as shown by the analyses, was more or less uniform—60 parts of copper to 40 of zinc—Muntz metal. An alloy of 70 per cent copper and 30 per cent zinc is considered to be the best in the presence of fresh unpolluted water, while if the water be polluted, or with salt water, one of 70 per cent copper, 29 per cent zinc and 1 per cent tin is excellent. The first named alloy is preferred as it embodies the maximum ductility of all the brasses, and because it lends itself better to cold working and annealing. Further electrolytic action is not possible.

For condenser tubes ductility rather than tensile strength is one of the governing factors and this the 70 to 30 mixture gives in greater measure than does one of 55 per cent copper and 45 per cent zinc, which has the greater tensile strength.

Cold drawing, when not too severe, assures a breaking down of existing crystallization, resulting in both smaller and better interlaced grains. It also makes annealing necessary between each set of cold drawings, both of which processes improve the quality of the tube. Too much cold drawing between annealings will distort the grain structure to such an extent as to produce heavy slip bands which are almost impossible to eliminate. It is more desirable to reduce the thickness of the tube by many light drafts than by a few heavy drafts. Not less than six drawings should be made, and twelve or even more cold drawings are to be preferred.

ON THE TRANSMISSION OF HEAT IN BOILERS

BY E. R. HEDRICK,[1] COLUMBIA, MO., and E. A. FESSENDEN, COLUMBIA, MO.

Non-Member Member of the Society

THE inadequacy of certain current theories of heat transmission in boilers,[2] and the difficulties experienced by the authors in attempting to check the theoretical formulae of Sir John Perry and others with the results of actual experiments quoted by Perry himself and by others have led to the outline of a new theory which agrees with known experiments to within reasonable limits of possible error.

The authors have found difficulty in checking the results of experiments quoted in the literature with the theories commonly proposed for the transmission of heat from the hot gases to the water in a boiler.

They have been led to an assumption which seems particularly reasonable since the resistance to heat transfer changes almost certainly with temperature. The assumption is that the quantity of heat lost by a given small weight of gas falls off as the gas passes down the pipe in accordance with the ordinary damping law usual in physical phenomena.

The theoretical consequences of such an assumption are worked out in detail, and are brought to a point where graphical check with numerical data is easily possible.

Perry's[3] formula for the efficiency E of a tube length l is

$$E = 1 - e^{-cl/d} \qquad [1]$$

where e is the Naperian base 2.71828

c is a constant

d is the diameter of tube.

For any particular tube, c/d is a constant k, and denoting distances along the tube by x the equation may be written in the form

$$E = 1 - e^{-kx}, \text{ or}$$
$$\log_{10}(1 - E) = -Kx$$

where $K = k \log_{10} e$

From values of E given by Perry[4] for the famous French experiments, the authors have computed K by two methods; *first*, by dividing the difference between successive values of $\log_{10}(1 - E)$ by corresponding differences in x, and *second*, by direct substitution in the equation $-K = \dfrac{\log_{10}(1 - E)}{x}$.

If K were constant, as it should be if Perry's formula holds, the two methods would of course give identical results. Instead, the values of K diminish steadily as x increases, and the last value is only about one-third of the first value.

Fig. 1 shows clearly the same discrepancy. In it, values of $\log_{10}(1 - E)$ are plotted against values of x. If Perry's formula [1] held, the resulting figure would be a straight line, which it clearly is not.

Similar data given by Kreisinger and Ray[5] show quite as great discrepancy. A considerable number of other sets of data are given in the authors' complete paper and these are compared in each case with the formulae of Perry and with those of this paper.

Perry's work is based on that of Osborne Reynolds. He makes the fundamental assumption that the amount of heat δH transmitted across a small length δx of the tube is proportional to the difference in temperature τ between the gas and the water, and to the area of the tube wall:

$$\delta H = b\tau\,\delta x \qquad [2]$$

where b is a constant.[1] This amounts to saying that the conductivity $\delta H/\delta x$ is a constant. From this he derives[2] the formula

$$\theta = \theta_1 e^{-cx/d}$$

where θ and θ_1 are equivalent to our τ and τ_0 and where c/d is a constant which we shall call c. Then

$$\log \frac{\tau}{\tau_0} = -cx, \text{ or } \tau = \tau_0 e^{-cx} \qquad [3]$$

where c is a constant, τ_0 is the value of τ at the fire-box end of the tube, and x is the distance along the tube, measured from the fire-box end.

A reasonable ground for the discrepancy in these formulae is to be found in the assumptions made by Perry of the constancy of heat conductivity, or its reciprocal, heat resistance. Everyone recognizes that the principal sources of heat resistance are the peculiar state and behavior of the gas and of the water next to the tube, rather than the intrinsic resistance of the tube wall itself, the total being of the order of one thousand times the intrinsic resistance of the tube wall alone, yet the effect of these peculiar conditions is apparently neglected.

The phenomena present around the walls of the tube depend upon temperature, as does the speed of the gas which contracts with cooling. The resistance itself, therefore, depends upon temperature, if we mean by resistance that total mentioned above rather than the intrinsic resistance of the metal alone. This explains why a discrepancy should be present in the Perry theory, and furnishes a basis for the assumptions to be made.

The original assumption is that as we proceed down the tube, the amount of heat loss from a small quantity of gas δQ occupying a length δx of the tube, in passing a given point, falls off according to the usual formula for any damping out process so that

$$\textit{loss of heat in } \delta Q = ce^{-mx} \qquad [4]$$

where m and c are constants.

It is assumed that the decrease $\delta\varphi$ in the entropy of the gas in a small section of the tube of length δx is proportional to

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[1] Dept. of Mathematics, Univ. of Mo.

[2] See for example Perry, The Steam Engine, 1909; and Bulletin 18 of the U. S. Bureau of Mines, by Kreisinger and Ray, entitled The Transmission of Heat into Steam Boilers.

[3] Perry, l.c., p. 591.

[4] Perry, l.c., p. 432.

[5] Bulletin 18, U. S. Bureau of Mines, p. 53, fig. 16.

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[1] The constant b depends upon and changes with the diameter of the tube, the gas velocity and other variable phenomena connected with the experiment, but is supposed to be the same throughout any one experiment.

[2] Perry, The Steam Engine, 1909, pp. 587-591.

the entropy difference $\varphi - \varphi_w$, where φ is the entropy of the gas at the temperature of the gas and φ_w the entropy the same gas would have at the temperature of the water.

Since φ_w is constant, $\delta\varphi_w$ is zero, and $\delta\varphi$ equals $\delta(\varphi - {}_w)$, and the fundamental assumption may be written in the form

$$\delta(\varphi - \varphi_w) = -m(\varphi - \varphi_w)\,\delta x \qquad [5]$$

where m is a positive constant. The following well known relations are also used:

$$\delta\varphi = \delta H/\theta \qquad [6]$$

$$H = c_p\theta \qquad [7]$$

$$\delta\varphi = c_p(\delta\theta/\theta) \qquad [8]$$

where θ is the absolute temperature

H is the heat content of unit weight

c_p the specific heat at constant pressure.

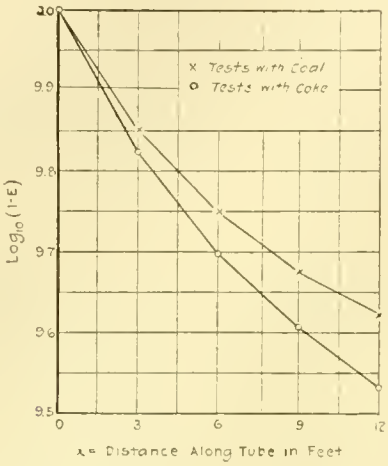

FIG. 1 FRENCH EXPERIMENTS, PERRY'S FORMULA FOR EFFICIENCY OF BOILER TUBE

We assume c_p constant, and the pressure p in the tube constant.

From [8]

$$\varphi - \varphi_w = c_p \log_e \frac{\theta}{\theta_w} \qquad [9]$$

and therefore [5] becomes, in the limit as δx approaches zero,

$$\frac{d\log_e(\theta/\theta_w)}{dx} = -m\log_e(\theta/\theta_w) \qquad [10]$$

If we denote $\log_e(\theta/\theta_w)$, which is proportional to $\varphi - \varphi_w$, by s, we have

$$\frac{\delta s}{dx} = -ms \qquad [11]$$

whence by integration

$$\log_e s = -mx + \kappa \text{ or } s = k\epsilon^{-mx} \qquad [12]$$

where κ and k are constants, and where $\kappa = \log_e k$. If $x = 0$, s has the value $s_0 = \log_e(\theta_0/\theta_w)$, where θ_0 is the absolute temperature of the gas as it enters the tube. Hence, inserting these values, $k = c_0$ or $\kappa = \log_e s_0$; and [12] may be written in the form

$$\log_e(s/s_0) = -mx \text{ or } s = s_0\epsilon^{-mx} \qquad [13]$$

In terms of θ these formulæ are

$$\log_e(\theta/\theta_w) = \log_e(\theta_0/\theta_w)\,\epsilon^{-mx} \quad \text{or } \theta/\theta_w = (\theta_0/\theta_w)\,\epsilon^{-mx} \qquad [14]$$

For comparison with numerical data it is desirable to have these formulæ expressed in common logarithms. Remembering that

$$\log_{10} N = \log_e N \times \log_{10} e$$

we may write the formula [14] in the form

$$\log_{10}(\theta/\theta_w) = \log_{10}(\theta_0/\theta_w)\,e^{-mx} \qquad [15]$$

Let us set

$$R = \log_{10}(\theta/\theta_w) \text{ and } R_0 = \log_{10}(\theta_0/\theta_w)$$

so that R is proportional to s used above, or to $\varphi - \varphi_w$. Using this notation, and taking common logarithms again, we have

$$\log_{10} R = K - Mx \qquad [16]$$

where

$$K = \log_{10} R_0 = \log_{10}[\log_{10}(\theta_0/\theta_w)], \text{ and } M = m\log_{10} e$$

In the numerical computations of this paper the quantities θ, θ/θ_w, R, and $\log_{10} R$ are tabulated in that order. Denoting the last of these by Φ

$$\Phi = \log_{10} R = \log_{10}[\log_{10}(\theta/\theta_w)] \qquad [17]$$

and we have

$$\Phi = K - Mx \qquad [18]$$

where K and M are constants defined above.

Prof. William Kent provides a set of direct temperature measurements in a locomotive boiler tube at every foot of its length. These measurements and the corresponding values of

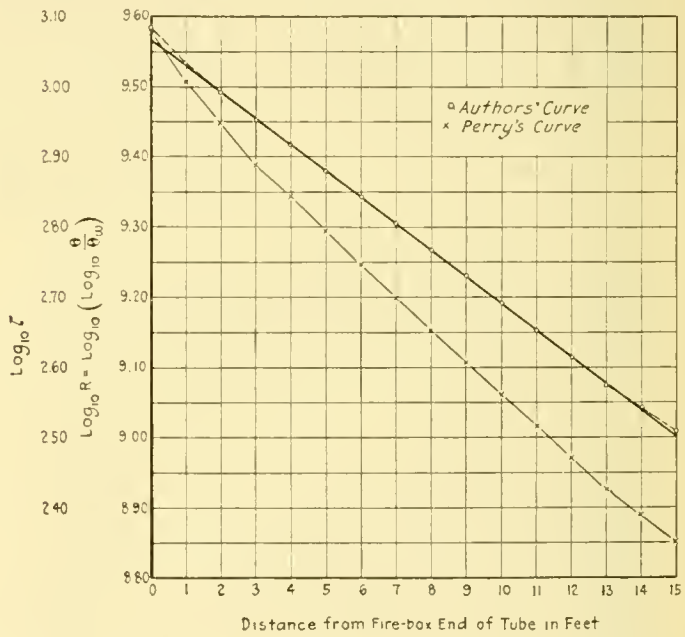

FIG. 2 KENT'S DATA CHECK AGAINST PERRY'S AND AUTHORS' FORMULÆ

the quantities R and Φ are tabulated by the authors in their complete paper. In Fig. 2, pairs of values of x and Φ are shown by small circles while for comparison with Perry's formula [3], the corresponding points for pairs of values of $\log_{10}\tau$ and x are marked by small crosses. Were formula [3] correct, these points would lie on a straight line. From this graphical presentation, it will be seen that the formulæ [14]–[16] agree with the observed values better than does the formula [3].

Evidence of error in measurement due to the radiation from the thermal couple exists in the diagram, making it reasonable to give less weight to the extreme points.

The complete paper contains tables and diagrams from data

of further tests in support of the theory of the authors, and confirmation is evident in tests made by Professor Fessenden to be published.

To convert the preceding equations into forms which can be compared with these measurements, let us return to equation [9], and let us substitute in it from [7] where H means the heat content reckoned from $H = 0$ at $\theta = 0$. We have then

$$\varphi - \varphi_w = c_p \log_e (H/H_w) \qquad [19]$$

and the further reduction is precisely similar to that above, with the ratio H/H_w in place of the ratio θ/θ_w. Hence we have, as in [14]

$$\log (H/H_w) = \log_e (H_0/H_w)\, e^{-mx}, \text{ or } H/H_w = (H_0/H_w)\, e^{-mx}$$

and also, as in [16] [20]

$$\log_{10} [\log_{10} (H/H_w)] = K - Mx \qquad [21]$$

where

$$K = \log_{10} [\log_{10} (H_0/H_w)], \text{ and } M = m \log_{10} e \qquad [22]$$

The authors have checked formula [20] with the experiments mentioned in precisely the same manner as formula [16] was checked with direct temperature measurements. In all of about forty experiments plotted by the authors, the agreement with the theory is at least as good as those published in their paper, while in the corresponding curves for Perry's formula there is a consistent tendency to be low in the middle.

The relation between M in equation [21] and the weight of gas per minute is shown graphically in Fig. 3 in which

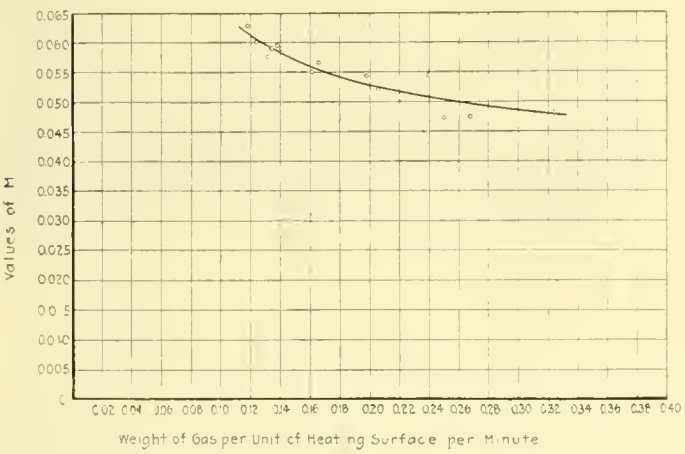

Fig. 3 Variation of M in Equation [21] with Weight of Gas Passing Through Tube

these two quantities are plotted against each other from pairs of values found in a series of nineteen experiments using a standard 2-in. boiler tube with different furnace temperatures and gas velocities. Other experiments, not yet sufficiently complete, in which smaller tubes are used, seem to indicate that M also varies with the size of the tube. The data are not yet sufficiently complete to warrant a definite conclusion as to the exact nature of this dependence, except that M is larger for small tubes than for large tubes.

If M were constant for all gas velocities, it would follow that the boiler efficiency would be constant for all rates of driving. The decrease in the value of M is in accord with observed practice, since it shows that the efficiency decreases as the boiler is forced.

If the efficiency E of a tube of length x be defined as the heat absorbed in that length of tube divided by the total heat content of gases reckoned above water temperature, we have

$$\left(1 - E\right) = \frac{H - H_w}{H_0 - H_w} = \frac{H_w}{H_0 - H_w} [\, (H_0/H_w)\, e^{-mx} - 1] \qquad [23]$$

where $m = M \log_e 10 = 2.3026 \times M$

The rate of drop in temperature along the tube is expressible readily on carrying out the indicated differentiation in [10]; this gives

$$d\theta/dx = -m\theta \log_e (\theta/\theta_w) \qquad [24]$$

or, by [14]

$$d\theta/dx = -2.3026\, m\, K_0\, \theta\, e^{-mx} \qquad [25]$$

Since the volume of a given weight of gas is proportional to its absolute temperature θ, the weight of the amount of gas δQ in a section of length δx is inversely proportional to θ, and we have

$$\textit{loss of heat in } \delta Q = + ce^{-mx}$$

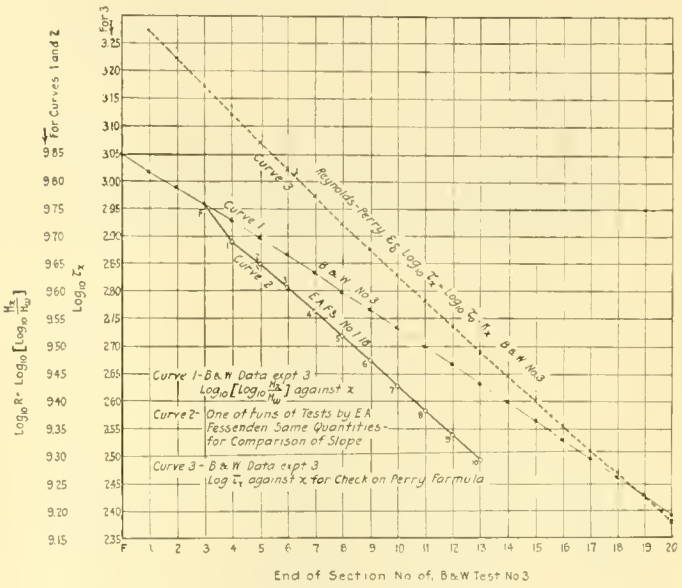

Fig. 4 Babcock & Wilcox Experiments No. 3 Check against Perry's and Authors' Formulæ

which agrees with [4], and shows the equivalence of the fundamental assumptions mentioned at the beginning.

Finally, the conductivity and its reciprocal, the resistance, may be formulated. The conductivity γ is

$$\gamma = c_p m \frac{\theta}{\theta - \theta_w} \log_e \theta/\theta_w = c_p m \theta \frac{\log \theta - \log \theta_w}{\theta - \theta_w} \qquad [26]$$

Since we have for values of θ less than twice θ_w the series

$$\log \theta - \log \theta_w = \frac{1}{\theta_w}(\theta - \theta_w) - \frac{1}{2\,\theta_w^2}(\theta - \theta_w)^2 + \ldots$$

we have also

$$\gamma = c_p m - \frac{\theta}{\theta_w}\left[1 - \frac{1}{2\,\theta_w}(\theta - \theta_w) + \ldots\right]$$

whence it follows that γ approaches $c_p m$ a limit as θ approaches θ_w. The constant m which occurs throughout the preceding work may therefore be thought of as proportional to the limiting value of the conductivity as the temperature of the gases approaches that of the water. Thus the fact that the value of M, which is proportional to m, is smaller for a large pipe, may be interpreted to mean that the gases in the large tube have less contact with the tube wall per unit of volume.

In an addendum to their original paper, the authors have checked against their theory the results of a new series of experiments made by the Babcock and Wilcox Company. Due to the conditions under which the experiments were made, which differed somewhat from those under which Professor Fessenden made his experiments, the authors are of the opinion that the data should give points slightly low at the hot end, and also slightly low on the cold end.

The data computed by the authors are plotted in Fig. 4. It will be seen that the check, which again consists in the fact that points should lie on a straight line, is very good. There appears to be a slight lowering of the points at both ends, as would have been expected.

On the same figure, the authors have shown an attempt to check the data with Perry's formula. The points vary from a straight line in a manner similar to the behavior of other sets of data previously discussed.

The formulae given by other writers and in Bulletin 18 of the U. S. Bureau of Mines are substantially the same as Perry's. Unsatisfactory attempts have been made by the authors to check Jordan's formula.

The authors have checked through the assumption of Prof. William Kent (Steam Boiler Economy) that the rate of transmission is proportional to the square of the temperature difference. Using the Babcock and Wilcox data, it was found that the exponent of the temperature difference should be 1.2 instead of 2 or

$$q = \frac{(T - t)^{1.2}}{a}$$

instead of

$$q = \frac{(T - t)^2}{a}$$

with a of value about 400 to satisfy the tests. It should be noted that q is the rate of transmission per unit surface but not per degree difference in temperature. The formulae of Rankine are substantially the same as those of Kent.

The authors feel that the tests agree substantially with the theory they present, but do not agree with any other formulae known to them to the same extent.

DISCUSSION

F. E. CARDULLO presented a written discussion in which he said that equation [4] of the paper, although appearing to be rational, could not represent any actual physical law as the quantity of gas considered was continually diminishing according to some law which was a function of x; and that the assumption that decrease in entropy in a small section of a tube of length δx is proportional to the entropy difference $\varphi - \varphi_w$ also appeared to be rational until, upon investigation, there was found to be no reason for believing that the entropy, or rate of change of entropy, had anything to do with heat transfer, the fact of its leading to a correct conclusion being a mere coincidence.

Since the velocity of gases flowing through a constant cross section will be greater at high temperatures, because of larger specific volume of gas, equations derived from assuming the rate of heat transfer proportional only to temperature difference will not represent the facts unless modified to take into account the well known fact of increased conductivity with increased velocity. Thus the empirical equation happily chosen by the authors, $Q = KTlogT/t$, where Q is the rate of heat transfer in B.t.u. per sq. ft. per hr., T the absolute temperature of the gas at the given point, t that of the water, and K an experimentally determined constant, depending, among other things, upon the weight of gases flowing through the cross section in a given time, leads to astonishingly accurate results, while the usual assumption, that $Q = K\ (T - t)$, gives systematic, though not serious, inaccuracies.

The equation from Perry is manifestly untrue unless we assume that the air supplied to the fire is at the same temperature as the water in the boiler.

The authors' equations, neither leading to new conclusions regarding boiler design, nor modifying appreciably our ideas of the rate of heat transmission, represent a refinement of accepted theories in an unfortunately cumbersome form, although simpler equations, representing the facts as accurately or through as wide a range probably cannot be discovered.

WILLIAM KENT, in a written discussion, pointed out that the chief value of the paper lay in its proof of the invalidity of the formulae of Perry and Reynolds which are based on

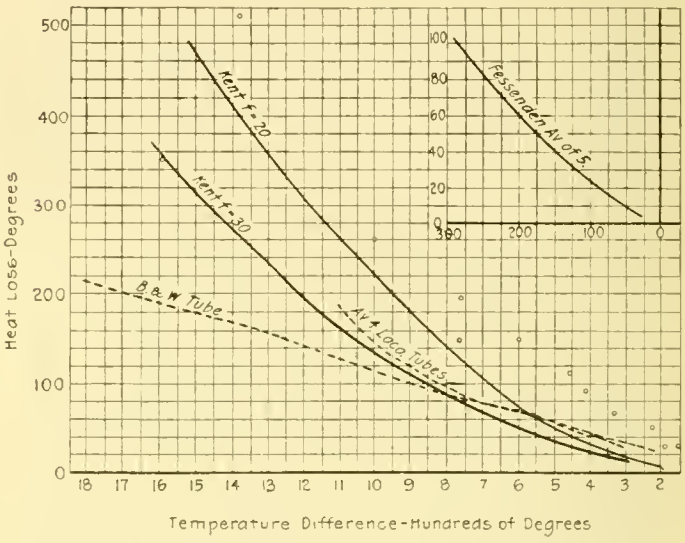

FIG. 5 RELATION OF HEAT LOSS TO MEAN DIFFERENCE BETWEEN TEMPERATURES OF GAS AND WATER

the assumption that the heat transmitted varies directly as the difference in temperature.

The results of boiler tests given in the authors' paper and accredited to Professor Kent are the averages of four tests made by C. B. Young and also given in the authors' paper.

His discussion presented a comparison of figures obtained by averaging Mr. Young's tests with the average of Professor Fessenden's five tests, the results of the Babcock and Wilcox test and the results of computations of two hypothetical cases, based on Rankine's formula, which differ only in the amount of gases ($f = 20$ and $f = 30$) per pound of fuel. (See Steam Boiler Economy, 2nd edition, p. 310.) Taking the difference in temperatures of two successive sections as a measure of the loss of heat by the gas and of the heat transmitted to the water, and the mean difference of the temperature between the gas and the water as the average of the temperatures at the beginning and at the end of a section, minus the constant temperature of the water, a table was constructed showing the relation of the heat loss to the mean difference between the temperatures of the gas and water. These figures are plotted on the diagram shown in Fig. 5.

It is interesting to note that the hypothetical curve for $f = 30$ agrees almost exactly with the four locomotive tube

tests between 1100 and 700 deg. temperature difference, but below the lower temperature, the curve merges with the curve of the Babcock and Wilcox tube. The curve of the Fessenden tube shows a steeper inclination between $(T_1 - t) = 297$ and 157 than it does at the lower temperature range, from $(T_1 - t) = 157$ to 33, while the curve of the Babcock and Wilcox tube shows a considerably flatter inclination at the higher than at the lower temperatures. All the curves, except that of the Babcock and Wilcox tube, show a distinct tendency to becoming convex to the axis of the abscissae. The Babcock and Wilcox tube curve cannot be made to fit the equation of any curve unless two of its points, $(T_1 - t) = 1350$ and 1246 are shifted downwards, when it becomes a straight line, indicating that the transmission of heat is proportional to the difference in temperature, which is contrary to all the other curves. The curves of the Fessenden tests coincide nearly with two straight lines of differing inclination. From $(T_1 - t) = 297$ down to 157, the loss of heat is $0.37(T_1 - t)$, while from $(T_1 - t) = 157$ down to 33, the loss is $0.29\ (T_1 - t)$.

The result of over thirty years' study has led Professor Kent to the conclusion that for boilers driven at a rate above

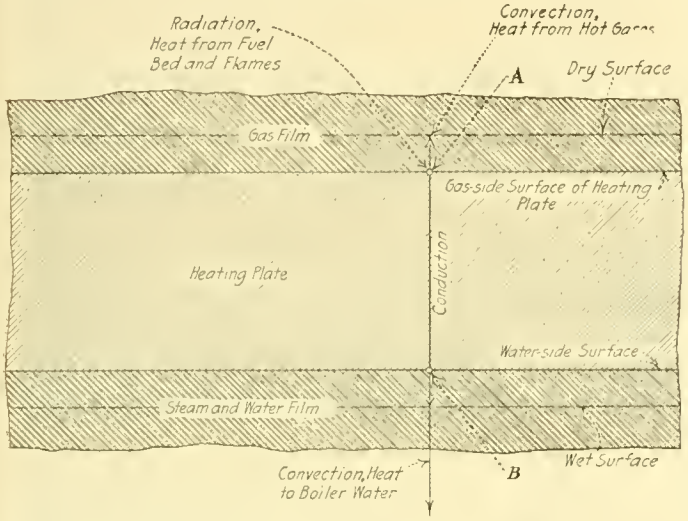

Fig. 6 Path of Heat Travel from Hot Gases Through Heating Plate Into Boiler Water

3 lb. evaporation per sq. ft. of heating surface per hr., at which the radiation loss is small, the formula for boiler efficiency is that of a straight line, $E = A - B(W/S - 3)$ in which A is the maximum efficiency at the 3-lb. rate of driving, W is the pounds of water evaporated from and at 212 deg. per hr., S is the square feet of heating surface, and B is an experimental coefficient, the value of which depends chiefly upon the amount of air per pound of fuel, but also upon the completeness of combustion and the cleanness of the heating surface. It apparently has no relation to the velocity of the gases.

The derivation of the straight line formula will be found in Kent's Steam Boiler Economy, 2nd edition.

Mr. Kent suggests the development of a formula based upon the assumption that the transmission of heat is $(T - t)^x \div a$, in which x is an exponent other than 2, say 1, 1.2, or 1.5.

Henry Kreisinger[1] and J. F. Barkley[2] presented a written discussion in which they reviewed the modes of heat propagation discussed by them in various publications.[3]

Fearful that the authors of the paper measured the temperatures in a manner not sufficiently accurate, Messrs Kreisinger and Barkley reviewed the reasons for and seriousness of these possible inaccuracies. From diagrams made by them from actual measurements, they show that temperature measurements taken in the centre of a boiler tube can not prove or disprove any theory of heat transmission.

The original equation of Reynolds,[1] $H = A\ (T - t) + B(T - t)qv$, not touched upon by the authors, applies to the convection part of the heat transmission in Fig. 6, stopping at the dry surface and not extending through the plate to the water; that is, t is the temperature of the dry surface. Perry distinctly states that t is the temperature of the film of gas next to the water. Further in his discussion,[2] he considers the

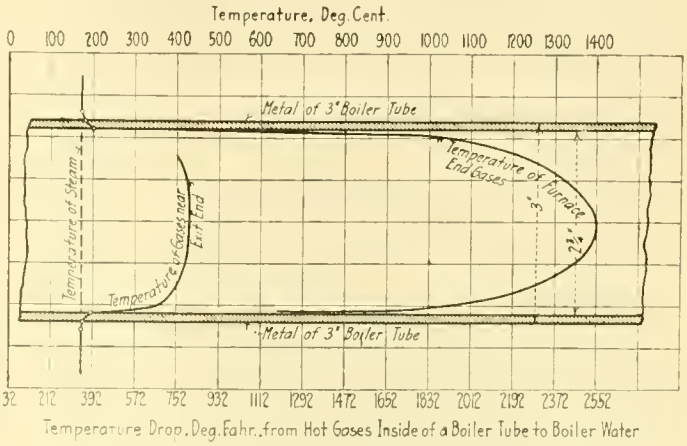

Fig. 7 Temperature Drop from Hot Gases in Boiler Tube to Boiler Water

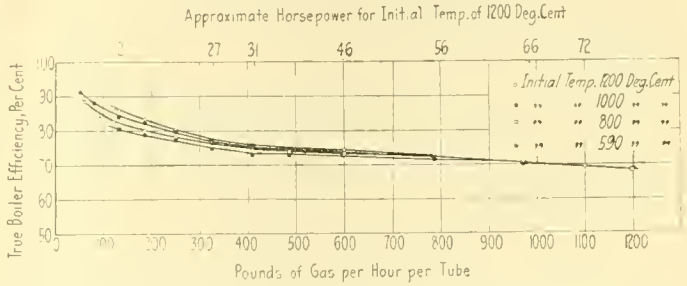

Fig. 8 Truth of Perry's Formula when Boiler Receives Heat Only by Convection

change in conductivity of the gas film and its effect upon t, obtaining an expression which includes the probable thickness and conductivity of the film as the velocity of the gases and their temperatures vary. He concludes that in existing boilers, the resistance of the metal itself is insignificant, but as better circulation is provided on both sides of the metal the total resistance must approximate more and more that of the metal itself. A footnote adds, "The above investigation shows that the following simple way of putting the whole matter is legitimate within certain limits of velocity, etc."

Perry then develops the simple form of equation used by the authors, $\theta = \theta_1\ e^{-cx}$, in which θ is the difference in temperature at any point along the path of the gases when the initial temperature θ_1 is given. In Fig. 4, the points obtained with the simple Perry expression are about as much one way from a straight line as the points derived from the authors' formula are the other way.

[1] Engineer, U. S. Bureau of Mines.
[2] Junior Electrical Engineer, U. S. Bureau of Mines.
[3] Bulletin 18, and Technical Paper 114, U. S. Bureau of Mines.

[1] Bulletin 18, Bureau of Mines, p. 114.
[2] Perry, The Steam Engine, 1909, p. 588.

Fig. 7 shows that the largest temperature drop is in the layer of gas about $\frac{1}{8}$-in. thick next to the wall of the tube, and only a very small drop from the gas side surface of the t tube through the metal and through the water film to the boiler water. The problem is to get the heat from the gas into the metal of the heating plate.

Perry's simple formula gives an expression for true boiler efficiency which is independent of the initial temperature. How nearly this is true when a boiler receives heat only by convection through its flues is shown in Fig. 8, which gives the results of some experiments. When a small weight of gas flows through the tube and the velocity is low, the efficiencies for 1200 deg. cent. and 600 deg. initial temperature are 4 or 5 per cent apart. As more gases are pushed through the tube at high velocity, the scrubbing effect increases, and the efficiency curves for the different temperatures come together. There seems to be considerable range, both as to temperature and weight of gas, for which the formula can be applied with but little error.

JOHN E. BELL,[1] in a written discussion, pointed out that the constant m in the authors' equation (24) has the dimension L^{-1} and is independent of θ, but depends on the physical characteristics of the gas, the velocity of flow, and the dimensions of the channel.

Introducing the entropy of the gas, particularly as a mean value, seems unwarranted, and certainly equation [8] is incorrect. The left hand side of this equation is the variation in the mean entropy of gas passing any section of the tube for a slight variation in the location of this section along the tube. This mean entropy must be measured in the same way as the mean temperature, which is found by averaging over the whole section, taking into account both the variation in temperature and the variation in velocity of flow. The mean entropy would be figured in this way, and equation [8] would not hold under these conditions.

If R represents the rate of heat transfer under different conditions, W the weight of the gas flow, and S the surface per unit length of channel, then, otherwise using the notation of the authors' paper,

$$\frac{d\theta}{dx} = \frac{-RS}{c_p W}(\theta - \theta_w)$$

Comparing this equation with equation (24) it is seen that

$$R = \frac{mc_p W}{S} \cdot \frac{\theta}{\theta - \theta_w} \log_e \theta/\theta_w$$

which is equation (26) of the paper with a little different notation. If this equation be correct, the transfer rate is the product of two factors, one $\frac{mc_p W}{S}$, independent of the temperatures and dependent on the weight flow and the dimensions of the channel, the other $\frac{\theta}{\theta - \theta_w} \log_e \theta/\theta_w$, independent of the weight flow and channel dimensions and dependent on the temperature of the gas only.

Experimental data published by the Babcock and Wilcox Company and dealt with in the authors' addendum shows that

$$R = a + bw$$

where a is a constant independent of the temperature and gas flow, b is a coefficient that varies with the temperature, and w is the weight of gas per sq ft. of flue area per hour. This cannot be of the form above unless the constant a has a zero value. Reynolds, Perry and other writers who have followed them, have assumed that such is the case, and have been led into conclusions which are not checked by facts. The experiments of the Babcock and Wilcox Company give to a the value 2.1, and the experiments of Jordan assign even a greater value. Since the value of this constant is unquestionably independent of the temperature, it appears that the law proposed in the paper can be only approximately true. It does not seem that Professor Fessenden's experiments were worked up to a point where the comparison made above could be satisfactorily carried out.

[1] 111 Broadway, New York.

LAWFORD H. FRY presented a written discussion in which he pointed out that the constants in the authors' empiric formula for transmission of heat along a boiler flue are constant only for each particular case, no means being offered by which the constants can be determined for varying conditions. Furthermore, it should be borne in mind that the temperatures measured in the flue in the tests of locomotive boiler tubes cited by the authors are probably affected by radiation to the walls.

If a general formula for heat transfer is to be established, it must take into account the nature of the gas flowing in the flue, the rate of flow, the dimensions of the flue, and the variation, if any, of the temperature along the wall of the flue. On such an equation, work has been done by Nüsselt (*Zeitschrift des Vereines deutscher Ingenieure*, 9 July, 1910) and by Leprince-Ringuet (*La Revue de Mécanique*, No. 1911). It would also seem necessary to take into account the variation in specific heat with the temperature. Equations for this variation as published by the Babcock and Wilcox Company are cited, and the instantaneous specific heat is calculated, for a smoke box gas of composition, $CO_2 = 11.1$ per cent, $O = 6.9$ per cent and $N = 82$ per cent, to be 0.2568 at 400 deg. fahr. and 0.3019 at 2000 deg.

THE AUTHORS. We are pleased to note that most of those who comment upon our paper agree that our formulae represent experimentally observed facts better than other proposed formulae. We regret that Messrs. Kreisinger and Barkley fail to appreciate this close agreement.

The original Reynolds-Perry equation used by the Bureau of Mines, and quoted by Messrs. Kreisinger and Barkley,

$$H = A(T - t) + B(T - t)qv. \qquad [1a]$$

we prefer to write in the form

$$H = (A + Bqv)(T - t). \qquad [1b]$$

In this form, q is the density and v the velocity of the gas. Then qv is proportional to the weight of gases passing, hence

$$H = (A + Bw)(T - t) \qquad [1]$$

In any single experiment, the weight of gases passing must obviously be the same for all parts of the tube, hence, for any single experiment, the equations above reduce precisely to a statement that the heat transmitted is proportional to the temperature difference, and lead directly to what we have called Perry's formula. Hence the statement that this formula was not touched upon in our paper is only superficially true. It should be obvious that a test of what we call Perry's formula should also be a test of this one.

Possibly formula [1] might be made to fit experiments if

the quantities A and B are admitted to be variables and not constants. Our own tests, as well as those of the Babcock and Wilcox Company, indicate clearly that B is itself a function of the temperature difference, which varies along the tube, and possibly also of the physical properties of the gases. These experiments also indicate that A probably varies with $(T - t)$.

We agree thoroughly with Messrs. Kreisinger and Barkley that temperatures measured by thermocouples placed in the tubes are highly unreliable. (See par. 27 and 28 of original paper). The Fessenden experiments were conducted by almost precisely the same methods as those used in the Babcock and Wilcox experiments. In neither were direct temperature measurements used, except at the end of the tubes.

Mr. Bell, quoting from the bulletin describing the Babcock and Wilcox experiments, uses the formula

$$R = a + bw \qquad [2]$$

to express the heat transfer rate. This is identical with equation [1] above except that b is a variable depending upon the temperature difference instead of a constant. It should be noted that the Babcock and Wilcox bulletin (p. 66) calls attention to the fact that the straight lines shown on the chart referred to are in reality secants or tangents to curved lines which really represent the facts. The same bulletin also shows that a varies with the weight; and we have some evidence, though not entirely conclusive, that a is also a function of the temperature difference. It would thus appear that equation [2] should be

$$R = u + vw$$

where u and v are functions of the temperature difference at least and probably also of other conditions. It then seems that equation [2] may in reality be simply the first terms of a series which might well be expressed by the logarithmic form we have used.

For Mr. Fry's information it may be stated that in all of our own experiments the specific heat of the gases was carefully taken into account.

It should be noted that in making his calculations upon the Fessenden experiments, Professor Kent has used the heat content of the gases above the water temperature instead of the temperature differences used in compiling other data, thus displacing the curve for these experiments far to the right of its proper place. We object seriously to the averaging of several tests; and wish to state that we did not know that the data so kindly furnished us by Mr. Kent was made up of averages from a number of Mr. Young's tests.

Professor Kent's contention that the boiler efficiency, and therefore the heat transfer rate, has no relation to gas velocity is manifestly incorrect. This has been shown by many experiments; and furthermore, Professor Kent's own formulae apparently take some account of gas velocity in that they employ the gas weight.

We do not understand Professor Cardullo's use of the term "rational" as opposed to "empirical." We contend that some assumption underlies every theory. We cannot conceive how any assumption can be called rational which does not check with experiment. The statement that the rate of heat transfer is proportional to the temperature difference is, in reality, an assumption; and as it is not borne out by experiment, why should it be styled "rational"?

A more complete presentation of the Fessenden experiments, together with detailed discussion of the results and the various constants and coefficients involved is now in preparation and will be published in the near future as a bulletin of the Engineering Experiment Station of the University of Missouri.

The Flow of Viscous Liquids Through Pipes has been investigated by the Research Laboratory of Applied Chemistry of the Massachusetts Institute of Technology and the results are given by W. K. Lewis in *The Journal of Industrial and Engineering Chemistry* for July 1916.

Mr. Lewis says that although our knowledge of the resistance to flow of water through pipe lines is relatively satisfactory and complete, there has been practically no publication on such resistance with liquids other than water, and a series of tests was made to study the flow of mineral oils of varying viscosity and at different rates of flow.

Liquids of even moderate viscosity flowing under low heads follow viscous motion unless the pipes be very large. It is very important to keep in mind the fact that, so long as the motion is viscous, doubling the size of the pipe increases the velocity four-fold and the discharge sixteen-fold for the same pressure drop. For the same discharge a pipe twice the size requires only one-sixteenth the pressure drop and, therefore, but one-sixteenth the power.

Introducing a paper on a description and tests of an eight-effect distilling plant, Frank T. Leilich says that all distilling plants are based upon the well-known principle that if water containing salts or other materials in solution or suspension be vaporized and the dry vapor condensed, the condensation will be free from impurities; but only, however, if the salts are not vaporized at or below the steam temperature.

In the distillation of sea water, apparatus for the production of pure water has, naturally, found its widest application in marine service, where it is imperative that "make-up" water for the boilers and also drinking water be supplied. Water containing up to 30 gr. NaCl per gallon may be used for drinking purposes, but it has a brackish taste.

Except where water is desired in very small quantities, the fuel consumption per gallon of output is perhaps the most important consideration, and the author mentions the logical development from the simple and familiar closed water vessel in combination with a coil condenser, heated by a gas burner, and very wasteful of heat, to the method of leading the steam from the closed vessel to tubes or coils immersed in water in a second similar vessel, known as an "effect," and thus cause the heat of the steam to evaporate water in the second effect, from which the steam may be lead to a third effect. In actual practice the first closed vessel is the steam boiler or some other source of steam supply.

Mr. Leilich gives a description and the data from tests of a 5,000 gal. plant being installed in an isolated fortification, where fuel is expensive and storage facilities limited. Diesel engines are used and the boilers for the distilling plant are fired with fuel oil. The specifications called for 5,000 gal. per day of twenty-four hours, and an average production of distilled water of 6 lb. for each 1,177 B.t.u. of total heat above 32 deg. fahr. contained in the steam supplied to the apparatus. Practically, this means operating at a six to one efficiency, 1,177 B.t.u. being the total heat of one pound of dry saturated steam at a pressure of 45 lb. gage; the minimum pressure allowed.

A diagrammatic arrangement of the piping is shown and the results of the tests are given in charted and tabular forms.—*Jour. Eng. Club of Baltimore*, June, 1916.

THE MEASUREMENT OF VISCOSITY AND A NEW FORM OF VISCOSIMETER

By H. C. HAYES,[1] SWARTHMORE, PA. and G. W. LEWIS,[2] SWARTHMORE, PA.

Non-Member Non-Member

IN determining the lubricating properties of an oil, the viscosity test is considered of great value, since by means of this test a good oil can readily be distinguished from a poor one. It is therefore very important that the engineer be able to measure the viscosity of an oil and also the variation of viscosity with temperature.

The present paper, dealing with the measurement of viscosity, gives in part the results of a somewhat extended research on the lubricating properties of oils. It is to be followed by a paper giving the relation between the lubricating properties of oils and some easily measurable physical properties.

VISCOSITY

Matter in all states exhibits a gradual yielding to tangential forces which tend to change its form. This property is termed viscosity and may be defined quantitatively as tangential force per unit area divided by shear per unit time.

To gain a clear physical concept of this definition, consider a plane surface, Fig 1, of area S, parallel to and at a distance d from another large plane surface, and the intervening space filled with a liquid whose coefficient of viscosity is η. If a given force, F, acting on this plane, is applied to S, the surface will be dragged along and will finally attain a steady velocity, which denote by V. In accordance with the above definition, the relation between these various factors would then be

$$\eta = F/S \div V/d \text{ or } \eta = F \,.\, d \div S \,.\, V \qquad [1]$$

the value of η depending on the units in which these various factors are measured. If absolute values are desired, the factors on the right hand side of the equation are to be measured in C.G.S. units; but if relative values will suffice, as is the case in nearly all engineering work, they may be measured in any units.

It must be borne in mind that equation [1] is not true when the velocity V, is changing, for then only a part of the force F, is used to overcome viscosity, a part being used in giving accelerated motion. Under such conditions, another term must be added to this equation. The nature of this term is not difficult to see, for let equation [1] be written $F = \eta \,.\, S \,.\, V/d$. When there is accelerated motion, the force, F, will be divided into two parts, the part used to overcome viscosity and that used to give accelerated motion. Call these parts f_1 and f_2 respectively, then at any instant $F = f_1 + f_2$,

[1] Prof. of Physics, Swarthmore College.

[2] Asst. Prof. of Engrg., Swarthmore College.

SYNOPSIS

The measurement of viscosity, the property of matter by which it tends to yield gradually to tangential forces acting to change its form, is the subject of this paper. This measurement is of first importance in determining the lubricating properties of an oil.

The treatment of the subject is lucid. The paper first defines the *coefficient of viscosity* and then develops a working formula for determining this coefficient. It continues with a description, with illustrations, of the various types of meters for measuring viscosity now on the market. These include short capillary meters, in which the liquid to be tested is forced through the capillary and the viscosity determined in terms of the time occupied in the flow, and orifice meters, employing an orifice in place of the short capillary. The paper predicts the errors introduced by the various types, and verifies these predictions in the case of the two types mentioned above by comparing the temperature-viscosity curve given by these meters for a light and a medium lubricating oil, with the true curves as determined by a modification of the capillary method used by Poiseuille, who, with Girard, first measured viscosity with accuracy.

The paper shows that the short capillary types give results about 50 per cent, and the orifice types about 100 per cent too small, and that none of the meters heretofore in use gives accurate comparative results for two different oils or for the same oil at different temperatures. It states that the only viscosimeter on the market that can be expected to give accurate results is the Stormer instrument, which attempts to measure the viscosity in terms of the torque required to spin a disc within the liquid. This instrument is debarred, however, on account of the mechanical difficulties involved.

The authors then describe their own meter, which they claim embodies all the good points of the Stormer meter and none of the defects. In this meter the viscosity is measured in terms of the torque which a cylinder experiences when suspended within a rotating liquid.

The specimen of liquid to be tested is contained within a cylindrical chamber which is rotated uniformly by a motor. A cylinder is suspended within the specimen by a wire so that the axes of the rotating liquid and cylinder coincide. The specimen chamber is surrounded by an oil jacket in which a thermometer is suspended. The jacket oil may be brought to any desired temperature by a heating coil. The cover of the jacket chamber has a scale graduated in degrees or may be calibrated to read the viscosity in terms of a standard liquid directly through the deflection of a pointer.

The authors have thoroughly tested out the meter, and found that the results given agree to within one per cent with the true curves for the light and medium oils and can safely be used as a standard.

The advantages claimed for the meter are: The instrument can be calibrated to give direct readings of the viscosity; the oil is not handled during a complete test at various temperatures; the design of the instrument is such that the temperature of the specimen follows closely the temperature of the bath, so the data for the temperature vs. viscosity curve can be taken while the sample is cooling; the meter gives the viscosity of mixtures, such as paints, as well as for liquids that have been carefully filtered; there are no glass parts to break; the personal error is eliminated and the meter can be made self recording.

In the discussion which followed the presentation of the paper, and which is here published, there was some criticism of the new meter, in some of which the extreme accuracy of the instrument was questioned, and some of which was incited by the fact that the meter gives results in other than absolute units, and so adds another scale to the existing scales of viscosities. The questions raised in the discussion are all answered in complete form in the authors' closure.

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where $f_1 = \eta \cdot S \cdot V/d$ and $f_2 = M \cdot dV/dt$, where M is the mass that is being accelerated and dV/dt is the average change of velocity per second of this mass. The complete instantaneous equation thus becomes

$$F = \eta \cdot SV/d + M \cdot dV/dt \qquad [2]$$

and the viscosity cannot be found from this equation unless the last term can be evaluated, which is usually difficult and often impossible.

DEVELOPMENT OF A WORKING FORMULA

In most physical measurements, comparative values are more easily obtained than absolute values. As a result measurements are made in terms of some standard, the absolute value of which has been determined by a more or less laborious process. In making measurements of viscosity, the standard usually chosen is water at a temperature of 20 deg. cent.

Girard and Poiseuille, by studying the flow of liquids

Fig. 1 Conception of Viscosity

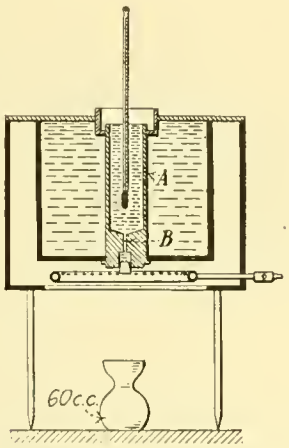


Fig. 2 Short Capillary Type Viscosimeter

through capillary tubes, were the first to measure the absolute value of viscosity with anything like accuracy. On the basis of his excellent experimental work on the viscosity of water, Poiseuille deduced the formula

$$V = K.D^4.H/L$$

where V = volume of liquid transpired
L = length of capillary
D = diameter of capillary
H = pressure
K = constant for each liquid at a given temperature.

Later, this empirical formula and its corrections were proved by several investigators.[1]

By assuming there is no slip at the surface of the capillary, that the liquid flows steadily without eddies or turbulent motion, and that there is no kinetic energy of efflux, then the transpiration formula for a liquid flowing under its own head becomes

$$\eta = \frac{\pi}{8} (hgr^4/lv)\, \rho t$$

where η = coefficient of viscosity (often contracted to viscosity)
h = liquid head
g = acceleration of gravity
r = radius of capillary
l = length of capillary
v = volume of flow
t = time of flow
ρ = density of liquid.

Experiment shows that the first assumption is true if the

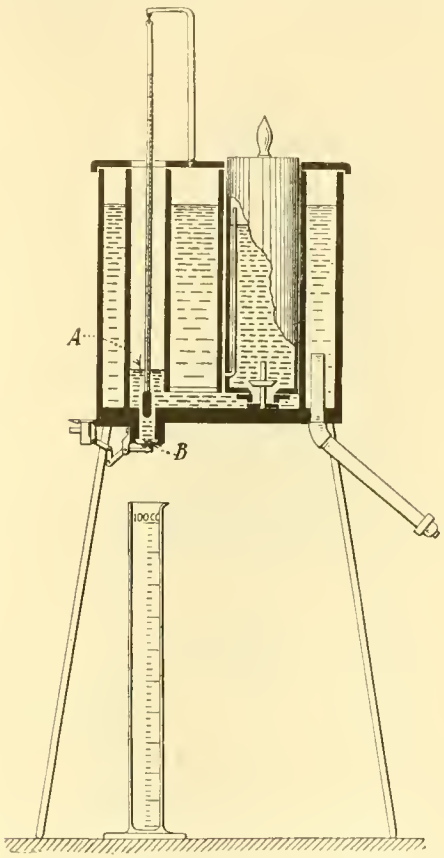


Fig. 3 Orifice Type Viscosimeter

liquid is one that wets the surface of the capillary. The work of Reynolds shows the second assumption is true if the velocity of the liquid through the capillary is kept less than $700 \cdot \eta/\rho \cdot r$ cm. per sec. The third assumption, of course, can never be true. The liquid must have kinetic energy when it leaves the capillary. In accordance with equation [2], a correction term must be added which, according to Couette, Finkener, and Wilberforce, should be $-v\,\rho/8\pi lt$. The complete expression for the viscosity is therefore of the form

$$\eta = \rho\ (A \cdot t - B/t)$$

where A and B are constants for any piece of apparatus, ρ and t are the density and time of flow, respectively.

After a thorough examination of the recorded data on the viscosity of water, Knibbs concluded that the correct formula should be

$$\eta = \pi hgr^4\rho t/8\ lv - 1.12v\rho/8\pi lt$$

It is to be noted that the correction term is larger than that

[1] Stokes, Trans. Camb. Phil. Soc., 1849, vol. 8, p. 287; Wiedmann, Poggendorf's Annalen, vol. 99, p. 177; Hagenoack, Pogg. Ann., vol. 109, p. 385; Stefan, Wien. Bar., vol. 46, p. 495; Couette, Ann. Chim. Phys., vol. 21, p. 433; Neumann, Vorträge über Hydrodynamik; Wilberforce, Phil. Mag., vol. 31, p. 407; Jacobson, Arch. f. Anat. u. Physiol., 1860, p. 80; Knibbs, J. Roy. Soc. N. S. W., vol. 29, p. 77; Boussinesq, Compt. Rend., vol. 110, p. 1160; Brillouin, La Viscosité (Gauthiér Villars, 1907.)

given by Couette. Moreover, this correction term varies with the time of flow, approaching zero when the velocity of flow is very slow, in which case t becomes very great. The value of the term increases with the temperature of the liquid since the time of flow decreases, and so the percentage of error in a viscosity vs. temperature curve due to neglecting this correction factor will increase abnormally toward the higher temperatures. This is due to two causes, the correction to be applied increases with the temperature and the value of the quantity to be corrected decreases rapidly with the temperature. Attention will be called to this fact when some of the various comparative methods are discussed. It is further to be noted that this correction term varies inversely as the length of the capillary. A short capillary requires a large correction term.

This formula, as corrected by Knibbs, has been submitted

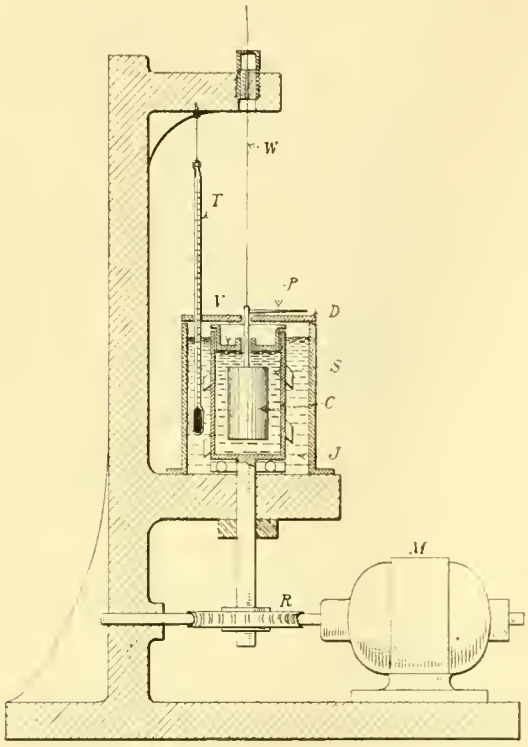


FIG. 4 THE NEW VISCOSIMETER

to careful experimental test by Hosking, and by Bingham and White. These investigators have determined the constants of the formula experimentally and have obtained fair agreement with theory. The capillary tube method, as employed by these experimenters, though complicated and laborious, can be depended upon for giving absolute values of the viscosity, and the accuracy of any viscosimeter can be determined by a comparison with the results obtained by this method.

CLASSIFICATION OF VISCOSIMETERS

Class 1. *Short Capillary.* In meters of this type, the liquid to be tested is forced either by gravity or by pressure through the capillary and the viscosity is determined in terms of the time required for a given volume to pass through the meter, as compared with the time required for a standard liquid to discharge the same volume.

A cross section of a meter of this type is shown in Fig. 2. The essential parts of the instrument are a cylindrical bowl, A, in which the oil is placed and a short capillary tube, B, through which it is discharged. The instrument must have temperature controlling and measuring devices, means for starting and stopping the flow and volume and time measuring apparatus.

To this class belong the Saybolt meter, adopted as a standard by the Standard Oil Co.; the Engler meter, adopted as a standard by the U. S. Government and Germany; the Redwood meter, adopted as a standard in England; the Scott meter; and the pipette, adopted as a standard by the Pennsylvania Railroad and much used by chemists. The majority of the viscosimeters on the market are of the short capillary type.

Class 2. *Orifice.* This type employs an orifice in place of the short capillary of the previous type. Fig. 3 is a section of such a meter, in the cylindrical bowl, A, of which the oil to be tested is kept at constant head above the orifice, B. The Carpenter meter belongs to this class.

Class 3. *Dropping a solid body through a tube filled with the liquid,* the solid body being usually a sphere or a plunger. Meters employing this principle determine the viscosity in terms of the time required for the body to drop a certain distance through the liquid, as compared with the time required

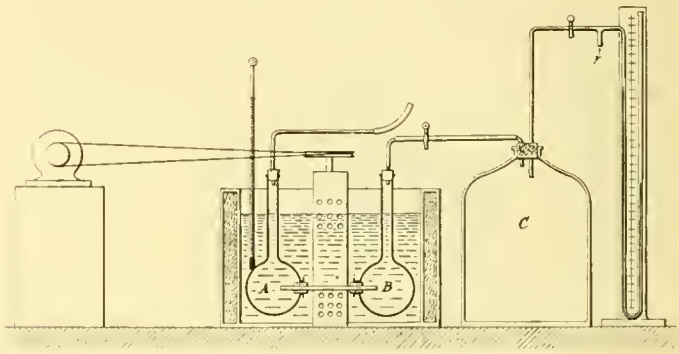


FIG. 5 CAPILLARY TUBE METHOD

for the same body to drop through a standard liquid. To this class of meters belong the Perkins meter, which employs a plunger and vertical tube, and the Flowers meter, which employs a small steel sphere and a slanting tube.

Class 4. *Oscillating Disk or Cylinder.* These meters determine the viscosity in terms of the damping which the oscillating disk or cylinder experiences when placed in the liquid as compared with the damping when placed in the standard liquid. The Doolittle meter is an example of this class.

Class 5. *Rotating Disk or Cylinder.* This type determines the viscosity in terms of the speed of rotation of the disk or cylinder in the liquid under test as compared with the speed of rotation in the standard, the driving torque remaining constant. The Stormer meter is an example of this class.

DISCUSSION OF THE VARIOUS TYPES

The paper here enters into a discussion of the value of each of the above types, so far as accuracy is concerned. It enumerates the following errors and indicates their causes and magnitudes:

Acceleration error. In all meters of *Classes* 1 and 2 the acceleration term ($M \cdot dV/dt$) is neglected since its evaluation is impossible. This introduces an acceleration error.

Surface tension error introduced in all flow types due to difference in surface tension of the standard liquid and the liquid under test.

Critical velocity error. A source of error in most capillary and orifice forms is that the dimensions of the instrument are such that for the standard, water, the flow exceeds the critical velocity and the resultant turbulent flow makes the value of t abnormally large.

These three errors are prominent in all meters named above as standards and cause the viscosity as given by these meters to be much too low.

The constant speed of rotation which a disk or cylinder immersed in a liquid will attain under the action of a constant torque is a true measure of the viscosity of the liquid. The Stormer viscosimeter attempts to operate in accordance with this principle, but the friction of the moving parts is necessarily such that a constant torque cannot be obtained. With proper refinement, this meter could be made to give good results. The fact that a meter based on this principle can theoretically give accurate results has led to the development of a new viscosimeter now to be described.

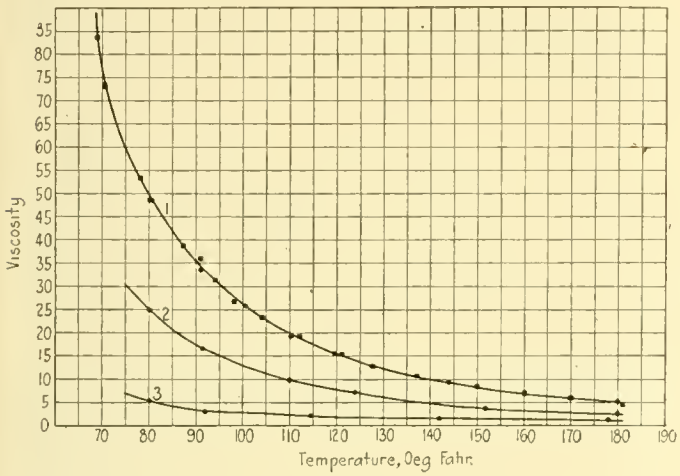


Fig. 6 Viscosity Curves for Medium Gas Engine Oil

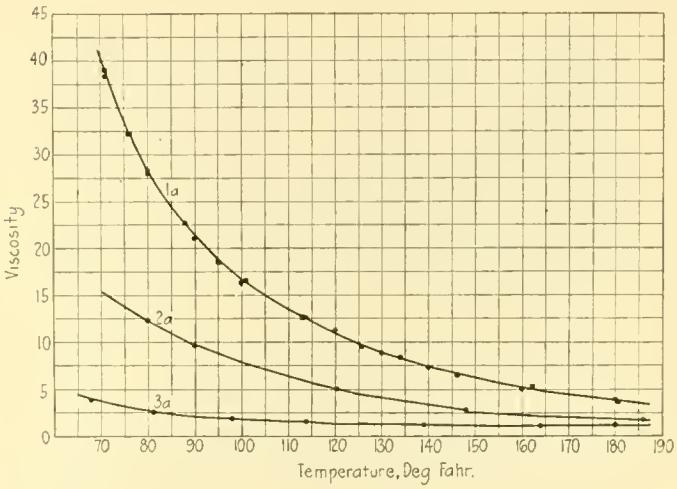


Fig. 7 Viscosity Curves for Light Gas Engine Oil

THE NEW VISCOSIMETER

This viscosimeter operates in accordance with the principle that a solid body having a surface of revolution experiences, when suspended in a rotating liquid, a torque which is proportional to the viscosity of the liquid. The instrument is shown diagrammatically in Fig. 4. The specimen, S, is contained within a cylindrical chamber which is caused to rotate uniformly by a motor, M, through a worm drive, R. A cylinder, C, is suspended within the specimen by a thin steel wire, W, so that the axis of the rotating liquid coincides with the axis of the cylinder. The specimen chamber is provided with a cap, V, so shaped that the excess liquid can overflow when the cap is seated and thus give constant conditions within the chamber. The specimen chamber is surrounded by an oil jacket, J, in which a thermometer, T, is suspended. The jacket oil may be brought to any desired temperature by means of a heating coil, or a side coil not shown in the diagram. The cover, D, of the jacket chamber is provided with a scale which is marked in degrees or may be calibrated to read off directly, through the deflection of the pointer, P, the viscosity in terms of a standard liquid. The specimen chamber and the suspended cylinder are both made of copper to insure constant temperature throughout the specimen and the outside of the specimen chamber is provided with blades which keep the jacket oil thoroughly mixed as the chamber revolves and thereby exposes the latter to a uniform temperature. This is an important factor toward insuring constant temperature throughout the specimen.

The experimental work has shown that the temperature of the specimen is uniform to within a small fraction of a degree. Moreover, the temperature of the specimen follows the temperature of the jacket oil so closely that the temperature-viscosity curve can be taken while the temperature is slowly raised or lowered. This proves to be a great saving of time. It also saves labor, for one does not need to stand by the instrument continually. The deflection of the pointer is at any instant a measure of the viscosity, so all that is required is to take simultaneous readings of temperature and deflection at intervals during the heating or cooling process.

EXPERIMENTAL RESULTS

To test the accuracy of this viscosimeter, the temperature-viscosity curve was found for a light and a medium gas engine oil by the capillary tube method, the apparatus for which is shown in Fig. 5. The oil was drawn from vessel A to vessel B, and vice versa, by connecting each in turn with the partial vacuum chamber, C. These vessels were submerged in a thermostat which could be maintained at any desired temperature. The results, in terms of the viscosity of water at 20 deg. cent., are given by the points enclosed in circles for curves 1 and 1a, Figs. 6 and 7, the latter referring to the lighter oil. The viscosity of these same oils as given by the new meter is represented on curves 1 and 1a by the points enclosed in squares. The agreement between the two methods is almost perfect.

The viscosity of these oils as given by a meter of the short capillary type, Fig. 2, is given in curves 2 and 2a. Curves 3 and 3a give the viscosity of these oils as obtained with a meter of the orifice form, Fig. 3. As predicted, the results given by the short capillary type are much too low (on the oils tested about 100 per cent too low) and the results given by the orifice type are still lower.

CONCLUSIONS

The errors inherent in all flow types of viscosimeters have been predicted and the predictions verified by experiment. The magnitude of the errors are such that these meters cannot be depended on for giving even approximate results. The various meters of this type on the market do not give results which are in agreement, and no one of these meters can justly be claimed as a standard.

The new viscosimeter of the non-flow type described has the following advantages:

1 It gives values for the viscosity which are in agreement with those given by the standard capillary tube method.
2 During a series of tests at various temperatures, the oil is not handled.
3 The sensitiveness of the instrument can be made anything desired by changing the speed of rotation of the specimen or by using suspension wires of various diameters.
4 The density or change in density is not a factor in computing the results, in fact the instrument may be graduated to read off the viscosity directly.
5 The viscosity of liquids which contain particles in suspension can be measured, and the operation of the meter is independent of the color of the specimen.
6 The temperature-viscosity curve can be taken with a fair degree of accuracy while the temperature is rising or falling, as the temperature of the specimen follows the temperature of the jacket so closely.
7 The personal error which arises in determining time intervals with a stop watch is removed.
8 The instrument is simple, rigid and self-contained. It has no separate parts to get lost or glass parts to get broken.

DISCUSSION

MR. HERSCHEL CONSIDERS THERE IS NEED OF IMPROVED LONG CAPILLARY VISCOSIMETER

WINSLOW H. HERSCHEL (written): The authors practically admit that the long capillary viscosimeter is the most accurate instrument for determining viscosity. No objection can be raised against this method on grounds of accuracy, neither is it necessarily "complicated and laborious." Couette, who experimented with both the capillary and the concentric cylinder methods, regarded the capillary method as the more exact, and ascribed the error in the latter method to eccentricity. As far as can be determined from Fig. 4, I should judge that this error would be greater in the authors' instrument than in that of McMichael,[1] in which the shear in the liquid is mainly between the bottom of a suspended disk and the bottom of the revolving cup. I believe there is more need of improving old forms of instruments and methods of calculating viscosity than there is in devising new instruments. What is required is an improved, long capillary viscosimeter which is self-contained and portable; and the abandoning of such instruments, formulas and methods as lead to the expression of results in any other terms than of absolute viscosity. The revolving cup type of instrument may have a field of usefulness in commercial work, where quickness of determination is of more importance than extreme accuracy, but it is handicapped by its greater cost as compared with a capillary tube instrument.

MR. BINGHAM RAISES SOME POINTS OF CRITICISM

EUGENE C. BINGHAM[2] (written). The great misfortune of technical viscosity is that the results are not expressed in terms of absolute viscosity. Instead of this we have Engler degrees, Saybolt seconds, and many other units corresponding to the different types of instruments already suggested. The property, of interest in lubricating for example, can hardly be expected to be simply related to Engler degrees or any other arbitrary unit, even if it is simply related to viscosity. It is an advantage of the proposed instrument that it can be calibrated to read in terms of absolute viscosity, as is true of the McMichael instrument. It is the more unfortunate that the authors have expressed their results in other than absolute units.

It is also an advantage of this type of instrument that an accurate determination of the density does not have to be made before the absolute viscosity can be determined. The density undoubtedly affects the rate of flow in instruments of the Engler and Saybolt type, although the density is quite a distinct property from the viscosity. Unless the density is determined, the best that can be done is to calculate the viscosity divided by the density, i.e., the so-called *kinematic viscosity*.

The revolving cylinder and disk methods have been found to be less simple mathematically and less accurate experimentally than the capillary tube methods. Before the use of any one of these instruments becomes established, it should be shown that it will reproduce the absolute viscosity of liquids of widely different, but accurately known, viscosities. The error due to kinetic energy correction, eddy currents, lack of perfect centering, etc., should be carefully studied.

The tests which the authors have made are not convincing. They refer to the loss of pressure in giving kinetic energy to the liquid as the *error*, which is quite confusing. In instruments of the Engler and Saybolt types the times of flow are simply compared to the times of flow of water. Since these are arbitrary numbers there is no *error* due to acceleration. There *are* sources of error in these instruments amounting to two or more per cent, due to lack of perfect temperature control, etc., but that is quite different from the 100 per cent *error* mentioned. The authors use the term *error* as synonymous with what we may better term *kinetic energy correction*. Their Figs. 6 and 7 indicate the different values of the kinetic energy correction for different instruments, which would have been brought out clearly had they at some point in their paper expressed their results in terms of absolute viscosity. The fact that the curves for the capillary tube and the revolving cylinder are nearly identical would appear to mean that the kinetic energy corrections in both cases are nearly the same. It certainly does not prove that the kinetic energy correction is negligible in either case.

Instruments of this type have often been suggested for use with suspensions. Such use should be made with caution, since contrary to the statement in the paper, plastic substances do not "exhibit a gradual yielding to tangential forces" unless the tangential force exceeds a certain limit. Suspensions may be plastic, in which case the results with instruments of this type may not be interpretable on the ordinary assumptions.

The authors (Figs. 6 and 7) have made the common mistake of regarding *times of flow* as proportional to viscosity. It cannot be emphasized too strongly that this is not the case, although apparent authority for such a statement may be found again and again in the literature of the subject. It is rarely that the serious consequences of this erroneous assumption are so clearly apparent.

[1] Journal of Industrial and Engineering Chemistry, Nov. 1915.
[2] U. S. Bureau of Standards, Washington, D. C.

MR. PEABODY EMPHASIZES NEED FOR INTERNATIONAL STANDARD OF VISCOSITY

E. H. Peabody (written). The determination of the viscosity of oils used for fuel purposes is becoming a matter of increasing importance, owing to the rapidly growing use of the so-called mechanical atomizer. This type of oil burner sprays the oil by means of centrifugal force which is imparted to it by forcing the liquid through small passages tangential to a central chamber, from which it issues from an orifice the center of which usually coincides with the axis of rotation. Thus, the viscosity of the liquid has a very direct and important bearing on the satisfactory spraying of oil by this method, and usually the viscosity of the oil has to be reduced by heating. A knowledge of the temperature-viscosity properties of fuel oils is almost a necessity to the users of plants in which the mechanical atomizer is installed.

Any discussion of the matter of viscosity, therefore, is to be welcomed, and a paper which has apparently been prepared with so much care as this one, and which describes research work the result of which presents such a list of advantages as those given in the final paragraph of the paper, is a distinct addition to the art.

On the other hand, there will be little gain, at least in so far as the users of fuel oils are concerned, if the net result of the work of the authors is to impose upon the unsuspecting public still another and additional *scale of viscosities*. Thus, in Figs. 6 and 7, temperature-viscosity charts are given, and the horizontal scale is perfectly intelligible to ordinary minds; we all have a reasonable idea of temperature in degrees fahrenheit. But I would like to ask the authors what the vertical scale signifies, wherein the viscosity is given in figures ranging from 0 to 85. They call it *viscosity*—and the trouble now is that there are a score or so of different viscosity scales in use.

Almost any one of the instruments named by the authors, particularly those which have been adopted as standards by various interests (as the Saybolt, Engler, Redwood, etc.) would be entirely satisfactory if everybody used it. In other words, comparative values are about all we need, and as long as everybody bases his work on the same comparative values little trouble will result. If, however, different standards are used, each having its own individual meaning, great confusion will result,—and this, unfortunately, is the case with regard to viscosity. Thus, viscosity measured on the Saybolt scale is a very different thing from that measured on the Engler or Redwood, and it becomes necessary to specify whether the results are given in one or the other scale. Further, there appears to be no very definite way of making comparisons between the various scales, due, doubtless, to the very errors which the authors of this paper so clearly point out.

There is a crying need today of some international standard for the measurement of viscosity, and it is to be hoped that either this Society or some other will initiate some movement which will result in this very desirable agreement of all authorities.

In this connection, a very interesting suggestion will be found in the discussion of viscosity in a work entitled An Examination of Hydrocarbon Oils, translated from the German of Professor D. Holde by Dr. Edward Mueller, and published by John Wiley & Sons, 1915. In this book a formula devised by Ubbelohde is described, by which viscosity in degrees Engler may be reduced to *absolute viscosity*. The suggestion is made that the viscosity of liquids be reported in terms of the viscosity of water; in other words, that the absolute viscosity of water be taken as unity, and the absolute viscosity of other liquids (having been determined by the Engler instrument and corrected by Ubbelohde's formula, or by some other method) be reported in terms of these units as *specific viscosity*. This seems to indicate a very satisfactory solution of the matter, and is worthy of consideration as an international standard. Why would it not be quite as satisfactory to report absolute viscosity of liquids in terms of the absolute viscosity of water, exactly as we take water as a basis in *specific gravity, specific heat*, etc.?

I trust that the authors will describe more fully the meaning of their viscosity scale, and possibly point out a method of applying it to an international standard.

MR. HAYES REPLIES TO THE POINTS RAISED IN THE DISCUSSION

H. C. Hayes. In reply to Mr. Herschel, the authors do not "practically admit" that the long capillary method for determining viscosity is the most accurate. They simply claim this is the best absolute method for determining the viscosity of some standard liquid, but there are other methods, comparative methods, which determine the viscosity of an unknown liquid in terms of the viscosity of a standard liquid with less error than is introduced by the long capillary tube method in determining the viscosity of the standard liquid.

The long capillary tube method is certainly complicated and laborious. I have found from practice that several days are required to secure the data for a temperature-viscosity curve for a single oil. It must be remembered that the relation between the head and the tube dimensions must be such that the flow will never exceed the critical velocity, and this requires that the time of flow for the more viscous oils and for all oils at low temperatures will be abnormally great. Moreover, these capillary tubes are difficult to clean and hard to duplicate.

In regard to the McMichael instrument, the lines of flow above and below the disk are spirals, and not circles. This is due to the centrifugal action of the rotating liquid, and as a result an error is introduced, due to the fact that the liquid undergoes acceleration. This error is not great, but, such as it is, it is largely avoided in the Hayes-Lewis meter, where a cylinder is used instead of a disk. In this instrument the ends of the cylinder do not approach the top and bottom of the specimen chamber closely, and as a result most of the viscous forces are confined between the cylindrical surfaces of the cylinder and the chamber. The stream lines within this region are true circles and the liquid undergoes no acceleration, and as a result the small acceleration effect at the ends is negligible. This is one of the reasons for our using a cylinder instead of a disk.

For most engineering purposes the specific viscosity (absolute viscosity divided by absolute viscosity of water at 20 deg. cent.) will serve fully as well as the viscosity expressed in absolute units. The specific viscosity is readily transformed to absolute units whenever such units are required, and the calibration of viscosimeters is somewhat simplified by calling the viscosity of water unity.

Replying to Mr. Bingham, no claim has been made that the Hayes-Lewis viscosimeter is more simple than the long capillary tube as an absolute instrument. It certainly is less simple mathematically, but this fact does not prevent the instrument from giving excellent comparative results.

In regard to the reproduction of the absolute viscosity of liquids of widely different but accurately known viscosity, we

have attempted to do this. We have worked with water, light and medium oils, and glycerine. In each case the absolute value was obtained by the long capillary tube method in accordance with Knibb's formula:

$$\eta_1 = \pi h g r^4 \rho t / 8 l v - 1.12 v \rho / 8 \pi \eta_1 l t$$

where the meaning of the various letters is in accordance with Par. 8 of the paper. The coefficient of water at 20 deg. cent. so obtained was within 0.5 per cent of the value obtained by Hosking, and we have assumed the values obtained for the oils and the glycerine by this same method were of the same degree of accuracy. The values so obtained were in each case divided by the value obtained for water. In the case of the oils these values are plotted as dots in curves 1 and 1*a*, Figs. 7 and 8. Then the deflection given by our meter when water at 20 deg. cent. was placed in the specimen chamber was taken by means of a mirror, attached to the pointer, and telescope and scale. This angle was divided into the deflection angle given by the oils and glycerine. These values are plotted as squares on the same curves. The curves show almost perfect agreement between the two methods for the oils at various temperatures. The agreement in the case of glycerine was not quite as good, the greatest variation being 2 per cent. We were several days in securing these results and attributed this variation to the absorption of moisture by the glycerine. All told, it seems these results are convincing.

It is to be noticed that all kinetic energy corrections were made in determining the absolute viscosities in accordance with Knibb's formula, and as the results given by our meter are in good agreement, the work does prove that the kinetic energy correction is negligible despite Mr. Bingham's statement to the contrary.

Lack of perfect centering and small variation in height adjustment of the cylinder cause little or no error, for the reason that the viscous forces are inversely proportional to the thickness of the oil between the cylinder and container. The gain in viscous forces on one side of the cylinder, due to imperfect centering, is largely offset by the loss on the opposite side, and this is also true for vertical displacement, providing the displacement or lack of perfect centering is not great.

The authors have not claimed an error of 100 per cent or any other figure for the Engler or the Saybolt instruments when they are merely used to obtain Engler degrees or Saybolt seconds respectively. Their paper, as the name suggests, deals with the measurement of viscosity. And when, as is usually done when viscosity is determined with these instruments the formula $\eta_x = \rho_x t_x t_w$ is used for computing the viscosity, the 100 per cent error mentioned will be given. This error is due to the kinetic energy correction which is not corrected for and which is quite confusing. It is true that Ubbelohde's formula is useful in making this correction for the Engler instrument, and the recent work done by the U. S. Bureau of Standards giving the relation between the Engler and Saybolt instruments makes possible the correcting of the Saybolt instrument readings. Even if Ubbelohde's formula were correct (and it is only claimed to be approximate) still corrections that must be made in this roundabout way are confusing. There is great need for an instrument that gives results which require no correcting when absolute values of viscosities are required, and which gives at all times readings proportional to the absolute values.

Suspensions made of tempered steel may be plastic if the tangential forces brought into play exceed the elastic limit, but there is no reason why such forces should be brought into play. In fact, our instrument is so constructed that the suspension cannot be twisted beyond this limit.

A close reading of the paper will convince anyone that the authors have not made the mistake of regarding time of flow as proportional to viscosity. Our curves show clearly the serious consequences of this erroneous assumption, and we have regarded this as the chief value of our paper.

In reply to Mr. Peabody, we did not intend to impose on the unsuspecting public another meaningless viscosity scale. In fact, when trying to interpret the results given by various meters we have found the same confusion that he has apparently found. We have also felt the need of some standard unit to which all readings should be reduced, and we decided that the best unit would be that of water at 20 deg. cent. (the same as Mr. Peabody has suggested). The ordinates of our curves are given as the values of the absolute viscosity of the oils divided by the absolute values of the viscosity of water at 20 deg. cent. It was due to an oversight that the ordinates were not labeled "specific viscosity" instead of "viscosity," but the paper states what the ordinates are.

Electric operation of freight trains has been introduced on the Shilden-Newport branch of the North Eastern Railway in England. Locomotives of 74 tons weight are used, direct current at 1500 volts being supplied from an overhead catenary system.—*Electric Railway Journal*, July 1, 1916.

Some interesting details of the making of paper from bagasse at the Preston Central, Cuba, are given in the Bulletin of the Canadian Department of Trade and Commerce. Ten months ago, as an experiment, this Cuban factory started a department for the manufacture of wrapping paper from the by-products of their cane mill. The venture has proved successful and arrangements are being made for the manufacture of all grades of paper. The present daily output is four tons. Three weights of wrapping paper are made, of which the highest is 80 lb., and it is claimed that this paper made from cane pulp is equal to, if not slightly better than that manufactured from imported kraft stock, while it can be produced and marketed at a considerably lower price.—*The International Sugar Journal*, June 1916.

Advocating the adoption of some generally intelligible and convenient unit of viscosity measurement, whose use would radically improve a state of affairs where few know how to translate the results which they obtain into results comparable with those obtained with another instrument, Parker C. McIlhiney states that it has been suggested that the unit of viscosity expressed in C. G. S. units be called the "poise" in honor of Poiseuille, but the suggestion has not been adopted generally and it is customary to speak of the "absolute" viscosity of a liquid.

The study of this important physical property of liquids has been seriously hampered by the lack of any kind of uniformity in its measurement, and if the "poise" be adopted as the name of the absolute unit, use might be made of the decimal multiple and submultiples of this unit, and then the centipoise—1 *cp.* = 0.01 *p.*—would be almost exactly the viscosity of water at 20 deg. cent. or 68 deg. fahr. Thus for all practical purposes in the lubricating oil business, it would be sufficiently near the truth to say that the viscosity expressed in centipoises is the specific viscosity, that is, the viscosity as compared with water at 20 deg. cent. or 68 deg. fahr.—*The Jour. Ind. and Eng. Chem.*, May, 1916.

BOILER SETTINGS FOR SMOKELESS COMBUSTION

Including the Latest Form of Double Arch Bridge Wall Furnace Now Used by the Chicago Smoke Department for Burning High Volatile Fuels

BY OSBORN MONNETT,[1] CHICAGO, ILL.

ONE of the old ideas with respect to smokeless furnaces was that if the fire were surrounded with a mass of fire brick, thereby keeping the flames away from the boiler heating surface, complete combustion and smokeless operation would be accomplished. Following out this idea a number of furnaces were installed along this line in the early days of the present Chicago Smoke Department. The first construction adopted was known as the full extension dutch oven setting, as shown in Fig. 1. This setting was extravagant of floor space and also necessitated setting the boiler high in order to get the heavy fire brick arch under the shell. It was expensive to install and to maintain.

DUTCH OVEN SETTINGS

In order to meet the objections of engineers and architects the setting was finally modified into a semi-extension setting as shown in Fig. 2, and later to the flush front setting, Fig. 3 None of these settings obviated the criticism of expensive headroom, nor did they remedy the difficulty of high maintenance charges.

Experience with these settings showed that the idea of surrounding a fire with fire brick for the purpose of smoke elimination was a fallacy. It developed in the course of the experiments that the intense radiation from the red hot fire brick had the effect of distilling the volatile matter off from the fresh coal more rapidly than would be the case with the old plain settings. When high volatile coal is thrown onto a fire there is a certain amount of volatile distillation, due to the temperature. We will call this the normal rate of distillation.

On the other hand, when coal is thrown into a dutch oven furnace there is a distillation effect in addition to that caused by the heat of the fire itself, due to the radiation from the fire brick arch. This produces a double distillation, which causes the volatile gases to pass away from the furnace so rapidly that it is difficult to prevent smoking.

DEVELOPMENT OF HAND-FIRED FURNACES

In the effort to develop a hand-fired smokeless furnace for return tubular boilers it was therefore necessary to take steps to reduce the rapidity of volatile distillation, bringing this down to a point which could be taken care of by the furnace. Following along this line, the old flush front dutch oven, as shown in Fig. 3, was modified by removing the fire brick arch from over the fire. This had the effect of increasing the economy and capacity of the setting as it took advantage of the direct radiation of the heat from fire to shell. It still provided a high temperature zone over and back of the bridge wall through which the gases had to travel, and then broke them up with a bulkhead and fire brick deflection arch in the combustion chamber. This construction, properly operated, was successful as far as the elimination of smoke was concerned. It was not, however, a commercial proposition as it then stood. The setting was rather high, expensive to install

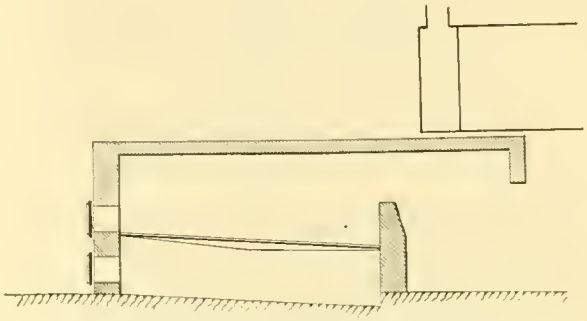


FIG. 1 FULL EXTENSION DUTCH OVEN FURNACE WITH DEFLECTOR ARCH

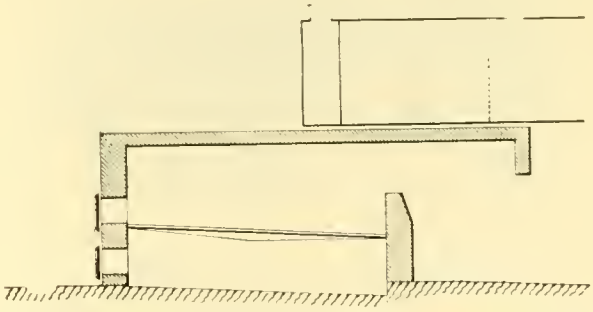


FIG. 2 SEMI-EXTENSION DUTCH OVEN FURNACE WITH DEFLECTOR ARCH

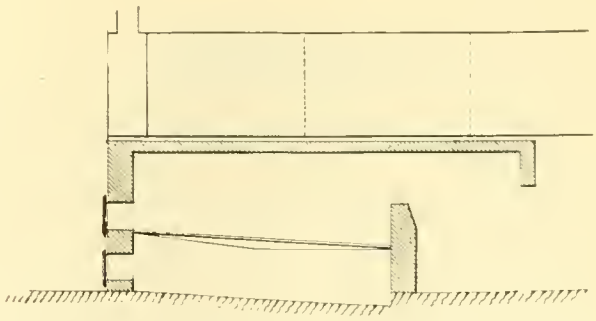


FIG. 3 FLUSH FRONT DUTCH OVEN FURNACE WITH DEFLECTOR ARCH

and maintain, and required buck stays in the side walls to take up the spring of the main arch. It was necessary to commercialize this setting, making it cheaper to install and to maintain, and reduce the head room required for its installation.

[1] Engineer, American Radiator Co.

Presented at the Cincinnati local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, October 21, 1915.

The construction finally worked out to meet the requirements is shown in Fig. 5. This is known as the double arch bridge wall setting, as now used by the Chicago Smoke Department. It consists of a plain grate with the shell of the boiler completely exposed to the heat of the fire and a high temperature zone over the bridge wall, built with a butterfly arch construction in two spans, this construction being adopted because it is cheaper and easier to install and repair; also it does not impose so much stress on the side walls. Following the butterfly arch is a single span deflection arch with a fire

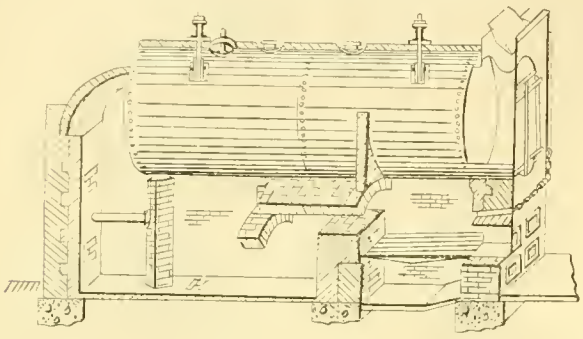


Fig. 4 Single Arch Bridge Wall Furnace with Single Span Deflector Arch

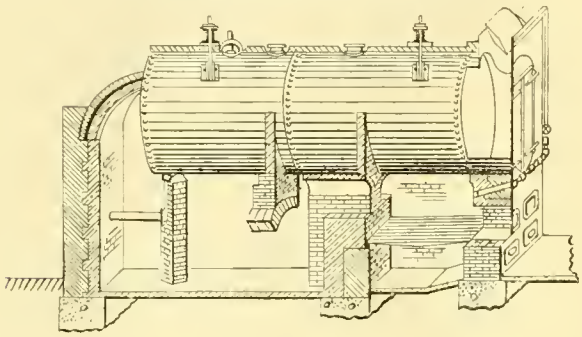


Fig. 5 Perspective View of Double Arch Bridge Wall Setting for 2-Course Boiler

brick bulkhead above, the bulkhead following the curvature of the boiler.

FIRING METHODS

The operation of the furnace then is as follows: When the fire is replenished by the alternate method of firing, the volatile matter distilling away from the fire passes back through the red hot tunnel of fire brick in which it is maintained at ignition temperature and where it mixes with the auxiliary air admitted through the air siphon steam jets and panel doors provided with the setting. In the combustion chamber this mixture of gas and air impinges against the bulkhead wall and passes under the deflection arch, being thoroughly mixed. Thus the conditions necessary for complete combustion are realized, namely, high temperature, which is obtained in the zone over the bridge wall; oxygen obtained by supplying auxiliary air and mixture of the gases. In such a setting it is possible to observe a secondary combustion taking place under the deflection arch, this combustion being as clean as a flame from a Bunsen burner.

The ordinary hand-operated air siphon steam jets as specified with this setting are shown in Fig. 6; while another type of steam jet, especially designed for a low setting, is shown in Fig. 7. Complete data for the installation of this furnace on all sizes of return tubular boilers are appended in Table 1, included in Fig. 8.

One of the old fallacies exploded by this setting was the idea that it is necessary to set return tubular boilers very high over the grates in order to get economical operation. It has been found that 36 in. from dead plate to shell is ample to get good combustion conditions with a 72-in. boiler. The areas through such a furnace, however, must be worked out carefully in order to insure success and not spoil the draft. The combined free area through the butterfly arches should be not less than 25 per cent of the grate surface. The free area between the bridge wall and the deflection arch should be not less than 40 per cent of the grate surface, while 50 per cent of the grate surface should be allowed under the deflection arch; if it is found impossible to get such area through this part of the setting with the combustion chamber on a level with the floor line, it is permissible to excavate the floor of

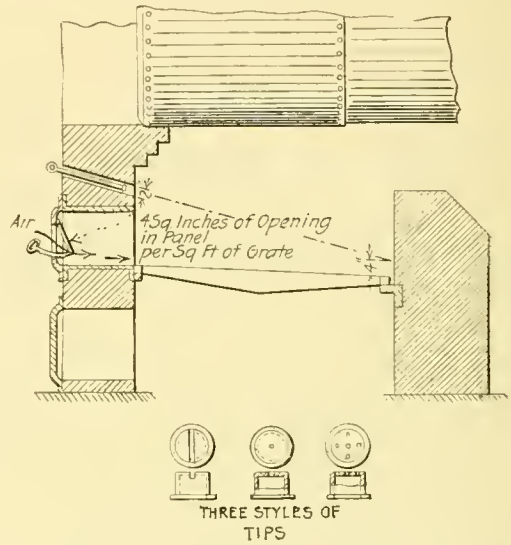


Fig. 6. Details of Steam Jet and Panel Doors

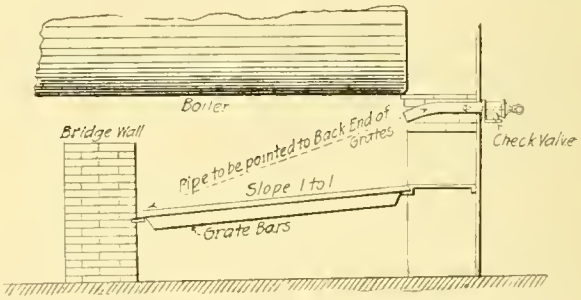


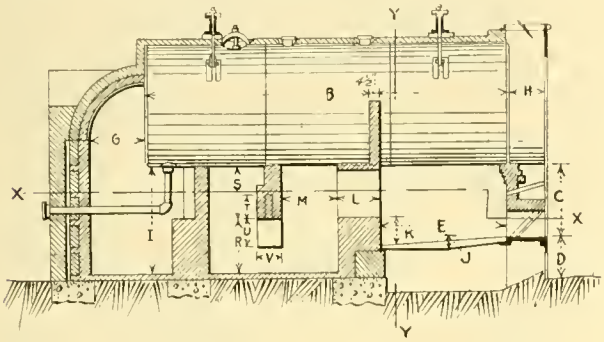
Fig. 7. Cincinnati Steam Jet for Low Settings

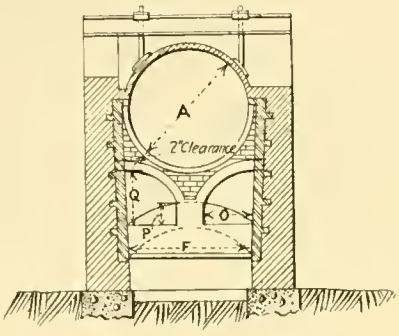
the combustion chamber to any depth desired. The combustion chamber should be paved with second grade fire brick on edge.

While the alternate method of firing has shown the best success, there are other points which should be observed to get the best results with such a setting. It has been found that the thick, heavy method of firing will make less smoke than the thin, spreading method. This would seem to be contrary to the old accepted ideas, but a few moments' consideration will show how this works out.

If two shovelfuls of coal are spread evenly over a clean, bright fire, all of the volatile matter in the coal is immediately

subjected to the intense heat of the fire and distilled off, making a great deal of smoke; if, on the contrary, the fire is replenished with six, eight and ten shovelfuls on one side, beginning at the bridge wall and filling up the low spots all the way to the front, it will be found that the rate of volatile distillation, and consequent smoke formation, is considerably less than in the first instance. The heat of the fire must penetrate the mass of coal more slowly, forming a film of dense smoke is illustrated in Fig. 9. A layer of fresh coal is thrown on the clean grates to a depth of about 4 in. and some red-hot coals are thrown into the furnace at the bridge wall, or a fire of clean kindling is built at this point. Ignition then takes place from the top downwards. The coal in front gradually becomes ignited and the volatile matter passing off from this part of the furnace has to pass over the hot fire at the bridge wall. As a result, it is possible to get steam on





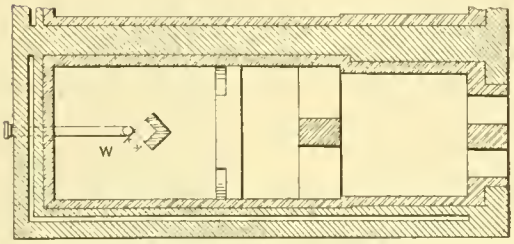


TABLE 1 - DIMENSION SHEET FOR DOUBLE ARCH BRIDGE WALL FURNACE

A	B	C	D	E	F	G	H	I	J	K	L	M	O	P	Q	R	S	T	U	V	W
42	12'0"	28	19	42	42	22	16	42½	3½	16½	18	21	16½	9	15	27½	15	9	8	13½	8
42	14'0"	28	19	42	42	22	16	44	4	15	18	24	16½	11	17	27	17	9	8	13½	8
48	12'0"	30	20	42	48	24	18	45½	3½	18	18	20	19½	7½	15½	30	15½	9	8	13½	8
48	14'0"	30	20	48	48	24	18	45½	4	16½	18	24	19½	9½	11½	28	17½	9	8	13½	8
48	16'0"	30	20	54	48	24	18	49½	4½	15	18	26	19½	11½	19½	30	19½	9	8	13½	8
54	14'0"	32	22	48	54	24	18	49½	4	16½	18	24	20½	11½	18	30	19½	9	9	13½	8
54	16'0"	32	22	54	54	24	18	54½	4½	15½	18	24	20½	13½	20	30	21½	9	9	13½	8
60	16'0"	34	22	60	60	26	18	55½	5	17	22½	26	23½	19	22½	33½	22	9	10	13½	8
60	18'0"	34	22	66	60	26	18	60½	5½	15½	22½	26	23½	15	24½	30½	24	9	10	13½	8
66	16'0"	34	24	60	66	28	18	54½	5	12½	22½	28	26½	11½	22½	34	20½	9	11	13½	8
66	18'0"	34	24	66	66	28	18	59	5½	17	22½	28	26½	13½	24½	36½	22½	9	11	13½	8
72	16'0"	36	24	66	72	30	20	59½	5½	18½	22½	30	29½	11½	24½	37	22½	9	12	13½	8
72	18'0"	36	24	72	72	30	20	60½	6	17½	22½	30	29½	13½	26½	40	24½	9	12	13½	8
72	18'0"	38	26	72	78	32	21	65	6	19	26	32	30	15½	27½	40	25	9	12	13½	8
78	20'0"	38	26	78	78	32	21	70	6½	11½	26	30	30	11½	29½	43	27	9	12	13½	8
84	19'0"	38	26	72	84	32	21	64	6	20	26	36	33	14	21½	40	24	9	12	13½	8
84	20'0"	38	26	78	84	32	21	69	6½	18½	26	36	33	16	29½	43	26	9	12	13½	8

Dimensions in inches, except as otherwise noted

Fig. 8 Double Arch Bridge Wall Setting Dimensions

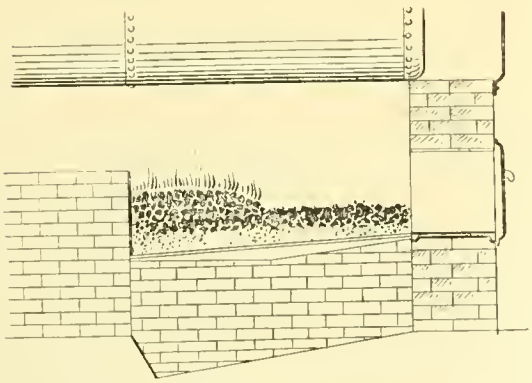


Fig. 9 Method of Starting Fire, Igniting Fuel from the Top

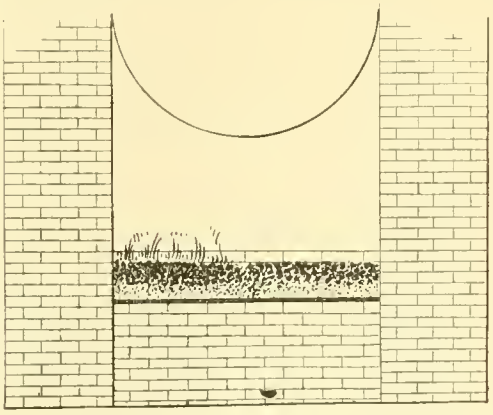


Fig. 10 Cleaning Fires, Winging Over Live Coals on Top of Fresh Fuel

ignited coal on top through which the gases must pass on their way to the furnace, causing an action somewhat akin to that of an underfeed stoker.

BUILDING AND CLEANING FIRES

Building and cleaning fires also must receive careful attention where it is necessary to keep the smoke down on hand-fired units. The method of building a fire without making the boiler without making dense smoke, by making liberal use of the panel doors to supply the necessary air for combustion.

In cleaning fires the same principle is used: Pull out one side of the fire, cleaning the grates, and then onto the clean grates throw a layer of fresh coal, quickly wing over red hot coal from the other side and allow the cleaned side to ignite from the top, as previously described. When this side has become well ignited and built up, the other side may be cleaned in the same manner. (See Fig. 10.)

HEATING LOADS

Many attempts have been made to design furnaces that would run at low rates of combustion such as on heating loads, without making dense smoke. None of the foregoing settings have been successful with this kind of load, owing to the fact that for success they all depend upon the maintenance of some form of brick work at a high temperature. When running at a low rate of combustion it is not possible to get the high temperature necessary to keep the fire brick construction hot; therefore these furnaces were not successful in reducing smoke at rates of combustion lower than 15 lb. per sq. ft. of grate surface per hour.

The type of furnace which has finally become standard for this class of service is a modification of the old down-draft principle (Fig. 11) formerly used for high-pressure purposes. The success of the down-draft principle as far as smoke performance goes depends on the frequency with which the fuel bed is disturbed. In high-pressure work where the rate of combustion frequently exceeded 25 lb. per sq. ft. of grate

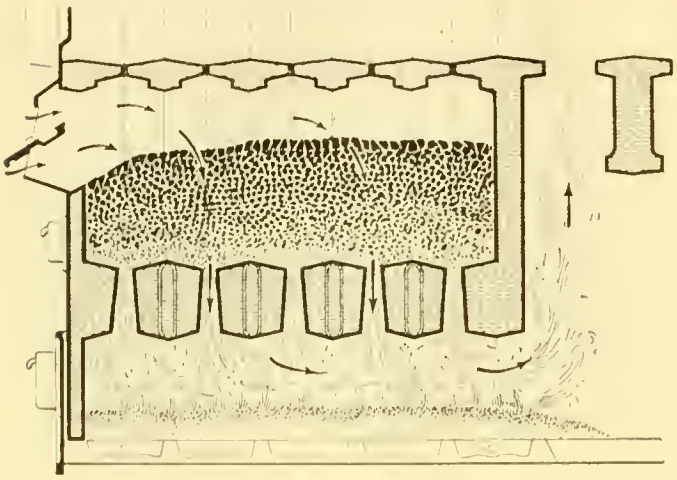


Fig. 11 Showing the Down Draft Principle as Adapted to Low Rates of Combustion

surface per hour, it was necessary to disturb the fuel bed at frequent intervals, sometimes so often as to slice green coal down through the water grates.

On the other hand for rates of combustion of not over 10 lb. per sq. ft. per hour, it has been found that this principle of burning is remarkably successful. Under low rates of combustion it is possible to run for long periods during which the fire is not disturbed, and during this time there is accumulating on the water grates a mass of coked coal which has gradually given up all of its volatile matter. When it becomes necessary to slice such a fire this supply of coked coal is all that falls to the bottom grate and no smoke is produced At the same time the volatile matter distilling from the coal has to pass down through the zone of high temperature thus insuring igniting temperature to the gases.

Another reason why this principle has been so successful on low rates of combustion is on account of the very efficient evaporative power of the water grates at these low rates. An ordinary plain grate boiler burning coal at very low rates of combustion drops its capacity to a point which is practically negligible; while the down-draft furnace will simmer along on a heating load at a very low rate of combustion and still make in the water grates themselves all the steam demanded.

The relative importance of water power as referred to transportation, dependent upon its cost and on that of competing steam power, is treated in a paper by L. B. Stillwell, presented at the 1916, Washington, D. C., meeting of the A.I.E.E.

Among the important points brought out by the author are the proportion which the cost of fuel for locomotives in the country as a whole, in various sections, and in the case of a number of different railroads, bears to the total cost of operation; the effect upon water power values of recent progress in the production of electric power, and power and transportation development on navigable streams.

Illustrations are given showing the limit of investment in developing a water power, as fixed by the cost of steam power in competition with it.

Railroad and canal operation are compared in the matter of power consumption for their respective speeds.—*Proc. A.I.E.E.*, XXXV-5.

With a reduction in its smoke production to an extent which the chief of the Bureau of Smoke Regulations places at 75 per cent, Pittsburgh is fast losing one of its distinctive titles.

The permissive density limit is less than No. 3 on the Ringleman smoke chart, while for densities equal to or above that value certain time limits are set beyond which the emission at such densities is prohibited.

This desired condition has not been reached without considerable expense nor without that harmony and accord between the industries and the smoke authorities, without which such ordinances usually remain dead letters. This coöperation is shown, in the case of the railroads, in the local use on their locomotives of coal of a lower volatility, and in the manufacturing plants by the use of appliances and methods better suited to the accomplishment of the desired end.

Encouraging progress seems to have been made in the abatement of the smoke nuisance in the Boston district, according to the annual report of the Board of Gas and Electric Light Commissioners of Massachusetts for the year 1915.

Fuel values per unit of cost, as investigated by Dr. J. H. Paterson, is the subject of a paper presented at the meeting of the Newcastle (England) section of the Society of Chemical Industry, held December 15, 1915.

The financial value to the consumer of a fuel must be measured by the amount of heat which can be obtained from that fuel by the expenditure of a definite amount of money. This value is totally distinct from, and is not affected by, the quantity of available heat which is utilized in any given process.

To meet the difficulty encountered in dealing with fuels of different classes the author makes the common unit of value the number of B.t.u. obtainable for a penny after there have been added to the price per ton all the costs of handling the fuel and causing it to burn. This he calls the absolute heat value of the fuel in question.

While very generally recognized that the less paid for coal the more incombustible matter (water and ash) it is liable to contain, it is by no means realized that the absolute heat value increases rapidly as the price decreases.

In tabular form the author compares some ten classes of fuels ranging, on the absolute heat value basis, from 200,000 B.t.u. down to 20,000 B.t.u.—*Jour. Soc. Chem. Ind.*, XXXV-1.

HIGH TEMPERATURE INSULATION

A Review of the Requirements of the Problem, and a Description of a New High Temperature Insulating Material, with Applications

By P. A. BOECK,[1] CHICAGO, ILL.

THE value and importance of efficient insulation for the prevention of thermal losses are shown in the extent of the investigation and research which have been devoted to that factor in the conservation of heat, but it was not until the comparatively recent introduction of the heat balance sheet that the various causes of heat losses and the reasons for their existence were brought to light.

Heat is a form of energy consisting of molecular vibrations of a periodic character and subject to the general laws of wave motion. It can be reflected, refracted and dispersed by creating the proper conditions. In other words, by the proper mechanical manipulation we can increase or decrease, within certain limits, the amount or rate of heat flow. One of the most common ways of doing this is by introducing alternate layers of materials having different heat-transmitting values, thus breaking up or changing the wave length. The introduction of air cells or voids within the body is a most effective method of accomplishing the reduction of the conductivity, though large voids have the effect of propagating heat by convection and radiation. The density of a body may be taken as an approximate criterion of its heat conducting capacity.

Heat is a form of energy consisting of molecular vibrations ferent methods, conduction, radiation and convection:

Conduction is the action taking place in the transfer of heat in which the heat energy is passed along from a particle at a higher temperature to one at a lower temperature by virtue of their contact. While this method of heat transfer applies to the three states of matter, it is of magnitude only in solids.

Radiation.—By radiation heat is transferred from one body to another without any material agency by wave motion; this applies only to the gaseous state of matter.

Convection is that process of heat transfer in which some portion of the body whose temperature is raised moves to another place in the medium where the temperature is lower, tending to raise the temperature of the medium. This method of heat transfer is therefore limited to liquids and gases.

Applying these methods to a steam boiler, the heat generated by the fuel burning in the firebox is imparted to the dry surface of the boiler plate by radiation from the hot fuel bed, furnace walls and luminous flames, and secondly from the moving gaseous products of combustion by convection. From the dry surface it travels through the soot, metal and scale to the wet surface purely by conduction and is in turn transmitted into the boiler water mainly by convection.

That portion of the heat which is transferred to the walls of the furnace setting by any of the three methods mentioned is conducted through the setting and lost by radiation or convection from the outer surface of the setting, if means are not provided to prevent. It is the heat lost in this manner and methods for its prevention that will be especially considered.

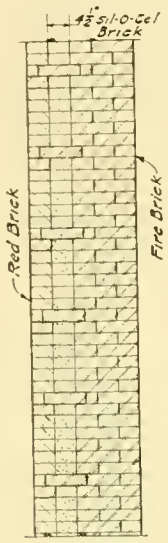


Fig. 1

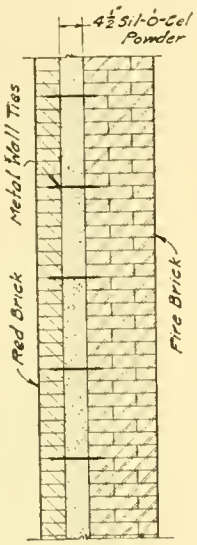


Fig. 2

Fig. 1 Boiler Setting Wall Insulated with Sil-o-cel Brick

Fig. 2 Boiler Setting Wall Insulated with Sil-o-cel Powder

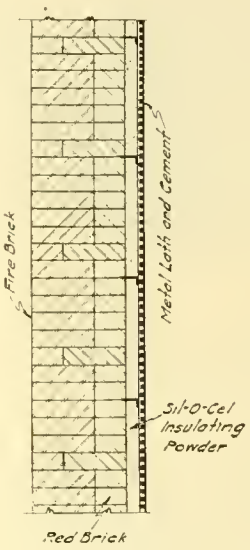


Fig. 3

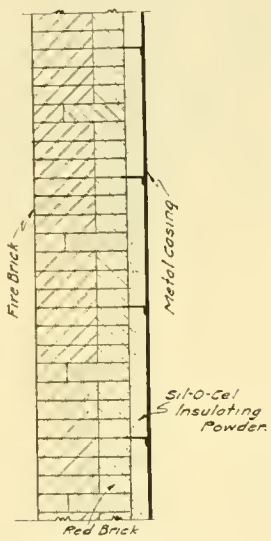


Fig. 4

Fig. 3 Typical Wall Construction Showing Sil-o-cel Powder Supported by Metal Lath Cement Finish

Fig. 4 Insulating Powder Between Wall and Metal Casing

RATE OF HEAT FLOW

The amount of heat conducted through a unit area from one part of the body to another is proportional to the difference in temperature of the two parts; directly proportional to the

[1] Chemical engineer, Kieselguhr Co. of America.

Abstract of paper presented at the Chicago local section of The American Society of Mechanical Engineers, January 14, 1916.

thermal conductivity of the body through which the heat passes and inversely proportional to the distance between the two parts of the body. In other words, the conduction of heat through a solid body from one place to another is a direct function of the conductivity of the body and the difference in temperature of the two planes, and an indirect function of their distances apart. This is identical with Ohm's law for transfer of electrical energy.

The heat transferred from one body to another by radiation is proportional to the difference of the fourth powers of the absolute temperatures of the two bodies. While this is strictly true only of the ideal "black-bodies," the variation is so small that, for all practical purposes, this relation holds good in ordinary procedure.

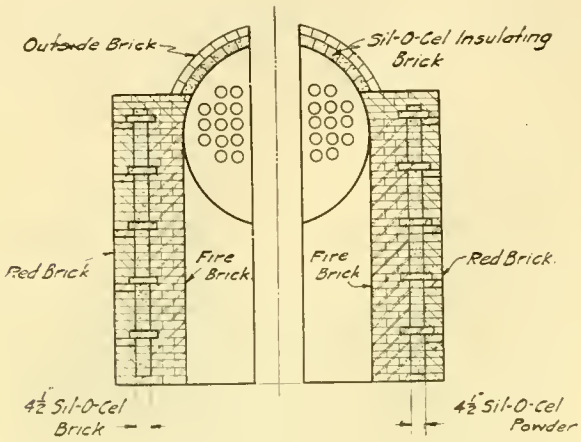


Fig. 5 Method of Insulating Boiler Setting Walls with Sil-o-cel Brick and Powder

This relation indicates why a hollow-wall space is an effective insulator in low-temperature work, such as refrigeration, etc., whereas in high-temperature operations the loss of heat by radiation through a hollow-wall space is so great that its insulating effect is less than if this wall space were filled with material of rather high thermal conductivity. This is especially true if the air space in the hollow wall is near the furnace side and becomes highly heated. This is entirely contradictory of the general belief that, since air is a poor conductor of heat, air spaces built into the walls of a furnace will greatly reduce heat loss by radiation. While the heat does travel very slowly through the air by conduction, it leaps over the air space readily by radiation, because the quantity of heat which passes across the hollow space is a function of the fourth power of the absolute temperature of the surfaces enclosing it, which loss is enormously increased by rise in temperature.

FURNACE WALLS

In general, in high-temperature furnace construction, there are two separate and distinct factors which must be considered to produce an effective wall.

The first of these is to provide a material having the ability to resist the action of high temperatures, sufficient mechanical strength and, possibly, the property of resisting corrosive slags, gases, etc., without spalling or being eroded.

The second is to prevent the excessive loss of heat due to conduction from the interior of the furnace to the outside where it is lost by radiation or conduction.

It is rare that a good refractory material is an insulator; usually it is necessary to augment or back up the refractory with some material having a much lower heat conducting capacity. Fig. 7 is a graphic presentation of heat transfers with and without such application.

The quantity of heat, H, in B.t.u. per hr. per sq. ft. conducted between two surfaces of a wall is

$$H = \frac{1}{\frac{d}{c} + \frac{d_1}{c_1} + \frac{d_2}{c_2} + + \cdots} \times (t_2 - t_3)$$

where d, d_1, d_2 = thickness in in. of component layers of wall, c, c_1, c_2 = thermal conductivities in B.t.u. per sq. ft. per in. thickness per hr. per 1 deg. difference in temperature at the average temperature of the component layers of wall, and t_2 and t_3 = surface temperatures of the respective sides of the wall in deg. fahr.

Fig. 7 is a graphic presentation of the heat loss through insulated and uninsulated walls; respectively 289 and 639 B.t.u. per sq. ft. per hr.

REQUIREMENTS OF FURNACE INSULATORS

The requirements of the insulating backing for the more refractory linings of furnaces are rather severe, and although

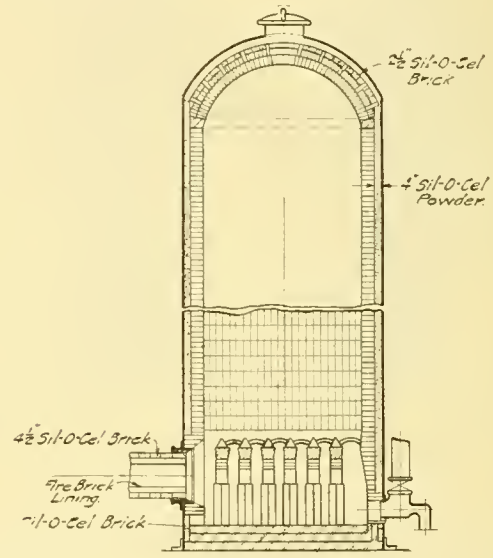


Fig. 6 Sil-o-cel Insulation of Hot Blast Stove

an enumeration of them would seem a somewhat formidable array, there are products upon the market which fulfill practically all of them.

When the kind of refractory material that is best suited to the surface has been determined, the next most important item is the thickness of the walls and the nature of the insulating material most suitable, and it is necessary to determine the degree of insulation which will produce the most effective results.

In attempting to obtain perfect insulation, it is entirely possible to over-insulate, causing a serious damage to the refractories in the high temperature zones of the furnace. To maintain the inner walls, it may be necessary to permit a considerable flow of heat through the wall, with a corresponding decrease in the temperature of the refractories at the heated point, in order to prevent their destruction.

However, the issue in some instances may be met by other practical methods, such as increasing the working capacity of the unit in order to make use of the additional heat available, rather than to let this valuable heat at the critical period

escape to save the refractory lining,—a method which makes the working load control the temperature.

In electric-furnace practice, where extremely high temperatures are encountered and where effective insulation is necessary because of the relatively high cost of current, the question of insulation or rather over-insulation, has been given more attention than in other lines.

DESCRIPTION OF CELITE

The requirements of an ideal insulator being known, it remains only to select such an insulator as apparently most nearly meets these requirements.

A material possessing remarkable non-conducting properties is "Celite," so-called on account of its extremely cellular nature. It is a mineral of a highly siliceous composition and of very light weight, and occurs on the Pacific Coast in an exceptionally pure state. Fig. 8 shows the material being quarried. It is composed of numerous hollow cells, and weighs in its natural rock form, air-dried, from 25 to 30 lb. per cu. ft. When this material is ground properly, it weighs but 8 lb. to the cubic foot, and has a thermal insulating power of about 9 to 12 times the insulating power of ordinary firebrick. In other words, a 1-in. layer of this material is the equivalent in insulating value of from 9 to 12 in. of firebrick. Being almost pure silica, its melting point is high, 2930 deg. fahr. (1610 deg. cent.) as reported by the U. S. Bureau of Standards, and it can be subjected to high temperatures without fear of alteration.

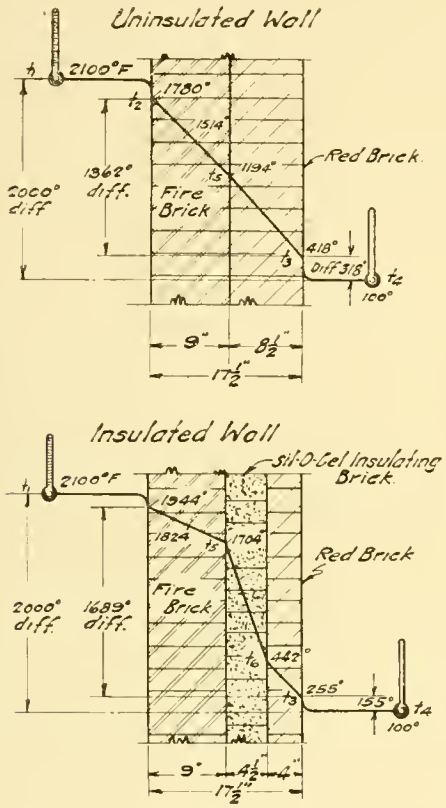


Fig. 7 Heat Flow and Temperature Gradient Through Heated Walls

Bricks and blocks of various sizes and shapes are prepared by sawing the natural material by means of gang saws. Standard 9-in. straight "Sil-o-cel" brick made from natural celite weigh from 1½ to 2 lb. each, and are equivalent in insulating value to many times their thickness of ordinary firebrick. In crushing strength these bricks withstand over 400 lb. per sq. in. and are sufficiently strong to stand transportation and handling.

The cost of these insulating bricks is but little more than that of firebrick, and that of the powder about one-third as much.

Because of the variation in forms in which Sil-o-cel products are supplied—that of brick, blocks of various shapes, in powdered form and as a plastic cement—this material is adaptable to almost any form of thermal insulation, as will be shown in the following typical examples.

Fig. 8 Celite Being Quarried on Pacific Coast

GENERAL TYPES

Fig. 1 indicates the usual method of using Sil-o-cel brick interlaid between a course of firebrick and red brick for the prevention of heat leakage through walls.

Fig. 2 indicates one of the methods of construction of an insulating wall in which an otherwise hollow space is filled with insulating powder. From 2 to 4 in. is usually sufficient. The powder is packed slightly to a density of approximately 12 lb. to the cubic foot, at which point it attains its maximum insulating value and is not subject to settling or contraction due to either vibration or heat. Where this form of construction has been in severe service in high-temperature furnaces for a period of years, no contraction or settling has taken place. Fig. 9 illustrates the cohesion of the material.

Figs. 3 and 4 indicate the methods of insulating brick walls which are already in place. In Fig. 3, expanded metal lath is erected on an angle iron at the required distance from the outer wall and coated on the outside with one or more coats of Portland cement plaster, to which approximately 20 per cent by volume of Sil-o-cel powder has been added to give greater plasticity and ease of working and to increase the heat-resisting properties of the cement. Sil-o-cel powder is packed to a density of 12 to 15 lb. per cubic foot between the brick wall and the expanded metal lath. In Fig. 4 the powder is packed between the brick wall and a metal casing.

Fig. 5 illustrates the insulation of boiler settings by means of Sil-o-cel insulating brick (left hand diagram and tops of both diagrams) and by means of Sil-o-cel powder in a hollow wall (right hand diagram).

Hot-blast stoves, Fig. 6, provide an excellent example of the requirements of an insulation for high-temperature work, not so much because of the high temperature to which they are subjected, but more especially because of the size, expansion and contraction of lining and shell, settling, shrinkage, elasticity and corrosion of the insulator and protection of the shell itself, the constant change in temperature and other factors.

In a 20 x 100-ft. stove, for instance, the column of brick in the lining may expand through heat as much as 5 or 6 in. in height from cold to maximum heat. Therefore, the insulator may be considered at all times being subjected to a certain amount of stress and friction requiring an elastic medium which will take up these continued strains without injury or danger of being crushed, which would result, as in the case of granular slag, in constant settling, the accumulation of fine material causing occasional bulging of the shell at the base of the stove on account of its inelastic nature. Two principal

Fig. 9 Cohesion of Sil-o-cel Powder After Removal of Front and End Supporting Walls

requirements of the insulator for this purpose are, then, elasticity with still sufficient strength to give the proper support to the brickwork and shell, and the proper amount of cohesion or high internal coefficient of friction and light weight so as to overcome any tendency toward settling under the movement or vibration of the stove.

Recent tests of a battery of stoves and mains insulated with Sil-o-cel powder and brick, as indicated in the illustration, prove conclusively not only that can a higher capacity be obtained from the blast furnace by insulating to produce a more uniform temperature throughout the stoves, but that a more uniform grade of product can be made by eliminating fluctuations in the temperature of the blast itself.

A report of a test carried out in a blast furnace, the bustle pipe of which was insulated with Sil-o-cel insulating brick, shows that the actual temperature of the blast at the tuyeres on the side of the blast furnace farthest from the main is more nearly the main temperature than can be obtained without insulation, in fact there is practically no temperature drop of the gases during their passage through the bustle pipe. This is due to preventing the radiation losses from the outside of the bustle pipe and gives a more uniform heat distribution through the stack and better temperature control.

Water containing ten grains per gallon of incrusting material used in a 500 h.p. boiler operating at normal rating and generating 15,000 lb. of steam per hour, has been stated to deposit about 3 lb. of scale per hr. The same boiler when operating at 100 per cent overload and generating 30,000 lb. of steam per hour, deposited 6 lb. of scale per hour. Not only was twice as much scale thus deposited, but the scale was baked harder to the tubes and boiler surfaces.

Many tests have been made upon engines using saturated and superheated steam under varying conditions, and all show a saving in steam consumption per unit of power developed when using a superheater. The ultimate gain, when the cost of equipment, depreciation, operation, etc., are taken into account, will vary, and while it is usually a substantial one, there may be cases where the use of superheated steam will result in a loss. Prof. G. F. Gebhardt, Mem.Am.Soc.M.E., gives the average reductions in steam consumption with superheating from 100 to 125 deg., based on continuous operation in existing plants, as from 40 per cent with slow-running, full stroke, or throttling engines, including direct-acting pumps, to 6 per cent with triple-expansion engines. Although large savings in fuel have been made in some cases by the use of a superheater, amounting to its first cost each year, these are not common; however, they should be favorably considered if their use would effect a net saving of 10 per cent on the first cost above depreciation and maintenance charges; a result which should be reached in any plant operated at one-third its capacity and burning coal at $2.00 or over per ton.

Owing to the lesser density of superheated steam, as compared with saturated steam, it is possible to employ much higher velocities of flow through the piping, and this in many cases permits reduction of pipe areas of 20 to 50 per cent. It must, however, be carefully borne in mind that certain materials entering into the construction of the piping system should be suitable for the higher temperature steam, and while there has been much discussion regarding the comparative merits of cast-iron and cast-steel for fittings and valves for this purpose, there does not seem to be any general agreement.

In comparing the performances of engines using saturated and superheated steam, it is necessary to base all results upon the *heat* consumed per horsepower rather than on the *steam* consumption in order to get a true comparison. While a saving in the weight of steam per unit of power developed by the engine may be obtained, it does not follow that the saving in fuel is in the same proportion, because the total heat contained in a pound of superheated steam at a given pressure is greater than that in saturated steam at the same pressure.

Another important item to be taken into account, especially in case of a new plant, is the reduction in boiler equipment. In the case of a plant already in operation, the addition of superheaters will give one or more reserve boilers.

All superheaters should be provided with safety valves set to blow at a pressure slightly below that of the boiler valves. This is necessary in order to insure a flow of steam through the superheater in case the load is suddenly thrown off the boiler; or overheating would be likely to take place.

In this country steam temperatures seldom exceed 500 deg., while in Europe 600 deg. is a common temperature, with a maximum of 850 deg.—Charles L. Hubbard, in *The Engineering Magazine*, June 1916.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

RELATION OF ENGINEERING SOCIETIES TO LEGISLATION AND PUBLIC AFFAIRS

To the Editor:

There was recently before the Engineers' Club of Philadelphia a question of the advisability of the Club going on record in favor of or against legislation in general.

A conviction has been growing for some time in the engineering world that engineers should and must take a place in the community in the shaping of public affairs—a place more in accord with the importance of engineering in the economic and social political affairs and life of the commonwealth.

Any citizen who feels that he can be of benefit to his fellows by placing his abilities at their disposal in aiding or carrying out legislation ought to consider it his duty to do so. That duty of the citizen is also a duty of the engineer as a citizen. In so far as the engineer has become, by training and experience, more thoroughly fitted for and more intimately acquainted with the community's needs, just so far is that duty of citizenship more definitely placed upon his shoulders.

Whatever holds for the individual engineer is true also for the engineer as a member of an engineering society, and again for engineers collectively through such societies.

A recognition of such duty is expressed in the charters, constitutions and by-laws of most engineering associations, in nearly all of which the furtherance of the public welfare, in so far as that may be affected by engineering activities, is stated as a fundamental purpose. With that recognition there is opened up the question of how best to realize this purpose.

The individual engineer will act in accord with the dictates of his personal conception of his duties as an individual citizen; that may lead him to offer himself as a candidate for and to accept public office as an executive or legislator, or to offer advice and counsel and advocate certain definite legislation. Can engineers collectively, when banded together into societies, follow, in carrying out their duties of citizenship, the same line of activity as the individual engineer?

Manifestly not altogether. Public office and direct legislation are restricted to the individual and are, at the present stage of the world's affairs, not open to societies. But the proffer of counsel and advice and the advocacy of legislation are activities as open to societies as to individuals.

It is true, moreover, that along these lines collective action by associations is apt to be more forcible and fruitful than similar action by a similar number of individuals acting separately. As this may be accepted as so self-evident as to be axiomatic, there remains for consideration the relative advisability of counsel as a basis for legislation as opposed to direct advocacy of special legislation.

As between these alternatives the choice ought to be governed solely by consideration of their relative effectiveness. It is granted that the only aim in the pursuance of either course is the incorporation into the conduct of communal affairs of such rules, regulations and laws as engineers collectively may have found through special training and experience to be best.

Man is known to be selfish and the more so as he lives for himself alone. This individual selfishness comes less to the fore as men band themselves into communities, partly by reason of the fundamental evolution to higher and higher ethics of conduct, and more immediately because the effect of community action is less directly connected with and traceable to the individual's personal interest.

When a person advocates a certain course, others are prone to ask "what has he to gain—what axe has he to grind?" Though the answer may be, and in all sincerity will be, "none," men are suspicious and not apt to accept such answer at its face value. This very natural attitude of doubt and tendency to impugn motives will be lessened the more, the more remote the advocate's personal interest is recognized to be.

When any of us wish to adopt the best possible course for any familiar undertaking or endeavor, what do we do? We secure the best advice procurable and from counselors who are best fitted by training, experience and expert knowledge in the particular field or specially involved. We go to the doctor, the lawyer, the engineer, as the case may be. More and more are communities following the same practice. Unfortunately, it is no new experience that individuals of great skill are found to have a personal interest that interferes with their ability to give entirely unbiased advice.

How safeguard against that? Why not, by securing the advice, not of an individual, but of a professional group widely representative of the aggregate training and experience of the community's specialists?

While individual elements of a group may have selfish motives, the very diversity of interests will rarely allow that of any one unit to govern, with the result that the collective sense of the majority will usually be fairly sound and but little tainted by self-interest.

If we felt ill would we consult a lawyer or an engineer? The answer is superfluous. Just as in such case we would see a medical man, we would in other circumstances seek legal or engineering aid.

Would we be likely to heed unsought advice, whether medical, legal or engineering, or would we give both ear and weight to that coming in response to our direct request and asked of those in whom we had faith? Again, the answer is self-evident.

To sum up, the best advice is always that of the trained specialist; the most disinterested counsel is that based on the collective experience of grouped specialists.

This brings us fairly to the question of the advisability of the Engineers' Club of Philadelphia going on record in favor of or against legislation in general.

Actually the question should be stated more broadly:

"How best can Engineering Associations, including our Club of Philadelphia Engineers, place their collective engineering knowledge, experience and training at the service of the community?"

Two ways are debatable: A stand in favor of or against direct legislation may be taken, or engineering matters affecting the community may be carefully considered and formu-

lated, to serve as a guide and basis for the formulation into laws by those more specifically fitted by experience and training in the framing of laws.

Some, at least, of the great national engineering societies, some by practice and some by direct constitutional requirement, have decided to absolutely refrain from recommending or formulating laws and to limit themselves to specific engineering advice and recommendation. In so restricting themselves, they have actually broadened and deepened their influence on actual legislation. They have not sought, nor do they seek, to influence legislation, and in so refraining they have actually gained a deep and beneficial influence in and for the community.

As any course of reasoning is most forcible when backed up by actual results, a case in point might here be cited. It is that of the A. S. M. E. Boiler Code Committee.

A number of engineers, members of the Society, largely interested in steam boilers and their safe construction and use, got together a number of years ago and were constituted into a special committee. Some members were fundamentally interested in safety alone, with no financial interests in any particular form or type of boiler; others were directly interested in some type or accessory detail. It was soon recognized that the matter was so broad and that it so fundamentally affected the entire community, not simply builders of boilers, that the committee was expanded until it actually represented the best specialized engineering talent of the entire country and covered every phase involved. The natural tendency of many individuals to look after only their own particular interests brought out their best arguments, to be countered by those of others possessed of conflicting interests, with the final result that a Code for boiler construction was evolved that, while restraining no maker of any particular type of boiler, made certain that any boiler built and used under the Code was as safe as the combined experience and skill of the designing, manufacturing and operating engineers of the country could evolve.

Did the engineering associations that participated in this work recommend the adoption of the Code as the law of the land? Many members of the committee most earnestly demanded that that should be done, but wiser counsel prevailed. The Code was published simply as what it was—the crystallization of the best knowledge of the engineering profession.

And what was the legislative result? Various legislatures in various States secured copies; some had the Code reprinted *in toto*, and many used it as the basis for a revision of their boiler laws. A number of legislatures have incorporated the Code in whole or in part into organic law.

Nowhere was the Code objected to, as must inevitably have been the case had its framers worked for the adoption into law. No point was raised of a selfish motive or a selfish end to be gained for any maker of a boiler or of a boiler accessory.

Even those engineers who advocated their societies putting themselves behind the enactment of the Code into law are now agreed that what they hoped for in the interest of the public and community actually came about much sooner and more readily as a result of their confining themselves to their special domain.

The above argument was presented before the Engineers' Club of Philadelphia by the writer, who, in order to bring out a discussion directed to a definite issue, followed it by this motion:

Whereas, it is the sense of the Engineers' Club of Philadelphia that Engineering Associations can best fulfill one of the basic purposes of their existence—that of serving the community, by bringing to bear on any particular phase of engineering involving the public welfare, the collective knowledge, training and experience of engineers and of the profession of engineering:

Therefore be it resolved that:

"The Engineers' Club of Philadelphia shall recommend neither legislation nor laws, but shall restrict itself to the formulation of the collective knowledge and experience of its members on any particular phase fundamentally involving engineering practice in the erecting or manufacture of engineering structures or constructions, which formulation may serve to guide those seeking the best collective knowledge of those fitted by engineering training and experience."

The writer's views upon this subject are here submitted for The Journal in the hope that they may stimulate thought and draw forth representative opinions which will be of guidance to the Society and to other organizations in any future questions concerning the engineering societies and legislation and public affairs.

Henry Hess.

Philadelphia, Pa.

MANUFACTURERS AND THE INDUSTRIAL INVENTORY

To the Editor:

As indicative of the frame of mind in which many of the manufacturers of this country find themselves, the replies which the writer and other members of the local committee on the Naval Consulting Board have received in response to their communications in regard to the Industrial Inventory are very illuminating. We arranged to send out return notice postcards with all the inventories, and delivered them by a messenger so as to avoid any trouble with the post office and any excuse that the mail was not received. Less than 10 per cent of the return postcards were mailed to us. After about ten days, the firms were approached by telephone and about 50 per cent replied that they did not see why they should fill out the inventory because they did not make any war material, and did not see what connection they had with it. Of course, the reply to this objection is, that practically every business is affected in case of a large war. It even applies to such apparently far removed businesses as hosiery, underwear and other clothing manufacturers. Most of the firms seemed to think that the only materials required in a war are rifles and ammunition. They forget altogether that the biggest part of supplies to an army are other materials than those for killing.

Not less than two men raised the objection that they did not believe that we ever would have a war, that they were staunch Wilson men, and as President Wilson had kept us out of war so far, he would probably continue to do it. The reply seems almost obvious, considering the conditions in Mexico. I have also asked these objectors what they think is going to be the position of the U. S. after the war, when the comparatively impoverished European countries with heavy holdings in Mexico are going to call this country to account for either bringing conditions to a proper state in Mexico or abandoning the Monroe Doctrine.

One manufacturer characterized the effort to get the inventory as "all nonsense," although I could tell from his replies that he had not even read the papers. Another objection is raised by the excuse that they are too busy and have not found time to fill out the inventory, some claiming that it takes them

about a week to do it. To this the reply is that it need not take more than two or three hours, if they go at it earnestly; and also that the information they obtain will be of benefit to themselves as well as to us. It seems hard to get them to realize that this matter is of much benefit, or more, to the manufacturers themselves than it is to the Government.

In all it would appear as if the average manufacturer did not take the situation in this country seriously enough, and I think that the publication of this information in The Journal, where it would be likely to reach a good many intelligent engineers by a more authoritative channel than usual, will have some influence upon the attitude of the manufacturers with whom they are employed.

It seems to me that as intelligent and energetic a campaign as the present one conducted by the five engineering societies, should receive all the support possible with a view to increasing the efficiency generally of governmental engineering matters.

R. J. S. Pigott.

Bridgeport, Conn.

About 90 per cent of the manufacturers in the countries involved in the European war are engaged in the production of materials which may be broadly classed as munitions. The guns, powder and shells represent but one phase of this work. There are nearly 35,000 items in the purchasing lists of the departments responsible for the maintenance of an army under effective fighting conditions. More than 4000 of the larger manufacturing plants in England alone have been taken over by the government, and are now being operated under government control. In addition to this unprecedented industrial activity in all the countries of Europe and in Japan, a large percentage of the manufacturing establishments of neutral countries, including the United States, have been called into munitions service for the supply of materials to the Allies.

In the event of any war in which this country becomes involved, every manufacturing plant within the boundaries of the country will be called upon to do its part for the national service. It goes without saying that no manufacturing institution in this country can, without months of fatal delay, begin to produce army and navy materials unless it has in time of peace been carefully taught the intricate methods and processes involved in the making of such emergency product.

True preparedness in this country can exist only through such an organization as will, in the event of emergency, place our manufacturing and producing resources instantly at the government service, and any and every plan for the protection of this country against invasion may be made effective only through such organization. Every manufacturer must take this great lesson of the European war home to himself, and realize his responsibilities under it. Every manufacturer must demand that he be taught, in time of peace, to make that thing for the Government for which his equipment and the training of his men best fit him, and which he will be required to supply for the support of the Army and the Navy or the civilian population in time of war.

In thus demanding that, through prearrangement, his manufacturing facilities be made readily and quickly available to the Government in time of need, the manufacturer at this same time serves his own best interest. He insures the operation of his plant at a reasonable profit in spite of the chaotic commercial conditions attendant upon war, and that his labor organization built up over a long period of years will be maintained intact as an integral part of the Industrial Reserve.—Editor.

STUMPF UNAFLOW ENGINE

To the Editor:

In the July issue of The Journal Mr. Wm. E. Bullock objected to the credit given to Prof. Johann Stumpf, of Charlottenburg, for the development of the Unaflow Engine.

It is evident, from the examples which Mr. Bullock gives, that the principle which Professor Stumpf invented, and which made such a remarkable success of his engine, is not understood. If Mr. Bullock would build the engine shown by Todd, or the engine illustrated in the patent to John M. Hirlinger, he would find that the economy recently secured by the Stumpf unaflow engine would not be obtained.

Professor Stumpf, as he stated in his book, was not aware of the patent to Todd, but devised the arrangement of cylinder, piston, inlet ports and exhaust ports from theoretical considerations, and used this construction only as a means for carrying out his real invention.

Professor Stumpf added to the Todd, Hirlinger, and several other unsuccessful engines—in which the steam entered the head end of the cylinder and was discharged at the middle—a steam jacket, through which was circulated the hottest steam. This steam jacket was located at the inlet ends and was protected by all available means from the colder cylinder spaces.

The cylinder surfaces near the inlet end were thereby maintained hot and dry during both expansion and compression strokes. The water of condensation, therefore, became concentrated on the colder cylinder surfaces near exhaust which never came in contact with the high temperature steam. When exhaust opens the wettest steam is eliminated and the dryer steam remaining is trapped by the returning piston and compressed against the heated inlet surfaces, receiving heat both from the jacket and the work of compression and producing a temperature in the clearance steam and the cylinder surfaces higher than that of the steam entering from the boiler. This prevents initial condensation on these surfaces to a degree which no other builder of unaflow engines approached, even remotely.

In designing his engine Professor Stumpf also reduced the area of the entrance port to the minimum. When local conditions required more heat he also jacketed a portion of the cylinder as well as the head, at the same time reducing the section of metal between that jacket and the exhaust port to the minimum.

The long piston kept the cylinder covered from contact with the exhaust steam for the longest possible time, thus preventing the extraction of heat from the cylinder wall, and its conveyance away by the exhaust.

It is evident that both Todd and Hirlinger invented a mechanism rather than a principle of operation. They both provided long entrance ports, with a surface that would be subject to changes of temperature, and which were not jacketed, and located their steam chests over the center of the cylinder where the heat could be readily conducted to the exhaust, and they did not heat the cylinder head.

An actual experiment has been made with a Corliss engine cylinder, first with Corliss exhaust valves at the head, and then with ports in the center of the cylinder. The results of careful tests showed very little gain in economy by the use of the central ports as compared with the ordinary exhaust valve, these experiments being made without any head jacket. When, however, the head jacket was introduced the economy of the engine was increased to correspond with the figures obtained by Professor Stumpf.

The tremendous success which Stumpf's unaflow engines have had in Germany, where some 600,000 or 700,000 h.p. had been built before the war, is a practical demonstration of the efficiency of his system, and he is therefore entitled to the credit for the success of the unaflow engine.

Some two years ago the writer saw in actual operation over 40,000 h.p. of these engines, built by Sulzer Brothers, and Ehrhardt and Sehmer, from 100 to 8000 h.p. in a single cylinder. These engines were running under all sorts of conditions, direct driven with generators attached, and in the case of the 8000 h.p. engine, direct connected to a 3-high train rolling mill. They were beautiful engines, extraordinarily well built, and operated perfectly.

The official government tests showed a steam consumption with ordinary vacuums of 9.5 lb. of steam of 150 lb. gauge pressure per i.h.p-hr. for engines of 500 h.p., which was better consumption than 1600 h.p. triple expansion engines made by the same companies, running alongside of them and tested under the same conditions. These results had become so well known in Germany that it was very difficult to sell anything but Stumpf unaflow engines, and the only competition was between makers of this type.

The United States is very much behind in the adoption of this type of machine, and while there are several American inventors who attempted the solution of this problem, they always failed to make the proper combination, and it was not until Professor Stumpf perfected his unaflow cycle that the economies, which warranted the construction of these machines, were obtained.

There are several examples in the prior art, from 1850 to 1885, of patents for unaflow engines, all of which missed realizing the vital principles of the engine which Stumpf finally developed in 1908. These only increase the credit which should be due him, as in spite of all this information, which was accessible to the thousands of engineers who were struggling to improve the economy of the steam engine, the use of multiple cylinders, with their many losses and complications, appeared to them to be the only solution.

Edward N. Trump.

Syracuse, N. Y.

THE GREAT NEED OF OUR INDUSTRIES AND CITIZENSHIP

To the Editor:

So much has been said recently upon the subjects of economic, social and civic preparedness, and our opportunities for making our country rank foremost with the other nations of the world have been pointed out in the columns of The Journal and elsewhere. The fact remains, however, that our factories are still looking for men, and men are looking for work.

What will become of our national industrial advancement unless engineers are soon provided with a body of thought on the part of workmen who must be depended upon for the execution of their plans? Where is the trouble?

Corporations have found it necessary to establish their own private schools. It was vital for them to have a certain number of skilled mechanics "coming along" to take care of the growth of business and replace those who are eliminated. It cost one corporation one thousand dollars a month just for waste material due to the inefficiency of a part of their so-called skilled workmen. A prominent decorator who had a large contract to finish hired six men in one day and the same night had to discharge five of them.

In one factory a large number of men were waiting at the employment office. "What can you do?" was asked. The reply was, "Nothing." Here was the factory tied up with work in search of employees and could not get them, and here were the men looking for employment but could not find it.

That, of course, is greatly intensified in large cities and large plants, but when you trace it down the condition is commensurate with and proportional to the size of the city and plant with equal importance.

The public school system has been regarded as one of our greatest and most democratic American institutions. Everyone thinks of it as wonderful and supreme in its management, direction and organization. One readily finds on analysis, however, that the system entails a tremendous loss, because it fails to fit the great mass of the people. On the other hand, it succeeds admirably in accomplishing the purpose it began—which is that of bringing the children from the first grade and the home up through the grammar school, the high school, into the college.

But there are 65 to 90 persons out of a hundred who are eliminated annually and thrown out upon the streets of every community with but little more than an average of six to seven years' schooling. Thus is industry supplied by the "slag" from the schools. These young people go out to recruit our skilled and efficient helpers and producers, to become future American citizens, and they have almost no training whatever.

In New York City it was recently shown that there were 86,000 children who entered the second grade of the grammar school. 42,000 of these graduated from the eighth grade, 23,000 entered the high school and but few over 4000 graduated.

What has become of the other eighty-odd thousand?

With the decline, due to specialization in industry and piecework, of apprenticeship as it existed in bringing forth the mechanics of today, it is impossible for the boy to receive his due quota of industrial training. As a result our industries and our people must suffer.

The ideal of the school system has changed, however, and it is beginning to bring education in touch with the industrial service of every community, large funds being appropriated annually by States and cities, while at the present time an appropriation of several millions is pending in Congress which will be dispersed as Federal aid. We have had to learn our lesson from the European countries and now it is pervading every State in the Union as an economic necessity.

The State of Wisconsin has adopted a unique and unusual plan, having taken advantage of the accumulated experience of Germany. Other States have adopted various other methods, differing according to their special condition.

We are facing the great problem of the unemployed, which is the result of our educational system, as a whole, not being entirely adapted to the welfare and vocational interests of all our people—except in so far as general schooling is generally helpful. We have been intensifying on the *self-respecting, intelligent* citizen. Let us see what can be done toward making him *self-supporting* as well.

In this lies our great opportunity for economic, social and civic preparedness which will make our country rank foremost with the other nations of the world.

Frank L. Glynn.

Madison, Wis.

Society Affairs

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES[1]

OFFICERS AND COUNCIL, 1916

President

D. S. Jacobus

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Vice-Presidents

Terms expire December 1916

Henry Hess
George W. Dickie
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

COMMITTEES, ETC.

STANDING COMMITTEE

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library, John W. Lieb
House, William N. Dickinson
Research, R. J. S. Pigott
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee to Determine Cost of Electric Power
Conservation
Electrical Engineering Standards
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R. Hutton
Boiler Code Committee, John A. Stevens
Engineering Education
Filter Standardization, George W. Fuller
Increase of Membership, Irving E. Moultrop
Metric System
Nominating Committee, Walter B. Snow
Patent Laws
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee, R. J. S. Pigott
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Investigation of the Clinkering of Coal, Lionel S. Marks
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Machine Tools, Leon P. Alford
- Sub-Committee on Safety Valves
- Sub-Committee on Steam Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A. Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, (Secretary not appointed)
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit (not appointed)
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

DETROIT and New Orleans have in the past month been added to the industrial centers where meetings of the Society will be regularly held. Close coöperation will be had between the new Sections and the local engineering societies of the respective cities, namely, the Detroit Engineering Society and the Louisiana Engineering Society. Similar coöperation with other national society sections is always the program of the Am.Soc.M.E. wherever it undertakes any work. The uniform policy is to build up a spirit of professional engineering and fraternity in each center with the local engineering society as the nucleus, the sections of the national societies coöperating.

The temporary committee in charge of the organization of the Detroit Section consists of R. Collamore, *Chairman;* F. H. Mason, *Secretary;* E. J. Burdick, H. H. Esselstyn (*ex officio*), W. R. Kales, and H. McCabe.

The Executive Committee of the New Orleans Section has been duly nominated by the local members and appointed by the Council and consists of W. B. Gregory, *Chairman,* Member of Council designate; H. L. Hutson, *Secretary-Treasurer;* R. J. Burwell, H. F. Rugan and E. W. Kerr.

Other centers which have plans for the establishment of Sections under way are Baltimore, Erie and Providence, and it is expected these will be fully developed in the fall.

Volume 37 of Transactions will be issued during the month to standing members in 1915. The page size, 6 in. x 9 in., is uniform with the preceding annual volumes. A synopsis of the contents is given below. The volume contains 1560 + XVIII pages, and is the largest annual volume ever issued by the Society. The work of preparation has been ably supervised by the Publication Committee, I. E. Moultrop, *Chairman.*

With the coöperation of the committees on Gas Power, Railroads, Machine Shop Practice, Industrial Buildings, Textiles, etc., the plans of the Committee on Meetings for the thirty-seventh Annual Meeting are developing rapidly. The Committee on Meetings calls attention to the necessity for receiving manuscripts of papers by September 20.

The Committee on Air Machinery reports that it has a large amount of research work on the measurement of air on hand in conjunction with the Navy Experiment Station at Annapolis.

The Research Committee, under the chairmanship of R. J. S. Pigott, has adopted a new plan of working this year. The Committee intends to hold three principal meetings, one on September 15, one on December 4, and the third before the Spring Meeting. At these meetings all the members of the Committee are expected to be present, as well as the chairmen and members of the sub-committees. The chairmen of all sub-committees report each month in writing to the chairman of the Standing Committee the progress made by the sub-committee during the month.

WELCOME THE AMERICAN SOCIETY OF CIVIL ENGINEERS!

Civil Engineers to Share Engineering Societies Building

The American Society of Civil Engineers has voted to accept the offer of the United Engineering Society to become an equal partner with the three Founder Societies, the American Institute of Electrical Engineers, the American Institute of Mining Engineers and The American Society of Mechanical Engineers in ownership, occupancy and administration of the Engineering Societies Building and all other activities which the Societies may jointly undertake. Thus is the hope of Mr. Andrew Carnegie, the donor of the building, fully realized—that the building should become the home and headquarters of the engineering profession in America.

The action of the Civil Engineers is the result of a letter ballot of its entire membership. This ballot closed on June 15 and was announced at the Pittsburgh convention of the society on June 27. The vote was six to one in favor of the removal of the society from its present headquarters on 57th St., New York.

Three stories will be added to the top of the Engineering Societies Building and specially planned for the extension of the Library and for the use of the Civil Engineers. The cost will not exceed $250,000. The arrangement with the Civil Engineers is to permit them to reimburse the United Engineering Society for the cost of the enlarged building, this sum being substantially the same as the amount paid by the Founder Societies originally for their participation in the enterprise. Thus all four societies enter upon the same basis and share equally in all respects.

Ten years ago, at the time the Engineering Societies Building was constructed, the Civil Engineers were invited by Mr. Carnegie to be a Founder Society in the Building. They decided at that time not to accept the offer, however, but to continue to occupy their own house on 57th Street, which they had built about ten years earlier.

At the time of the undertaking of the Founder Societies, there was doubt as to the success, financially and technically, of the scheme for associating several societies in one building. The construction and dedication of the building were looked upon by some as the first steps of a severe trial of the management of the societies. Many questioned whether the three participating societies in Mr. Carnegie's gift would live together in harmony and be able to carry out the plans suggested. Some questioned the feasibility also of uniting the three independent libraries of the societies into one joint library, useful to members of any of the three societies for research and consultation. Some did not see how the housing of the three national societies and several minor associations under one roof would bring about the desirable closer coöperation of the various members of the profession, without at the same time causing some of the organizations to be "swallowed up" by some of the others.

The experience of ten years has shown that all these criticisms of the project have become groundless. The financial stability of the Engineering Societies Building is now fully established. The building represents an investment of practically $2,000,000. The societies own it free of all encumbrance, and have in addition over $70,000 in a separate reserve fund to provide for depreciation and amortization. Each society has itself prospered. The Civil Engineers will now pay about $225,000 for the addition to the building, and each of the four Founder Societies will then hold an equity in the property of over half a million dollars.

Eighteen societies, including the three original Founder Societies, now make the building their headquarters. Each is under its own management absolutely, and all live in independence and harmony. Frequent conferences are held in matters pertaining to the welfare of the engineering profession as a whole.

With the Civil Engineers, the total membership represented in the building will be 52,677, as shown by the following figures of present membership of the resident societies:

American Society of Civil Engineers	8022
American Institute of Electrical Engineers	8308
American Institute of Mining Engineers	5597
The American Society of Mechanical Engineers	7149
Aeronautical Society of America	200
American Society of Heating and Ventilating Engineers	705
American Gas Institute	1530
Association of Edison Illuminating Companies	73
American Institute of Aeronautical Engineers	121
Empire Gas and Electric Association	115
Illuminating Engineering Society	1350
Municipal Engineers of the City of New York	600
National Electric Light Association	14000
National Association of Engine and Boat Manufacturers	175
New York Electrical Society	705
Society for Electrical Development	1128
Society of Naval Architects and Marine Engineers	900
Society of Automobile Engineers	1975
U. S. Naval Consulting Board	24

Truly the aspirations of Mr. Charles F. Scott, Past President of the American Institute of Electrical Engineers, Mem. Am.Soc.M.E., who in 1902 pictured a magnificent building, the "Capitol of American Engineering," and the hopes of those progressive engineers who have so long worked in various ways toward the common end, will now be fully realized, when this enormous membership—the largest in the world under one roof—is concentrated in one headquarters.

The Joint Library of the United Engineering Society has in ten years become the greatest and potentially the most useful engineering library in the world. Accessions are now being made at the rate of three thousand annually, and the collection amounted, at the time of the last annual report of the Library Board, to over 62,500 volumes. 1020 publications were at that date being received periodically, and current numbers of over 1000 periodicals were on file upon the shelves in the reading room so as to be readily accessible. The consolidation of the valuable Civil Engineers Library with the others will enlarge the scope of the Library so that it will become of use to any member of the entire engineering profession.

There has been of late an increasing amount of coöperation between the societies through their governing bodies in matters affecting the general welfare of the engineering profession. There has likewise been increasing and notable coöperation between the Government and the societies. There has been increasing coöperation between the parent societies and their local affiliations, and in turn there has been increasing coöperation with the local affiliations of the various societies with each other.

The testimony of all will therefore be that the action of the Civil Engineers to come in establishes their desire to do their part in the great coöperative movement in which the engineers of America are engaged for the purpose of promoting the welfare of the profession as a whole and, through it, of the public at large.

VOLUME 37 OF TRANSACTIONS

The affairs of the Society during the year 1915 are recorded in Volume 37 of Transactions, to be issued during the month of August to standing members in 1915. A general review of the work of the Society for this year is given in the Annual Report of the Council included. The Volume contains a calendar of all the meetings of the Society—general meetings and local meetings—held during the year; and the papers, with discussion, presented at the Spring Meeting in Buffalo, April, 1915, the Annual Meeting in New York, December, 1915, and the additional general meeting in San Francisco, September, 1915, in connection with the Panama-Pacific International Exposition and the International Engineering Congress, 1915, are published practically in full. Papers read at local meetings and presented subsequently at a general meeting are also included; other local meeting papers will be found in The Journal, where a more detailed account of the local meetings is given. The reports of special committees received by the Council during 1915 and ordered published are included in the volume; of special note among these is the report of the Power Test Committee. The reports of Standing Committees for the year are published in The Journal, December, 1915.

A member's badge was recently found in Chambers Street, New York City, near the Sixth Avenue Elevated Railway. The badge will be returned to its owner upon application to the Secretary.

The United Engineering Society has installed a photographic duplicating machine for the reproduction of pages from books and periodicals, maps and charts, in the Library of the Engineering Societies, and it is now in operation. Orders may be sent to the Library of the Engineering Societies, 29 West 39th St., New York.

The process produces a photograph (white on black) direct on bromide paper, and from this negative print a positive may be made by re-photographing. The charge for a print 11 in. x 14 in., which may cover two pages of an octavo volume which face each other, is 25 cents for a negative print and 50 cents for a positive print. Enlargements and reductions up to 11 in. x 14 in. are easily made. The process has the advantage of accuracy and cheapness.

A Minnesota Joint Engineering Board has recently been proposed for the purpose of securing the most effective coöperation among engineers of various affiliations for the welfare of the profession, to correlate the work of the various engineering associations in that State for unity of action, and to work generally for the betterment of the standards of practice and clearer recognition of the engineer as a civic asset.

AMBROSE SWASEY ELECTED HONORARY MEMBER

PERHAPS no more fitting name was ever added to the list of illustrious men who have been honored by the Society than that of Ambrose Swasey, student, scientist, inventor, mechanical engineer, traveler, philanthropist and man of affairs, who has just been elected to honorary membership in the Society.

Certainly no engineer living merits more the distinction of being ranked by the Society with Holley, Eiffel, Sweet, Edison, Brashear, Leavitt, Bessemer, Westinghouse, Isherwood, and a score or more of others whose names grace its list of honorary members, than does Dr. Swasey. If he were only known (with his partner) for his achievements in constructing and erecting the largest telescopes ever made his fame would be assured, but, coupled with this attainment, his genius as an inventor, his ever increasing efforts toward advancement of the engineering profession and education in general, his unselfish generosity, and his wholehearted interest in other people, have more than obligated for him any recognition it is in the power of any individuals or associations of individuals to bestow.

AMBROSE SWASEY

The story of Mr. Swasey's life is a continuous record of tasks planned, carried through with perfect method, and completed precisely as planned. To attempt to enumerate these in the short space of an article would be futile, and a description of any one of them would reveal his remarkable character, his aptitude for detail and the precision to which he works. For instance, in each of his journeys around the world—and he has made two such complete journeys—he always prepared and printed in advance a complete itinerary covering the whole trip from the day of leaving Cleveland to the day of returning, and this he carried out to the letter, returning precisely on the day indicated. The preparation and carrying out of such an itinerary was but an infinitesimal task compared with the planning and execution of the epoch-making professional works in which he has engaged, but it well illustrates his capacity for taking pains, which is the essence of all genius.

Sketches of Mr. Swasey's life have been written a number of times, but the facts and incidents are so interesting and instructive as to be well worth reviewing again.

Ambrose Swasey was born in Exeter, N. H., in 1846, and like many of the foremost engineers in the country he never had the advantages of what is known as a technical education, but received what schooling he had in the Little Red Schoolhouse. At the age of eighteen he entered upon the machinist's trade in Exeter, and while learning his trade, Worcester R. Warner came to the same shop and began his apprenticeship, and the two struck up a companionship. In 1870, in company with Mr. Warner, he left his native state to enter the employ of the Pratt and Whitney Company at Hartford, Conn. His energy and ability soon attracted attention, and his aptness in the solution of mechanical problems was soon called into demand. While in charge of the gearing department, he invented and perfected the epicycloidal milling machine, and a few years later an entirely new process for generating and cutting spur gears which proved a practical solution of the very important factor of the interchangeable system of gearing.

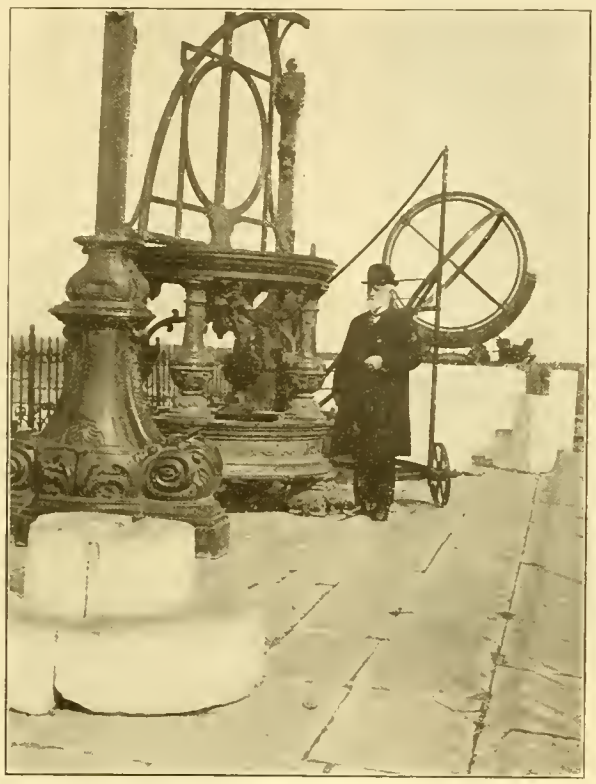
In 1880 began that remarkable business association—the firm of Warner and Swasey, with the history of which all mechanical engineers in America are familiar. Its original business was that of machine construction, but Mr. Warner's taste for astronomy and his interest in the appliances used by astronomers, combined with Mr. Swasey's love of design and his ability as a mechanical engineer, naturally led them into the perfection and manufacture of astronomical instruments. The history of the firm's work in this field is linked with the history of the development of large telescopes from the time of the 36-in. refractor constructed by that firm for the Lick Observatory in 1886 (at that time the largest and most powerful ever constructed and a radical departure in design from any previous standards) to the present, which includes the completion and installation of the present largest telescope, the 72-in. reflecting telescope for the Dominion Astronomical Observatory, Victoria, Canada, described in The Journal, July, 1916.

The manufacture of meridian circles, transits and other astronomical instruments of extreme accuracy and precision has formed a large part of the firm's work, and in the designing of all these instruments Dr. Swasey has taken a prominent part. He took up the problem of designing a dividing engine of sufficient accuracy for graduating astronomical circles, and perfected such an engine capable of automatically dividing circles up to 40 in. in diameter, within an error of less than one second of arc. He has also given special attention to the development of instruments of precision for use in sea-coast defense, and the notable Swasey depression range finder, adopted by the United States Government, is by far the most perfect and most practical ever invented.

Turning from his engineering achievements, one's mind is

focused upon his philanthropic and beneficent works, which have contributed equally to his fame, and which indicate his real motive of life. Monuments to his generosity are the handsome observatory he gave to Denison University, Granville, Ohio; the science building to the University of Nanking, China; the Young Men's Christian Association Building to the Canton (China) Christian College, the Baptist Ministers Fund, and—as members of the Society recall with pleasure—his generous gift for the inauguration of The Engineering Foundation. These should be supplemented by an account of his establishment of the school of apprentices of The Warner and Swasey Company, and by details of many of his other works of benefaction known only to a few.

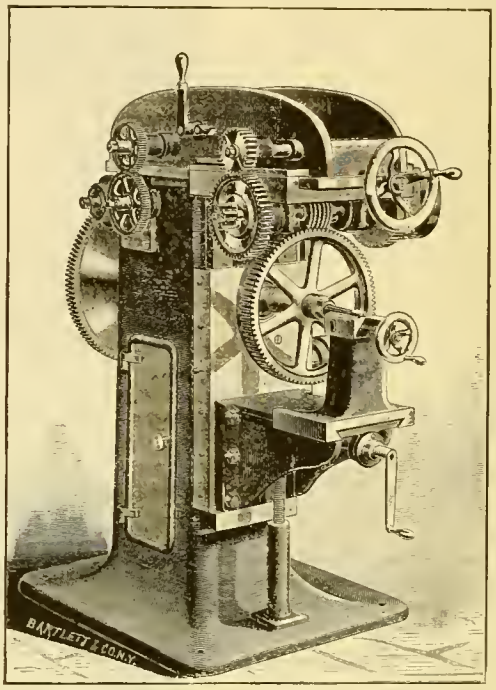
One of Mr. Swasey's characteristic traits is his extreme modesty, and the honors that have come to him have certainly not been of his own seeking. In 1900 he was decorated by the French Government with the Legion of Honor for his achievements in the design and construction of astronomical instruments. In 1905 Case School of Applied Science conferred upon him the honorary degree of Doctor of Engineering, and five years later he received the honorary degree of Doctor of Science from Denison University.



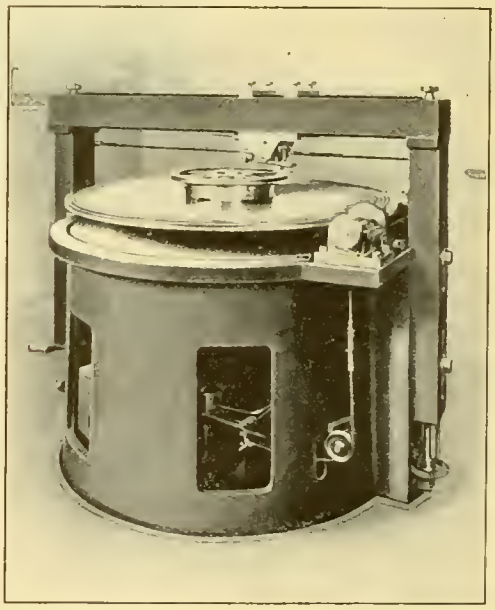
Mr. Swasey at Chinese Astronomical Observatory on Great Wall of China

Mr. Swasey's connection with the Society goes back to the beginning, for he was one of the original forty-eight men whom Professor Sweet called to meeting in 1880 for the purpose of taking steps to organize the Society. During his period of membership he has served on numerous committees, including the Executive Committee, the special committee on National Museum, and the John Fritz Medal Committee; he was chairman of the Nominating Committee in 1912. He served as Vice-President of the Society, 1900-1902, and as President during 1904. In the latter capacity he presided at Chicago at the joint meeting of the Institution of Mechanical Engineers of Great Britain and this Society. He entertained the visiting members of the Council of the Institution at a handsome dinner in New York before they started for the meeting and graciously invited the members of the Council of the Society to act with him as hosts. The papers of the meeting were by both British and American authors and were published in the Transactions of both societies.

He presided at the twenty-fifth annual meeting of the Society in New York, 1904. His presidential address was entitled, Some Refinements of Mechanical Science, and discussed the coming of the standards of accuracy of the scientist and instrument maker into the domain of the engineer, the accuracy of mechanical work and measurement involved in graduated limbs of optical apparatus, and the wave length of light as a unit of such mechanical measurement.



Swasey Spur Gear Cutting Machine



Warner & Swasey Circular Dividing Engine

His first contribution to the proceedings of the Society was made in 1890, when he described a new process for generating and cutting the teeth of spur wheels; the principle of the process was the utilization of a rack as the cutting tool. The machine described was the subject of much comment, to which Mr. Swasey replied that it was simply made to demonstrate the practical solution of a principle, which it did with very satisfactory results. He subsequently contributed discussions to the Transactions upon a variety of subjects, including bevel-gear cutting, microstructure of metals, industrial photography, steam turbines, centrifugal pumps, etc.

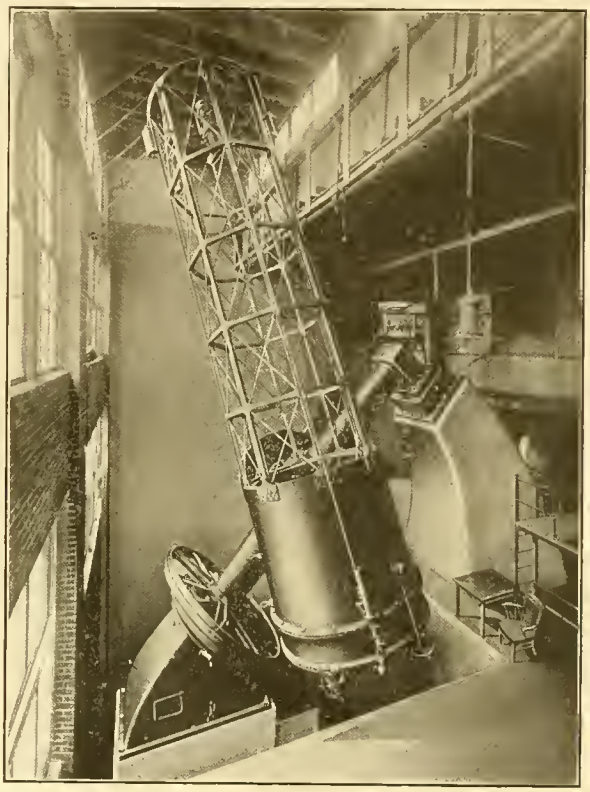
On the occasion of the inauguration of The Engineering Foundation, the President and Trustees of the United Engineering Society tendered a testimonial dinner to Mr. Swasey at the University Club, New York. Those who had the good fortune to be present on that occasion will long remember the overwhelming greeting to him and the pledge to carry out faithfully the trust he had assigned to them.

His connection with other scientific and engineering societies includes membership in the Institution of Mechanical Engineers of Great Britain and in the British Astronomical Society. He is a Fellow of the Royal Astronomical Society and a past-president of the Cleveland Engineering Society. He was a member of the Jury of Awards of the Nashville, the Pan-American, and the St. Louis Expositions, and he was also Vice-President of the Jury of Awards of the Jamestown Exposition.

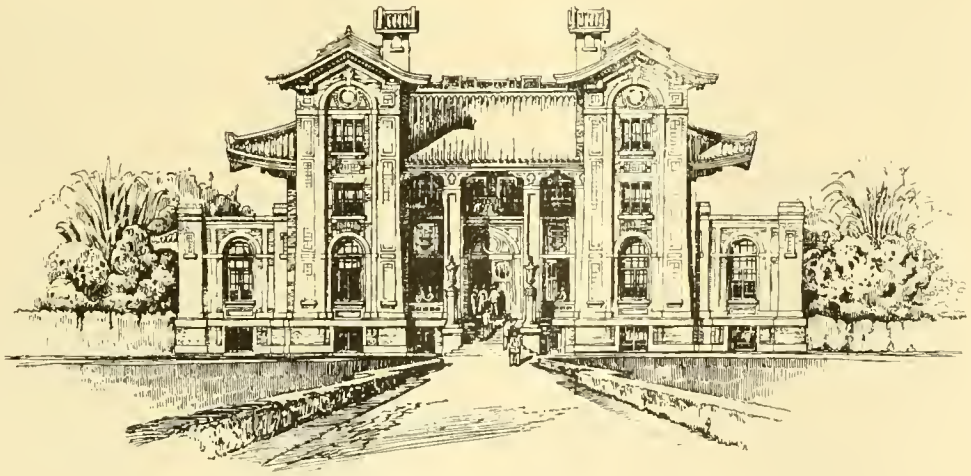
In 1905 he served as President of the Cleveland Chamber of Commerce, and he performed the duties of his position in a most unselfish, intelligent and painstaking fashion. President Roosevelt appointed him a member of the federal commission to test coins in the government mints. In 1907 Mr. Swazey was made first vice-president of the National Board of Trade.

The record of Dr. Swasey's life and attainments well illustrates the remarkable power of one man to rise by force of character, will power and energy, to the highest pinnacle of the profession. Analyzing his methods of living and working, we find them, as in the case of all notable men, remarkably simple. Writing to Prof. M. P. Higgins, member of the Massachusetts Commission on Industrial Education, in reply to a request for his opinion as to the nine essential qualifications of a machine shop foreman, Dr. Swazey specified:

1 Good character and habits
2 Ambition to succeed through meritorious work
3 Adaptability to chosen occupation
4 Studiousness and industry
5 Tidiness in personal appearance and surroundings
6 Faculty for reading and handling men
7 Knowledge and experience in modern machine shop practice
8 Judgment as to amount and quality of work done
9 Resourcefulness in new and improved methods



72-In. Reflecting Telescope by the Warner and Swasey Company



Y. M. C. A. Building, Canton Christian College, Canton, China

qualifications which are so well reflected in his own personality.

It is given to few of us to achieve the wonderful record which Dr. Swasey has attained, but, inspired by him, may we all emulate the best example, as has been his life-long aim.

SOME REFINEMENTS OF MECHANICAL SCIENCE

By Ambrose Swasey

The division of the circle and the measurement of angles has ever been among the unsolved problems of the astronomer, yet in the instruments used by him circles have formed a most important part.

Long before the telescope was invented, Tycho Brahe, the Danish astronomer, "the founder of modern astronomy," constructed for his observatory, instruments of various kinds having graduated circles and arcs of circles. His instruments for the most part were improvements on those used by Arabian astronomers in the eighth and ninth centuries, and these, in turn, were copied after similar instruments used by the Greeks and Egyptians a thousand years previous, and it is supposed that such instruments were used by the Chinese at an even earlier period, so that graduated circles have come down to us from the far-off ages.

The first circular dividing engine was made in 1740 by Henry Hindley, of York, England, for cutting the teeth of clock wheels, and it is interesting to note that in the same year Huntsmann, another clock-maker, of Sheffield, invented the process of making crucible steel, that he might have a metal suitable for the springs of his clocks

Of the several engines constructed later, the one most successful and representing the greatest progress was that made by Ramsden, in 1777. This engine, automatic in its movements, was made especially for graduating circles, and because of the great precision with which he divided the circles of the instruments used by the Government, the Board of Longitude awarded him the sum of six hundred and fifteen pounds. A further and most potent recognition of the excellence of his work lies in the fact that all subsequent circular dividing engines have followed closely the same general principles of construction embodied in the Ramsden engine.

Many excellent dividing engines have been made that are quite sufficient in point of accuracy for the work for which they were intended, but the perfection required in the graduation of circles for astronomical instruments is such that it has been found to be one of the most difficult of all mechanical problems to make an engine to meet such requirements.

In such an engine the chief essential is that the spindle carrying the master-plate shall be as nearly round and as closely fitted in its bearings as is possible, for the degree of excellence with which that work is done determines how closely a circle can be divided.

It seems almost incredible that a well-lubricated spindle of four inches in diameter at its largest part and tapering three-quarters of an inch to the foot, can be made so nearly round and so closely fitted in its bearing that a movement of one-thousandth of an inch in or out of its bearings, will in one case cause it to turn with difficulty, and in the other with perfect freedom, yet this has been found to be within the limits of mechanical refinements.

The greatest accuracy thus for attained in such engines, is one second of arc, which arc, with a radius of three miles, equals one inch, and at twenty inches, which is the radius of the silver ring upon which the graduations on the master-plate are made, a line one-thousandth of an inch in width is equal to twelve seconds of arc, or twelve times the accumulated errors of any number of divisions, or twenty times the greatest error of any single division.

In automatically graduating a circle, it has been found to be impracticable to cut more than six lines in a minute, and it requires about thirty-three hours to divide a circle into two-minute spaces. As with the running of the finest clocks, the best results can only be obtained when the engine is surrounded with every favorable condition possible. Instead of the large circles and sectors used by the ancients, they have been made smaller in diameter as the methods for graduating have been improved, until those of the more modern instruments are seldom more than thirty inches, and some of the latest meridian instruments have circles of but 25 in.

A twenty-five inch circle read with a microscope having a power of forty would be equivalent to a circle of about eighty feet in diameter, and a single second of arc as seen through the microscope would be equal to 0.0024 of an inch, a quantity easily subdivided.

Step by step from the methods of the Arabian astronomers to the time of Tycho Brahe and on down to the present day, improvements in the instruments and methods for the measurement of angles have been going on, until astronomers can measure double stars with a separation of one second of arc, and within less than one second they can define their positions in the heavens.

In the realm of the measurements of minute linear distances, and the perfection of curved and flat surfaces, the refinements are even greater than those pertaining to the measurement of time and of angles.

Most important in the linear dividing engine is the screw, and although much had been accomplished in bringing such engines to a high degree of excellence, it was for Professor Rowland to make an engine which has a practically perfect screw; and without doubt it is in all respects the nearest perfect of all the mechanisms that have been employed for ruling lines exactly parallel and equally spaced.

The Rowland engine was made especially for ruling diffraction gratings which are made of speculum metal, and with it a metal surface has been ruled with 160,000 lines, there being about 29,000 to the inch, and as many as 43,000 lines to the inch have been ruled.

The gratings mostly used have from 14,000 to 20,000 lines to the inch, and with such exactness is the cutting tool moved by the screw that the greatest error in the ruling does not exceed one millionth of an inch.

The production of these gratings, which has enabled the physicist in his study of the spectrum to enter fields of research before unknown, has not only called for the highest degree of perfection ever attained in the spacing of linear distances, but it has also called for a refinement most difficult in the optical surfaces upon which the lines are ruled. To Mr. Brashear was given the problem of producing such surfaces, and notwithstanding the many difficulties encountered in working and refining the speculum metal plates, he has made many hundred plates with surfaces either flat or curved with an error not to exceed one-tenth of a wave length of light, or one four hundred thousandth of an inch.

As the established standards of length, which are the yard of Great Britain and the meter of France, are made of metal, and liable to destruction or damage, Professor Michelson conceived the idea of determining the lengths of these standards in wave lengths of light, which would be a basis of value unalterable and indestructible.

For the purpose of carrying out these experiments, the interferometer was constructed, an instrument which required the highest order of workmanship and the greatest skill of the optician. Again Mr. Brashear proved to be equal to the occasion, and made for the instrument a series of refracting plates, the surfaces of which were flat within one-twentieth of a wave length of light, with sides parallel within one second. This was the most difficult work ever attempted in the refinement of optical surfaces.

Professors Michelson and Morley devised a method for using the interferometer to make the wave length of some definite light an actual and practical standard of length. So satisfactory was the result that Professor Michelson was invited to continue the experiments at the Bureau of Weights and Measures, at Sèvres, France, where the standard meter, which is kept in an underground vault and inspected only at long intervals, was used for that important work. The final result of the experiments, which occupied nearly a year, shows that there are 1,553,164.5 wave lengths of red cadmium light in the French standard meter, at 15 deg. cent. So great is the accuracy of these experiments, that they can be repeated within one part in two millions. Should the material standard of length be damaged or destroyed, the standard wave length of light will remain unaltered, as a basis from which an exact duplicate of the original standard can be made. These two marvelous instruments, the Rowland dividing engine and the Michelson interferometer, show the possibilities in the perfection of linear divisions and the standards of length.

Abstract of Mr. Swasey's Presidential Address which was published in Vol. XXVI of Trans. Am.Soc.M.E.

WHAT THE SECTIONS HAVE DONE THIS YEAR

LAST month we were able to publish reports from the Sections at Birmingham, Ala.; Buffalo, N. Y.; Cincinnati, O.; Los Angeles, Cal.; New York, N. Y.; Philadelphia, Pa., and San Francisco, Cal., summarizing their activities for the season just closed. Similar reports have since come to hand from the Sections at Chicago, Ill.; Boston, Mass.; New Haven, Conn.; St. Louis, Mo.; Worcester, Mass., and from the Minnesota Section, and are published below.

CHICAGO HAS FOUND DINNER MEETING A SUCCESS

To the Secretary:

We feel that the Chicago Section is about as much alive as any part of the Society. Included in our membership I find the names of some of the ablest engineers in the country, and they all seem to have an interest which is deep and enthusiastic. We had four well attended meetings the past year, at which an average attendance of at least 200 was recorded. It is very difficult to say what technical subjects aroused the greatest interest, as they were all particularly well received. Speaking broadly, however, it would appear that matters relating to power plant design or operation, particularly the combustion part of it, seem to bring out the largest numbers. We apparently struck a happy medium between the social and technical aspects of these meetings. It is not desired to have them entirely one or the other, but a happy combination of both. The dinner which precedes the business affords the opportunity of social intercourse and mutual exchange of ideas. This lasting for an hour or so gives ample opportunity for free discussion and intermingling. By the time the dinner is over we are all ready for the intellectual feast.

We are planning a very similar series for next winter, and it is going to be our endeavor to secure the very highest class of talent for them. There is nothing too big or too good for the Chicago Section, and with the possibility of bringing out three or four hundred engineers of standing, the ablest speaker finds a worthy field for his endeavors.

Joseph Harrington,
Chairman, Chicago Section.

BOSTON ALSO FOSTERS SOCIAL MEETINGS

To the Secretary:

We can only be very enthusiastic over the splendid results obtained in connection with some of our activities during the season just closed. The total attendance of meetings has been much greater than that of any season before.

During the season of 1915-16 we held five meetings, besides three joint meetings and a joint engineers' dinner under the auspices of the Boston Section of the Am.Soc.M.E., and a big joint meeting in Providence with the Providence Association of Mechanical Engineers.

The best attended meeting during the season was the joint meeting at Providence, at which there were over 600 present, with inspection of several of the large manufacturing plants and the laboratories of Brown University, and a dinner at the Narragansett Hotel, at which each person present had telephonic communication with a group of engineers gathered in San Francisco. We had some notable addresses at this meeting,—one on Explosives and the Engineer, by Charles E. Munroe, of George Washington University; also Experience of an Engineer in Public Office, by Morris L. Cooke, Director of Public Works, Philadelphia, and Development of a National Telephone System, by N. C. Kingsbury, vice-president of the American Telephone & Telegraph Company. This was unquestionably the biggest Am.Soc.M.E. meeting ever held in New England.

The next meeting of importance of the season was the seventh Annual Joint Dinner of the three Societies at the Boston City Club, conducted by the Boston Committee of the Am.Soc.M.E. At this there was an attendance of 373. Some able addresses were made in reference to the usefulness of the engineer in connection with the campaign for Preparedness now being waged, and also the engineer's usefulness in case of war.

Two others of our meetings were very largely attended. At one of these Prof. Ira N. Hollis, of the Worcester Polytechnic Institute, presented his paper on Naval Lessons of the Great War for America. The other was the last meeting of the season on May 23, when the subject was: Measurement of Steam Flow to Determine Boiler Output and Measurement of Condition of Fuel Beds. The last mentioned paper doubtless brought out the most discussion of any paper presented during the season. Attendance at each of these meetings was about 150.

The Committee of the Boston Section, together with a Committee from the Boston Society of Civil Engineers and the Boston Section of the A. I. E. E., have had several meetings at which an attempt has been made to secure more coöperation between the different engineering societies, and if possible reduce the total number of engineering meetings held in this community during the season, it being hoped that we might in-so-far as possible pick out subjects for papers in most cases of such general interest that we could have more joint meetings and fewer meetings of the individual sections.

The success of all our meetings at which the social feature has played some part has convinced us that this type of meeting draws the crowd far better than one where we merely present a technical paper and a discussion. This was shown by the large attendance at the joint meeting in Providence, at the joint Annual Dinner, and at the meeting at the Engineers' Club, at which a simple buffet luncheon was served after the discussion. The interest and the attendance were by far the greatest at these three meetings.

The Boston Committee feels very strongly that the important thing to do is to have a few meetings at which we can have a large attendance and an opportunity for social intercourse, believing that such events tend more strongly to up-build and develop engineering organizations than a larger number of meetings which are purely technical in their program.

H. N. Dawes,
Chairman, Boston Section.

SOCIAL AND ENGINEERING ELEMENTS MIXED AT NEW HAVEN

To the Secretary:

The local membership of the New Haven Section has increased nearly fifty per cent recently and interest in the Society was never keener than at present. The coöperation of the Sheffield Scientific School has aided us greatly by providing ideal facilities for meetings and service of its faculty on the Section committee. The heads of the mechanical and electrical engineering departments, Professors Breckenridge and Scott, are members of this Society and much interested in its work. Active student branches are organized in both departments and hold frequent meetings under their own management. Changes in the Section committee are the retirement of Prof. L. P. Breckenridge and Frank L. Bigelow after five years' service and the appointment of their successors, Prof. J. W. Roe of the Sheffield Scientific School and F. L. Mackintosh of the Winchester Repeating Arms Co.

Two meetings have been held during the year with afternoon and evening sessions for reading papers and discussion. About 150 persons attended each meeting and half that number were at the dinner and social hour between sessions. The registration showed that half the attendance consisted of non-members, and many were present from neighboring cities, Bridgeport, Waterbury, New Britain and Hartford. The spring meeting was a joint one with the civil, electrical and mining engineers of this city.

Four additional informal meetings for members only have been held, with an average attendance of twenty. One meeting was a noonday luncheon at the Hotel Taft, the others were evening meetings with a brief talk by one of the members.

The last meeting, June 29, was held in the Mason Laboratory, when P. J. G. Reuter gave an interesting talk on the Diesel Motor, with pictures of Swiss machine shops where

the machines are built. The interest in the monthly meetings shows the possibility of continuing them during the summer, and another has been planned for July.

The new feature of the year has been the monthly meeting with combined social and engineering elements that promise well for the future. The committee of the New Haven Section is H. B. Sargent, *chairman;* Prof. E. H. Lockwood, *secretary;* J. Arnold Norcross, Prof. J. W. Roe, and F. L. Mackintosh.

E. H. Lockwood,
Secretary, New Haven Section.

MINNESOTA'S EXPERIENCES AND PLANS

To the Secretary:

In reviewing the work of the Minneapolis Section of the past year, the questions of policy for future action naturally resolve themselves into specific classes; for instance, how to increase our active membership, to make the section a more potent force in the State, to be of greater value to the members in their varied lines of specialized work, and to promote a higher standard of engineering ethics.

Suitable material for membership is not wanting, but the principal difficulty in enlisting local engineers in the Am. Soc. M. E. is due to the number of local engineering activities to which they already subscribe, and a reluctance to assume further financial obligations or to withdraw from obligations already incurred. A more active canvass for the coming year will be necessary.

The Section realizes that it can profitably lend itself to any progressive plan to increase its value to the State, and willingly holds joint sessions with other engineering societies. We have representation in the Minnesota Joint Engineering Board, an organization which has as its object the promotion of engineering interests in the State.

The meetings of the past year have not been as well attended as the character of the papers presented would warrant. The topics discussed in the papers covered a wide range of engineering work.

A symposium on Gas Engines requiring both afternoon and evening sessions was very successful, and it is the intent to have a similar session during the coming year, featuring some other line of work.

The dinner dance was the big social event of the year, and it served as an occasion to invite the participation of engineering friends and wives and sweethearts of the members. This feature will be repeated.

Occasionally a meeting is preceded by a luncheon, which permits of closer contact of members and is conducive to a free interchange of ideas.

We have access to moving picture machines, which have been used to present papers requiring their use and to present films of a less serious character.

Located as we are a long way from New York, there seems to be a lack of close contact with headquarters, a condition which I believe will be largely mitigated by the annual visit of the President. It is hoped that we may be able to get other men of large caliber to visit us and leave a message, both stimulating and inspiring. We also hope to have all local papers prepared either in full or in abstract to be distributed prior to their presentation, so that a fuller discussion of them may be had.

John V. Martenis,
Chairman Minnesota Section.

ST. LOUIS PLANS TO INCREASE ITS MEMBERSHIP

To the Secretary:

Our meetings of the present year differed from those of last year in better attendance, more social meetings, scarcity of local papers, and a wide interest in military topics.

The meeting in October when Dr. Brashear was our guest was of such an epochal nature as to put it in a class by itself. Dr. Brashear's lecture was, of course, the largest meeting we have held. In fact, we rather think it is a record-breaker for any engineering meeting in this City. The attendance was over 1,200.

Mr. Carl Barth's paper in January drew forth quite a crowd, with probably an attendance of about 125.

On account of our relations with the Engineers' Club of this City, it is a little hard to say specifically what kind of a meeting draws the best. A first class paper at the Engineers' Club will bring about seventy to one hundred at any time, although the proportion of this attendance that represents the Am.Soc. M.E. depends very largely on the nature of the paper, whether mechanical, electrical, etc. The attendance of strictly Am.Soc. M.E. men is generally better at the social meetings than at any one of the joint meetings just mentioned. The Am.Soc. M.E. turns out very well at any one of the trips to surrounding plants, such as the one to the St. Louis Plate Glass Works last summer.

The freest and best discussions come out at social meetings, where 90 per cent of the members are Am.Soc.M.E. men, and the topics are of more specific interest. At such meetings there is no professional paper, but a talk of general interest is given by someone outside of the Society and a discussion of this almost always drifts into a technical discussion.

For next year, the new board has in mind the following features:

An increase in social meetings
One, if not two, local technical papers
Several interesting industrial trips
Greater activity in securing new members.

The following suggestions are made to you at headquarters: You could keep us better posted as to the election of new members and inform us more quickly of movements of members to or from this Section.

At social meetings more effort should be put forward to really make the men acquainted. We ought to have badges of some kind, having letters not less than 3/8 in. high, giving the name and firm to which connected.

The members should not only be introduced, but at dinners they should be arranged in groups of not over six at a table, and further care should be taken that at different meetings different groups will seat at the same table. We find this a much better arrangement than seating all of the members at one large table.

You could send us some suggestions regarding making up a new executive committee. As now arranged here, the two previous chairmen automatically become members of the new committee and three new members are elected. The two ex-chairmen are not eligible for office on the new committee. We believe that such a committee should not have over five members, but for many reasons it would be very desirable to have the past Secretary on this new committee, as at present the succeeding Secretary has to feel his way for some months, getting little help from the retiring Secretary.

We regret very much that we have no special programs or circulars to send you, other than such as have already been sent covering the October meeting, when Dr. Brashear was present. While these invitations were not unique, they certainly were successful in performing their function in drawing a record attendance.

George R. Wadleigh,
Secretary, St. Louis Section.

WORCESTER'S FIRST YEAR A SUCCESS

To the Secretary:

Regarding the work of the Worcester Section for the season just concluded, this was our first year and only two meetings were held. The first in the fall was addressed by Frank B. Gilbreth on Motion Study for Crippled Soldiers and was held at Worcester Polytechnic Institute. Attendance about 125.

Our second meeting was combined with a dinner at the Hotel Bancroft and was addressed by Dr. Ira N. Hollis who spoke on What Constitutes a Well Rounded Fleet. The attendance this evening was a little over 200 and was a very enthusiastic meeting.

Our local Committee was reelected for another season. We have placed before many local engineers, membership literature and have met with a number of favorable replies. I regret that exact figures are not available as I write to show the net increase in membership for the section but believe it is

a sound and healthy growth coming from the individual rather than from the efforts of pressure by the Committee.

We feel that our expenditures have been small considering that we are maintaining a mailing list of upwards of 1,000 names.

E. Howard Reed,
Chairman, Worcester Section.

TRIBUTE TO DR. E. D. LEAVITT

The special committee, consisting of C. T. Main, A. M. Mattice, appointed by the Council to prepare resolutions upon the death of Dr. Erasmus Darwin Leavitt, Past President and Honorary Member, has drafted the following:

RESOLUTIONS UPON THE DEATH OF DR. E. D. LEAVITT

The Council desires to express its profound sorrow at the death of its past President and Honorary Member, Dr. Erasmus Darwin Leavitt, which occurred on March 11, 1916.

In Dr. Leavitt's death the engineering profession and the Society lost a pioneer in the study of economical and high-class steam engineering, and an engineer of rare insight and judgment in general mechanical construction. Without special preliminary and technical instruction, the advantages of which nearly all engineers of the present day possess, he was able to work into the mysteries of the behavior of steam and the properties of materials, and through his own unaided efforts became skilled in theoretical and technical matters. No mechanical engineer has left for our contemplation more impressive monuments of human skill than he.

The Society owes to Dr. Leavitt a special debt of gratitude for his efforts in its foundation.

In pumping engine design Dr. Leavitt, for a time, was almost the sole occupant of the profession in the best productions. He took up steam economy where it was left by the Cornish engine and carried it on, step by step, to almost its present state, and in the application of sound principles, propriety of design and excellence of form, he was unsurpassed. Dr. Leavitt was able to carry on this work in spite of some delicacy of health.

There are few of his contemporaries in the Society now living, but they and the younger members who knew him will miss his unfailing courtesy.

The Council of The American Society of Mechanical Engineers hereby places this resolution upon its records, and sends a copy to his family and to affiliated associations.

ALFRED NOBLE MONUMENT

Congress has granted a site for a monument to be erected as a memorial to the late Alfred Noble, Past President of the American Society of Civil Engineers and of the American Institute of Consulting Engineers, and Past Vice-President of this Society and member of the Council at the time of his death, which occurred April 18, 1914.

The location selected is opposite the new building of the Department of the Interior, on New York Avenue, Washington, D. C. The preliminary designs are in the hands of a sculptor, and the committee having the matter in charge expects to report as soon as possible on the design chosen.

There are many monuments to statesmen and soldiers, and but few to engineers, consequently this will be an opportunity to which engineers should enthusiastically respond.

ENGINEER SECTION OF OFFICERS RESERVE CORPS

The engineers of the country will be fully alive to the opportunity for national service afforded by the passage of the Army Reorganization Act, which became law on July 1, and which provides for an Engineer Section of the Officers Reserve Corps.

The Act avoids any specific mention as to how the organization of the Engineers Section is to be carried out, this matter being left to the War Department. Meanwhile, General Black has requested the Joint Committee of the National Engineering Societies on the Organization of a National Engineer Reserve to recommend for local boards of examiners civilian engineers in each district, representing the civil, mechanical, electrical, and mining engineering professions, such engineers to serve with the officers of the Corps of Engineers in recommending candidates for appointment to the Officers Reserve Corps.

For the purpose of supplying to those interested full and complete information as to the requirements for commissions in the several grades, including Second Lieutenant, Lieutenant, Captain and Major, and for Master Engineers and Sergeants, and the method of procedure to secure commissions or enlistment, it is proposed to divide the country into twenty-eight districts, with headquarters in each district.

It is hoped that in the next issue we may be able to give complete information.

ENGINEERING RESEARCH STATIONS

Of special interest to engineers is the Newlands bill for establishing experiment stations in engineering, corresponding to the existing agricultural experiment stations, in the land grant colleges.

The land grant colleges and their agricultural experiment stations have been of value not only to agriculture, but to education in the several states locally and to the nation. They have as well assisted in the establishment of the state universities as a thoroughly useful element in any community and correspondingly increased the respect of the people for the college. The land grant colleges and the institutions of which they are a part received in 1914 from the United States $2,500,000, and from the states and from other sources over $30,000,000. They have 9,000 instructors and 105,000 students.

By the Hatch act of 1887 and the Adams act of 1906 the sum of $30,000 a year in each state is appropriated for research in agriculture in the experiment stations. On the other hand, the colleges have more students of mechanic arts than of agriculture, but there is no provision for research in the mechanic arts and engineering, and the sciences, such as physics and chemistry, on which they are based. The plan is that research in the engineering sciences will now be equally encouraged by the passage of the Newlands bill, which appropriates $15,000 to each state and territory for conducting investigations in engineering and publishing the results.

As a result of the greater service which agricultural departments render, their prestige is greater than the engineering departments. Further, by the lack of appropriations for the engineering departments the standing and state of development is not only below that of the agricultural departments in the same colleges, but is below the standard of other engineering colleges.

There is a difference of opinion as to just how to accomplish this improvement, but there can be no doubt of the necessity of bringing up the standing of the engineering departments of the land grant colleges.

An Am.Soc.M.E. sub-committee on Increase of Membership has been established for the State of Tennessee. Eugene C. Patterson of Chattanooga has been appointed chairman.

Lucien Buck has been appointed chairman of the Rochester, N. Y., sub-committee on Increase of Membership, succeeding John C. Parker.

ROLL OF HONOR

THE Society is desirous of publishing lists of all members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Navy, or in any other capacity in the services of the country. Every member who is, or who knows of any other member who is, engaged in the service of the country is requested to notify the Secretary. In response to the announcement in this regard in the July issue of The Journal, the following names have been received:

ADDICKS, LAWRENCE, Member Naval Consulting Board

BALL, BERT C., Oregon State Director, Committee on Industrial Preparedness, Naval Consulting Board

BEERS, R. L., Assistant Fuel Engineer, U. S. Bureau of Mines, Pitts-Pittsburgh, Pa.

BEHR, F. J., Captain, Coast Artillery Corps, U. S. A., Fort Monroe, Va.

BERGEY, J. E., Leadingman Draftsman, Machinery Division, Navy Yard Bldg., Philadelphia, Pa.

BILLMYER, CARROLL D., Corporal, First Company, Coast Artillery Corps, National Guard of Virginia

BIRNIE, ROGERS, Colonel, Sandy Hook Proving Ground, Fort Hancock, N. J., and Governor's Island, N. Y.

BUYERS, A. S., Second Lieutenant, Coast Artillery Corps, U. S. A., Adjutant, Fort Jay, Governor's Island, N. Y.

CARLSSON, CARL A. V., Ordnance Engineer, Navy Yard, Washington, D. C.

CARPENTER, R. C., Mississippi State Director, Committee on Industrial Preparedness, Naval Consulting Board

CHADWICK, GEORGE A., Leading Ordnance Draftsman, U. S. Naval Gun Factory, Washington, D. C.

CHANDLER, R. E., Florida State Director, Committee on Industrial Preparedness, Naval Consulting Board

CHARLES, L. J., New Mexico State Director, Committee on Industrial Preparedness, Naval Consulting Board

COBURN, FREDERIC G., Naval Constructor, Construction Corps of the U. S. Navy, Boston, Mass.

COFFIN, HOWARD E., Member Naval Consulting Board

COKER, J. L., JR., South Carolina State Director, Committee on Industrial Preparedness, Naval Consulting Board

COLE, WINTHROP, Mechanical Engineer, Engineering Experiment Station, U. S. Naval Academy, Annapolis, Md.

CONTI, ANGELO, Chief Computing Draftsman, Bureau of Steam Engineering, Navy Department, Washington, D. C.

COOKE, STANLEY S., Private, Troop D, 1st Squadron Cavalry, Colorado National Guard

COYLE, A. M., Mechanical Engineer, Coast Defense, Board of Engineers, U. S. A.

CROCKARD, F. H., Alabama State Director, Committee on Industrial Preparedness, Naval Consulting Board

CROUCH, CALVIN H., North Dakota State Director, Committee on Industrial Preparedness, Naval Consulting Board

CURTIS, GREELY S., Lieutenant, Junior Grade, 10th Deck Division, Massachusetts Naval Militia

DAVIDSON, M. W., South Dakota State Director, Committee on Industrial Preparedness, Naval Consulting Board

DE BAUFRE, WILLIAM L., Mechanical Engineer, U. S. Naval Engineering Experiment Station, Annapolis, Md.

DIAMOND, GEORGE A., Alaska Director, Committee on Industrial Preparedness, Naval Consulting Board

DICKIE, G. W., California State Director, Committee on Industrial Preparedness, Naval Consulting Board

DOTY, PAUL, Commissary General, with rank of Brigadier General, Minnesota National Guard, St. Paul, Minn.

DOW, ALEX, Michigan State Director, Committee on Industrial Preparedness, Naval Consulting Board

EDISON, THOMAS A., Chairman, Naval Consulting Board

ELSAS, OSCAR, Georgia State Director, Committee on Industrial Preparedness, Naval Consulting Board

EMMET, WILLIAM L. R., Member, Naval Consulting Board

FISHER, F. P., Oklahoma State Director, Committee on Industrial Preparedness, Naval Consulting Board

FLAD, E., Missouri State Director, Committee on Industrial Preparedness, Naval Consulting Board

FLAGG, SAMUEL B., Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.

FLATHER, J. J., Minnesota State Director, Committee on Industrial Preparedness, Naval Consulting Board

FRY, THOMAS W., New Hampshire State Director, Committee on Industrial Preparedness, Naval Consulting Board

GANTT, H. L., New Jersey State Director, Committee on Industrial Preparedness, Naval Consulting Board

GARDNER, WILLIAM M., Assistant Engineer, U. S. Engineer Office, Memphis, Tenn.

GILLIS, H. A., Committee on Engineer Reserve Corps

GLADFELTER, HERBERT S., Junior Mechanical Engineer, U. S. Engineer Office, Memphis, Tenn.

GOSS, DR. W. F. M., Illinois State Director, Committee on Industrial Preparedness, Naval Consulting Board

GURNEY, DAYTON A., Draftsman, Charge Field Carriage Div., Ordnance Office, U. S. A.

HAMMETT, P. M., Maine State Director, Committee on Industrial Preparedness, Naval Consulting Board

HARTNESS, JAMES, Vermont State Director, Committee on Industrial Preparedness, Naval Consulting Board.

HOEFER, E. G., Wyoming State Director, Committee on Industrial Preparedness, Naval Consulting Board

HOLLIS, IRA N., Massachusetts State Director, Committee on Industrial Preparedness, Naval Consulting Board

HOLMES, URBAN T., Commander, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

HOOD, OZNI P., Chief Mechanical Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.

HUMPHREYS, ALEX. C., Committee on Engineer Reserve Corps

HUNT, ANDREW M., Member, Naval Consulting Board

HUNT, LEIGH, Lieutenant, Machine Gun Company, 1st Kansas Infantry, Eagle Pass., Texas.

IRELAND, MARK L., Captain, Coast Artillery Corps, U. S. A., Fort Greble, R. I.

JENKS, GLEN F., Major, Ordnance Dept., U. S. A., Manila Ordnance Depot, Manila

JOHNSON, ARTHUR E., Designer, Ordnance Office, War Department, Washington, D. C.

JOHNSON, THEODORE W., Professor Mathematics, U. S. N., U. S. Naval Academy, Annapolis, Md.

KENNEDY, JULIAN, Pennsylvania State Director, Committee on Industrial Preparedness, Naval Consulting Board

KENNEY, LEWIS H., Draftsman-in-Charge, Machinery Div., Navy Yard, Philadelphia, Pa.

KINGSTON, ARTHUR, Lieutenant, U. S. Marine Corps, Marine Barracks

KREISINGER, HENRY, Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.

LAWATSCH, FRANK R., Ordnance Draftsman, Sandy Hook Proving Ground

LEE, WILLIAM S., North Carolina State Director, Committee on Industrial Preparedness, Naval Consulting Board

LEWIS, WILFRED, Committee on Engineer Reserve Corps

LOCKETT, A. M., Louisiana State Director, Committee on Industrial Preparedness, Naval Consulting Board

McGREGOR, A. G., Arizona State Director, Committee on Industrial Preparedness, Naval Consulting Board

McKEEN, WM. R., Nebraska State Director, Committee on Industrial Preparedness, Naval Consulting Board

MARSHALL, W. H., New York State Director, Committee on Industrial Preparedness, Naval Consulting Board

METZ, WALTER R., Supt. of Buildings, Government Printing Office, Washington, D. C.

MILLER, SPENCER, Member, Naval Consulting Board

MOUNT, W. D., Virginia State Director, Committee on Industrial Preparedness, Naval Consulting Board

NORDBERG, C. V., Montana State Director, Committee on Industrial Preparedness, Naval Consulting Board

NORTON, HAROLD P., Captain, U. S. N., Mem. Naval Examining and Retiring Boards, Navy Yard, Washington, D. C.

OSGOOD, WENTWORTH H., Ensign, U. S. N., U. S. S. Nevada

PELOT, JOSEPH H., Captain, Ordnance Dept., U. S. A., Frankford Arsenal, Philadelphia

PATERSON, JAMES V., Washington State Director, Committee on Industrial Preparedness, Naval Consulting Board

POTTER, A. A., Kansas State Director, Committee on Industrial Preparedness, Naval Consulting Board

QUINLIVAN, OSWALD, Mechanical Engineer, U. S. Engineer Office, Albany, N. Y.

RAYNAL, ALFRED H., Mechanical Engineer, Bureau of Steam Engineering, Navy Department, Washington, D. C.

REED, CHARLES M., Engrg. Observer, U. S. Naval Engrg. Exper. Sta., Annapolis, Md.

REED, JAMES, JR., Naval Constructor, U. S. N., Mare Island Navy Yard, Vallejo, Cal.
RIKER, ANDREW L., Member Naval Consulting Board
RITTENOUR, FREDERICK H., Draftsman, Department Marine Engineering and Naval Construction, U. S. Naval Academy, Annapolis, Md.
ROCKWOOD, GEORGE O., Indiana State Director, Committee on Industrial Preparedness, Naval Consulting Board
RUSSELL, JAMES GORDON, Instructor Mechanical Engineering, Post Graduate Department, U. S. Naval Academy, Annapolis, Md.
SANDERS, NEWELL, Tennessee State Director, Committee on Industrial Preparedness, Naval Consulting Board
SANDSTROM, C. O., Captain, Company L., 3rd Regiment, Mo., Laredo, Texas.
SARGENT, H. B., Connecticut State Director, Committee on Industrial Preparedness, Naval Consulting Board
SAUNDERS, WILLIAM L., Second Vice-Chairman, Naval Consulting Board
SCOTT, FRANK A., Ohio State Director, Committee on Industrial Preparedness, Naval Consulting Board
SCRUGHAM, JAMES G., Nevada State Director, Committee on Industrial Preparedness, Naval Consulting Board
SHARPE, HENRY D., Rhode Island State Director, Committee on Industrial Preparedness, Naval Consulting Board
SMEALLIE, JOHN M., Lieutenant, U. S. N., Navy Yard, Brooklyn, N. Y.
SMITH, CARL D., Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.
SMITH, R. W., Delaware State Director, Committee on Industrial Preparedness, Naval Consulting Board
SMITH, WILLIAM WALKER, Lieutenant, U. S. N., Pittsburgh, Pa.
SPEED, W. S., Kentucky State Director, Committee on Industrial Preparedness, Naval Consulting Board
SPERRY, ELMER A., Member, Naval Consulting Board
STEARNS, T. B., Colorado State Director, Committee on Industrial Preparedness, Naval Consulting Board
STEEL, REGINALD A., Corporal, Company A, 22nd Corps of Engineers, National Guard, New York
STRATTON, S. W., District of Columbia Director, Committee on Industrial Preparedness, Naval Consulting Board
STROTHMAN, L. E., Wisconsin State Director, Committee on Industrial Preparedness, Naval Consulting Board
STUART, MILTON C., Mechanical Engineer, U. S. Naval Engineering Experiment Station, Annapolis, Md.
SWIFT, JOHN B., Lieutenant, Company E, 1st Battalion, Illinois Engineers
TAYLOR, L. B., Torpedo Engineer, U. S. Naval Torpedo Station, Newport, R. I.
THOMAS, C. C., Maryland State Director, Committee on Industrial Preparedness, Naval Consulting Board
TUTTLE, W. B., Texas State Director, Committee on Industrial Preparedness, Naval Consulting Board
VOORHEES, ALBERT C., Draftsman, Charge Government Division, California Shipbuilding Co.
WADDELL, GEORGE F., Idaho State Director, Committee on Industrial Preparedness, Naval Consulting Board
WARD, CHARLES E., West Virginia State Director, Committee on Industrial Preparedness, Naval Consulting Board
WESTERVELT, W. I., Major, Ordnance Department, U. S. Government, Sandy Hook Proving Ground, Fort Hancock, N. J.
WILEY, WM. H., Chairman, Committee on Engineer Reserve Corps
WILSON, B. N., Arkansas State Director, Committee on Industrial Preparedness, Naval Consulting Board
WOOD, HORATIO N., First Lieutenant of Engineers, U. S. Coast Guard, U. S. Cutter Morrill, Detroit, Mich.
WOODWARD, S. M., Iowa State Director, Committee on Industrial Preparedness, Naval Consulting Board
WRAITH, WILLIAM, Utah State Director, Committee on Industrial Preparedness, Naval Consulting Board

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

ANNOUNCEMENTS

Ralph W. Bunge has become associated with the Wm. H. Bunge Company, Chicago, Ill.

Lester G. French, editor of The Journal, has recently undergone a severe operation, but is now out of danger and is recovering rapidly.

Dennis J. O'Brien has assumed the duties of assistant superintendent of power of the New Orleans Railway and Light Company, New Orleans, La.

Holden A. Evans, formerly vice-president and general manager of The Baltimore Dry Docks and Ship Building Company, was elected president of the company on June 1.

George T. Snyder, formerly chief engineer at the National Tube Company, McKeesport, Pa., has been transferred to a similar position at the Lorain Works of the Company at Lorain, O.

Henry G. Stott, superintendent of motive power, Interborough Rapid Transit Co., New York, has recently undergone a severe operation. According to the latest report, he is recovering rapidly.

Louis E. Strothman, manager and chief engineer of the pumping department of the Allis-Chalmers Manufacturing Company, Milwaukee, Wis., was recently elected president of the Engineers' Society of Milwaukee.

Frank L. Allen, representative of The Landis Tool Company, Waynesboro, Pa., has been elected secretary-treasurer and member of the Board of Directors of the Dugger Motor Sales Company of Indianapolis, Ind.

Joseph H. Pound, instructor in charge of mechanical engineering, Rice Institute, Houston, Tex., is assisting with the plans for increasing the capacity of the plant of the Houston Lighting and Power Company.

Reginald Trautschold, who has specialized in the power plant field for a number of years, is the winner of the second prize of $25 offered by the Diamond Power Specialty Company for the best papers on mechanical soot blowers.

H. Kenyon Burch, chief engineer of the Inspiration Consolidated Copper Company, has completed his work pertaining to the design and construction of the plant, and left on July 1 for an extended vacation trip throughout the East.

Walter N. Polakov, recently superintendent of power of the N. Y., N. H. & H. R. R., and consulting engineer to the Board of Estimate and Apportionment of the City of New York, is now directing the foreign-trade engineering work of David Vershbinsky, Inc., New York.

CHANGES OF POSITION

Ralph W. Bingaman, formerly engineer with the Communipaw Steel Company, New York, has become associated with the Morris Iron and Steel Company, New York.

Rhea H. Robinson has become affiliated with L. V. Estes, Inc., Chicago, Ill. He was until recently in the employ of the Economy Fuse Company of the same city.

W. Doke Scott, formerly engineering assistant with the Syracuse Lighting Company, Syracuse, N. Y., has become affiliated with the New Haven Gas Light Company, New Haven, Conn.

Henry W. Crowell, formerly connected with the Eureka Air Compressor Company, Inc., Montclair, N. J., has accepted a position with the Otis Elevator Company, New York, N. Y.

Frank L. Cocks, formerly connected with Arbuckle Brothers, in the capacity of special machine designer, has become identified with the Obex Laboratories, Marietta, Ohio, as superintendent.

Ernest B. Nelson, formerly in the employ of the Chile Exploration Company, Chuquicamata, Chile, S. A., has become associated with the Andes Exploration Company, Chanaral, Chile, S. A.

William H. Gillam, Jr., has resigned his position as superintendent of James Boyd and Brothers, Inc., Philadelphia, Pa., to accept a position with the Scott Paper Company of the same city.

James F. Cyphers has resigned his position as supervising engineer of Merck and Company, Rahway, N. J., to become mechanical superintendent of the Eagle Rock Manufacturing Company, Verona, N. J.

Paul E. Good, formerly connected with the Southwark Foundry and Machine Company, Philadelphia, Pa., as mechanical engineer, has accepted a position with the Rateau Battu Smoot Company of New York.

Parker M. Robinson, until recently associated with Yale University, New Haven, Conn., has accepted an industrial management position with H. L. Gantt, and is located at The Celluloid Company, Newark, N. J.

Laurence Meharg has resigned his position of mechanical engineer with the Allis-Chalmers Manufacturing Company, Philadelphia, Pa., and has accepted a position with the Hazel-Atlas Glass Company, Washington, Pa.

George S. Wheatley, instructor of mechanical engineering, University of Pennsylvania, Philadelphia, Pa., has become associated with the Cambria Steel Company, Johnstown, Pa., in the steam engineering department.

John W. Morton has assumed the duties of chief draftsman of the Baltimore Oil Engine Company, Baltimore, Md. He was formerly connected with the designing department of the McIntosh & Seymour Corporation, Auburn, N. Y.

Henry W. Johnson has resigned his position as efficiency engineer with the Russell, Burdsall and Ward Bolt and Nut Company, Port Chester, N. Y., to accept the position of superintendent of the Putnam Machine Company of Fitchburg, Mass.

Conrad R. Adams has resigned his position of assistant engineer with the Chandler Motor Car Company, Cleveland, O., and has become connected with the Sibley Machine Tool Company, South Bend, Ind., in the capacity of factory manager.

Henry O. Pond has resigned as mechanical engineer of Westinghouse, Church, Kerr and Company, to take charge of the timber, pulp and water power interests in the northwest of E. B. Cadwell and Company, Inc., with offices at 25 Broad Street, New York.

Burt H. Weston, formerly instructor in mechanical and engineering drawing and design in The David Ranken, Jr., School of Mechanical Trades, St. Louis, Mo., has severed his connection with the school and has opened an office in Dayton, O., where he will conduct the business of consulting and equipment engineer. Mr. Weston is the inventor and patentee of a disk valve for internal combustion engines.

APPOINTMENTS

O. C. Skinner has been appointed superintendent of the Standard Steel Works Company, Burnham, Pa.

A. L. Hoerr, steam and hydraulic engineer of the National Tube Company, McKeesport, Pa., has been appointed chief engineer at the National works to succeed George T. Snyder.

E. J. Burdick has been appointed assistant general manager of the Detroit United Railway. Mr. Burdick has been engaged in operating work with the company and its predecessors for the past thirty years.

George W. Fuller has been appointed special lecturer on sanitary engineering (sewage disposal) at Sheffield Scientific School, Yale University, New Haven, Conn. Mr. Fuller has also been made supervising engineer of the operation of the sewage-disposal tank at York, Pa.

L. H. Mesker, formerly in charge of the Ohio territory of Kearney and Trecker Company, Milwaukee, Wis., has been appointed sales manager of the company, with headquarters in Milwaukee. He will have complete charge of the sales department and will also retain supervision over the Ohio territory through the Cleveland office.

AUTHORS OF PAPERS, ETC.

Thomas T. Eyre is the author of a paper entitled Effect of Early Cutoff on Wiredrawing which appears in a July issue of *Power*.

Cloyd M. Chapman has contributed a brief article on Strength the Essential in Concrete Aggregates to the July 8 number of *Engineering Record*.

Dr. John A. Brashear delivered an address on the attitude of science to engineering at the June 27-30 convention of the American Society of Civil Engineers in Pittsburgh, Pa.

NECROLOGY

GEORGE MEREDITH PEEK

George Meredith Peek was born at Richmond, Va., on September 29, 1870. He received his preparatory education in the home schools and at the age of 16 began his business life as an apprentice in the machine shop of the Baltimore & Ohio Railroad at Baltimore. In 1888, as traveling electrician for the Baxter Electric Motor Company, he had charge of their exhibit at the Milwaukee Industrial Exposition. From 1888 to 1891 he was engaged in machine work and general drafting with the Richmond Locomotive Works and also in the drawing room of the Newport News Shipbuilding and Dry Dock Company.

In 1890, Mr. Peek entered the University of Virginia at Charlottesville, as a student. He remained at the University for six years, during which period he received degrees in both mechanical and civil engineering and became an instructor under Prof. William H. Thornton. From 1896 to 1898 he occupied the chair of Civil and Mechanical Engineering at the University of Arkansas.

After this extended period of study, he engaged in consulting work for a year and then entered the employ of the Pelton Water Wheel Company in New York as engineer, designing and installing water power plants. While with this company he designed and installed plants in the United States, Mexico, Canada and Spain, pre-eminent among which were the Animos Power Plant in Colorado and the power plant for the Companie General de Asfeltos y Portlant in Spain. Mr. Peek also designed the motive power equipment of the Niagara Falls pumping plant and designed and erected the regulating apparatus.

In 1910 he entered the employ of the St. Louis Water Department and devoted his energies to many improvements in the service. He was appointed engineer-in-charge of the construction branch, which position he held up to the time of his death which occurred on May 2, 1916.

Mr. Peek became a member of the Society in 1892.

CHESTER BIDWELL ALBREE

Chester Bidwell Albree was born at Allegheny, Pa., on April 8, 1862. He received his preparatory education in the Western University of Pennsylvania and his technical education at the Worcester Polytechnic Institute in Massachusetts, from which he graduated with the degree of B. S. in 1884. Following his graduation Mr. Albree spent a year in travel, visiting manufactories in various cities, and selling lubricating oils. Before entering into business with his father, he worked in the drawing room at Thomas Carlin's Sons in Allegheny.

The remainder of his business life was spent in establishing and managing The Chester B. Albree Iron Works.

While his principal business was ornamental iron, Mr. Albree started to manufacture pneumatic compression riveters in 1900, and did all the designing of these machines himself. He originated the very successful universal bail, whereby a suspended machine may be turned in any position by merely swinging it through a bail, so constructed as to keep always the center of gravity of the machine at the same height, and thus preserve stable equilibrium. Among his other valuable patents was one covering an automatic pneumatic compression riveter which does away with the adjustment screw entirely. He was widely known as a manufacturer and designer of bridge railing, and many of his beautiful designs can be seen in all parts of the United States.

Mr. Albree was a past president of the Engineers' Society of Western Pennsylvania and a member of the American Association for the Advancement of Science. He became a member of this Society in 1886. He died on May 27, 1916.

DON JUAN WHITTEMORE

Don Juan Whittemore was born at Milton, Vt., on December 6, 1830. After his graduation from the Bakersfield Academy, Mr. Whittemore joined the engineering staff of the Vermont Central Railway, later going with the Western Railway of Canada and the Central Railway of Ohio.

Mr. Whittemore became chief assistant engineer of the La Crosse & Milwaukee Railroad, where he served for four years, and was then made chief engineer of the Southern Minnesota Railway and assistant chief of the Western Railway of Cuba. He later returned to the La Crosse & Milwaukee Railroad and in 1863, became connected with the Chicago, Milwaukee & St. Paul Railroad, where he remained until 1910, retiring as consulting engineer of the road.

Mr. Whittemore was a past president of the American Society of Civil Engineers, and had received the degree of C. E. from the University of Vermont and those of Ph. D. and LL. D. from the University of Wisconsin.

He became a member of the Society in 1889. He died at his home in Milwaukee on July 17, 1916.

WILLIAM A. WARMAN

William A. Warman was born at Latrobe, Jackson Co., Ohio, on June 28, 1861, and received his education at the home schools. From 1878 to 1886 he devoted his time to developing inventions and following this he had six years' shop experience in various western railroad shops. From 1892 to 1894 he was connected with the Rodwell Co., of Buffalo, and the following year he managed a shop of his own at Niagara Falls. In 1898 he was engaged by the Buffalo Metal Manufacturing Co., and from 1898 to 1901 he held a position with the Ritter Dental Company. During 1902 and 1903 he was with the Dieks Press Guard Manufacturing Company, and became a pioneer in the development of press guards for stamping presses. In 1904 he worked for the American Tobacco Company and in 1905 formed the Warman Company, which soon thereafter consolidated with the Keller Mechanical Engraving Company. With this concern he held the position of designer of special machinery. He also did much original research work in connection with internal combustion engines and gas turbines until the time of his death.

Mr. Warman was the inventor of a number of safety devices, also of the hollow set screw. He became a member of the Society in 1908. He died on July 2, 1916.

Professor Ernest Mach recently died in Munich, Germany, at the age of 78. His treatises on Mechanics and The Theory of Heat have long since become classics. Just before his death he completed a book on The Principles of the Theory of Light, as a companion volume to the two former books. The works of Dr. Mach have been noted for the broad spirit in which they treated complicated problems of physics, and for the interesting investigations of the historical development of theories of physical phenomena.

There is now being inserted in the pages of the Advertising Section of The Journal each month (See p. 57 this month) a Card Index summarizing the contents of The Journal for the preceding month. A facsimile of this index appears below. Members may clip this out of the Advertising Section and paste it on a card for use in their files.

The Journal of The American Society of Mechanical Engineers

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The Illuminating Engineering Society will hold its annual convention in Philadelphia, September 21 to 28.

Following the convention, a course of lectures on illuminating engineering will be given under the joint auspices of the society and the University of Pennslyvania, at the University. Associated with the lectures will be an exhibition showing the latest developments in illuminating appliances and novel applications of light. R. H. Fernald, Mem. Am. Soc. M. E., is a member of the University Committee in charge of participation.

The executive committee of the Board of Supervising Inspectors of the United States Steamboat-Inspection Service has adopted a rule eliminating the requirements for reduction of area of steel boiler plate, pending an investigation by the U. S. Bureau of Standards. The amendment was approved by the Secretary of Commerce on June 7, 1916.

The requirements referred to and which were eliminated were contained in the first paragraph of Section 5, Rule 1, General Rules and Regulations of the Board of Supervising Inspectors. The paragraph as amended reads as follows:

5. When the tensile strength determined by the test is less than 63,000 lb., the minimum elongation shall be 25 per cent for plates over ¾ in. and under in thickness and 22 per cent for plates over ¾ in. in thickness. The quench-bend specimen shall bend through 180 deg. around a curve the radius of which is three-fourths the thickness of the specimen. When the tensile strength determined by the test is 63,000 lb. or greater the minimum elongation shall be 22 per cent for plates ¾ in. and under in thickness and 20 per cent for plates over ¾ in. in thickness. The quench-bend specimen shall bend through 180 deg. around a curve the radius of which is one and one-half times the thickness of the specimen. (See 4430 R. S.)

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON AFTER SEPTEMBER 10, 1916

MECHANICAL ENGINEERS desirous of securing membership in the Society during the current calendar year must file their applications not later than August 25. Favorable action will then entitle them to attend the Annual Meeting, 1916, as members, receive the 1916 volume of Transactions and be listed in the 1917 Year Book.

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every Member to promote. Unless objection is made to any of the candidates posted, by September 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary about October 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ARMSTRONG, E. R., Mech. Supt.,
E. I. du Pont de Nemours & Co., City Point, Va.

BACON, WILLIAM, Supt. Prentice Dept.,
Reed-Prentice Co., Worcester, Mass.

BARRETT, GEORGE E., Asst. Engr.,
Sprague Elec. Wks., General Electric Co., Bloomfield, N. J.

BAUMIS, FRANK J.,
with Manning, Maxwell & Moore, New York

BEESON, ALEXANDER C., Chief Engr.,
Four States Coal Co., Worthington, W. Va.

BEST, WILLIAM E., Supt.,
The National Cash Register Co., Dayton, Ohio

BLAKESLEE, JUDD W., Supt.,
Blakeslee Mfg. Co., Du Bois, Ill.

CLINE, MCGARVEY, Vice-Pres.,
Florida Pine Co., Jacksonville, Fla.

DANIELSON, JOHN W., Engr., Mgr., Secy.,
Mecca Machinery Co., Brooklyn, N. Y.

DAVIS, EDWIN P., Engr. Exper. Dept.,
Remington Arms & Ammunition Co., Bridgeport, Conn.

DURR, HERBERT A., Cons. Engr. and Mech. Engr.,
Schmidt, Garden & Martin, Chicago, Ill.

FOSTER, DEAN E., Prof. of Mech. Engrg.,
State College of Washington, Pullman, Wash.

FRENCH, THOMAS E., Prof. of Engrg. Drawing,
The Ohio State Univ., Columbus, Ohio

GAGE, WILLIAM P., First Vice-Pres. and Genl. Supt.,
Lone Star Gas Co., Fort Worth, Tex.

GRANGER, DEAN M., Head of Engrg. Dept.,
Washburn & Granger, New York

HADLOW, H. RALPH, Cons. Mech. Engr.,
918 Citizens Bldg., Cleveland, Ohio

HAWLEY, RANSOM S., Prof. and Head of Mech. Engrg. Dept.,
Colorado School of Mines. Golden, Colo.

HICKS, R. L., Mech. Draftsman,
Alabama Power Co., Birmingham, Ala.

HOLLANDER, WALTER L.,
Winchester Repeating Arms Co., New Haven, Conn.

KNOWLES, CLARENCE R., Supt. Water Service,
Illinois Central & Yazoo & Mississippi Valley Railroads, Chicago, Ill.

LATHAM, BERNARD W., Asst. Mech. Engr.,
New York Central R. R., New York

LENONE, JOSE M., Asst. to Chief Draftsman,
Armour & Co., Chicago, Ill.

MCKENNA, ALEXANDER F., Supt. of Erection,
Western Canada Babcock & Wilcox Co., Montreal, Canada

MCPARTLAND, MICHAEL B., Master Mech.,
Chicago, Rock Island & Pacific R. R., Goodland, Kan.

MOORE, JAMES S., Engr.,
Greensboro Supply Co., Greensboro, N. C.

MORTON, ARTHUR B., Chief Draftsman,
Messrs. Thompson & Co., Prop. Ltd., Castlemaine, Victoria, Australia

PANGBORN, THOMAS W., Pres.,
Pangborn Corp., Hagerstown, Md.

PESCAY, CHARLES H., Adjuster,
Fire Losses, New Orleans, La.

ROBERTSON, DONALD M., Chief Draftsman,
The Holt Mfg. Co., Stockton, Cal.

ROWE, HARTLEY, Elec. Supt.,
Elec Div., The Panama Canal, Balboa Heights, C. Z.

TROTTER, HENRY R., Mech. Engr.,
S. K. F. Ball Bearing Co., Hartford, Conn

UPTON, GEORGE B., Asst. Prof. of Exper. Engrg.,
Sibley College, Cornell Univ., Ithaca, N. Y.

WALKER, EDWIN C., Indus. Engr.,
The Hess Spring & Axle Co., Cincinnati, Ohio

WOOLSON, CLIFFORD G., Asst. to Chief Engr.,
Barber Asphalt Paving Co., Maurer, N. J.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BISHOP, ERNEST B., Draftsman,
Remington Typewriter Wks., Ilion, N. Y.

BJORGE, OSCAR B., Chief Engr.,
Clyde Iron Works, Duluth, Minn.

FELLERS, WILLIAM M., Chief Draftsman,
U. S. Navy Aeronautic Sta., Pensacola, Fla.

HOFFMAN, J. ROY, Vice-Pres.,
Smith-Booth-Usher Co., Los Angeles, Cal.

HUBBARD, CECIL R., Designing Engr.,
National Metal Molding Co., Ambridge, Pa.

INGALLS, JAMES A., Mech. Asst., Testing Bureau, Elec. Engrg. Dept.,
Transit Development Co., Brooklyn, N. Y.

ISHIMURA, SAKICHI, Draftsman,
U. S. Electro Galvanizing Co., Brooklyn, N. Y.

KING, HOWARD V., Inspector,
with Lima Locomotive Corp., Lima, Ohio

MCNINCH, HARRY T., Engr.,
Babcock & Wilcox Co., Bayonne, N. J.

MAYER, EDWARD R., Supt.,
City Light & Water Co., Amarillo, Tex.

MEIGS, ROBERT R., Motive Pwr. Insptr.,
Pennsylvania R. R., Pittsburgh, Pa.

MILLER, EMILIO G., Tech. Staff,
Shipyard "Officina Camelier," Para, Brazil

MOREY, EDWIN, Secy. and Supt.,
E. J. Flather Mfg. Co., Nashua, N. H.

ROLLINS, LEWIS M., Consulting Engr.,
2908 E. Franklin Ave., Minneapolis, Minn.

SILLCOX, LEWIS K., Mech. Engr.,
Illinois Central R. R. System, Chicago, Ill.

SPATZ, RALPH L., Erecting Engr.,
H. Koppers Co., of Pittsburgh, Pa., Lorain, Ohio

THOMAS, LEON I., Managing Editor "Factory,"
A. W. Shaw Co., Chicago, Ill.

VERSHBINSKY, DAVID M., Pres.,
David Vershbinsky, Inc., New York

WENZLIK, RICHARD H., Architect and Engineer,
Houchin-Aiken Co., Inc., Brooklyn, N. Y.

FOR CONSIDERATION AS JUNIOR

ALSFELDER, Ferd P., Draftsman,
The Lunkenheimer Co., Cincinnati, Ohio
ANTHONY, Graham H., Equipment Supt.,
William L. Gilbert Clock Co., Winsted, Conn.
BRES, Edward W., Inspector,
United States Engrg. Dept., New Orleans, La.
CALLAN, John, Engr.-in-charge Roller Plant,
Louisiana Irrigation & Mill Co., Crowley, La.
CHALKLEY, Curtis R.,
with Cincinnati Planer Co., Cincinnati, Ohio
DEAN, Hubert R., Engr.,
with John A. Stevens, Cons. Engr., Lowell, Mass.
de GROOT, John, Asst. Engr.,
Westinghouse, Church, Kerr & Co., New York
EARL, Ralph,
with George G. Earl, New Orleans, La.
FARNHAM, George W., Junior Engr.,
The Elbert Clarke Co., Rochester, N. Y.
HAYES, Ralph S., Student,
Dartmouth College, Hanover, N. H.
JACOB, Charles L., Engr.,
Jarrett Chamber Co., Paris, Idaho
JONES, Warren G., Vice-Pres.,
W. A. Jones Fdy. & Mch. Co., Chicago, Ill.
KOCH, Charles, Ordnance Draftsman,
Philadelphia Navy Yard, Philadelphia, Pa.
LIGHTOWLER, George R., Engr.,
Austin Baldwin Co., New York
LITHGOW, Richard P., Chief Engineer,
Arkansaw Water Co., Little Rock, Ark.
LORENTZEN, Gustav A.,
with W. F. Schrafft & Sons Corp., Boston, Mass.
McCARTY, Dale, Mech. Rep.,
Enterprise Rwy. Equipment Co., Chicago, Ill.
MANUEL, Charles J., Mch. Designer and Mech. Engrg.,
Lewiston Bleachery & Dye Wks., Lewiston, Me.
MUIR, Leonard S., Ch. Draftsman,
with Dwight Seabury, Arch. & Engr., Pawtucket, R. I.
NEWMAN, Paul A., Asst. Engr.,
New York Rwys. Co., New York
PARADIES, Walter F., Mech. Engr.,
Chile Exploration Co., New York
PRUDEN, Richard M., Exper. Engr.,
Advance Rumely Co., La Porte, Ind.
REED, James K.,
with S. Keighley Metal Ceiling & Mfg. Co., Follansbee, W. Va.
SCHMITZ, Arthur J., Engr.,
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
SCHUBERT, Frank R., Engrg. Dept.,
Ferro Mch. & Fdy. Co., Cleveland, Ohio
SHEA, Thomas F., Engr.,
Canal Construction Co., Memphis, Tenn.
SOLOMON, Reuben J., Draftsman,
The H. P. Townsend Mfg. Co., Hartford, Conn.
STROTT, John C., Asst. Works Engr.,
Curtis Bay Chemical Co., Curtis Bay, Md.
VANSANT, William L.,
with Dravo-Doyle Co., Pittsburgh, Pa.
WAY, William F.,
2 First Avenue, Johnstown, N. Y.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

FLOWERS, Dean W., Supt. Gas Wks. Dept.,
St. Paul Gas Light Co., St. Paul, Minn.
TILLSON, Benjamin F., Head of Mining Dept.,
The New Jersey Zinc Co., Franklin and Ogdensburg, N. J.
WALDEN, Albert E., Supt. and Chief Engr.,
Baltimore County Water & Elec. Co., Baltimore, Md.

PROMOTION FROM JUNIOR

CAREY, Herbert W., Chief Draftsman,
Harley Co., Springfield, Mass.
NEWCOMB, Robert E., Supt., Deane Pump Wks.,
Worthington Pump & Mchy. Corp., Holyoke, Mass.
STONE, Thomas W., Mech. Engr.,
Western Gas Constr. Co., Fort Wayne, Ind.
WINTERROWD, William H., Asst. to Chief Mech. Engr.,
Canadian Pacific Rwy., Montreal, Canada

SUMMARY

New Applications	83
Applications for change of grading:	
Promotion from Associate-Member	3
Promotion from Junior	4
Total	90

GEOGRAPHICAL LIST

(Applications for promotion from any grade will be indicated by the initials of that grade)

Alabama
Birmingham—Hicks, R. L.
Arkansas
Little Rock—Lithgow, R. P.
Australia
Castlemaine—Morton, A. B.
Brazil
Para—Miller, E. G.
California
Los Angeles—Hoffman, J. R.
Stockton—Robertson, D. M.
Canada
Montreal—McKenna, A. F.
Winterrowd, W. H. (J.)
New Westminster, B. C.—Peck, J.
Canal Zone
Balboa—Rowe, H.
Colorado
Golden—Hawley, R. S.
Connecticut
Bridgeport—Davis, E. P.
Hartford—Solomon, R. J.
Trotter, H. R.
New Haven—Hollander, W. L.
Winsted—Anthony, G. H.
Florida
Jacksonville—Cline, M.
Pensacola—Fellers, W. M.
Idaho
Paris—Jacob, C. L.
Illinois
Chicago—Durr, H. R.
Jones, W. G.
Knowles, C. R.
Lenone, J. M.
McCarty, D.
Silleox, L. K.
Thomas, L. I.
Du Boise—Blakeslee, J. W.
Indiana
Fort Wayne—Stone, T. W. (J.)
La Porte—Pruden, R. M.
Kansas
Goodland—McPartland, M. B.
Louisiana
Crowley—Callan, J.
New Orleans—Bres, E. W.
Earl, R.
Pescay, C. H.
Maine
Lewiston—Manuel, C. J.
Maryland
Baltimore—Walden, A. E. (A. M.)
Curtis Bay—Strott, J. C.
Hagerstown—Pangborn, T. W.
Massachusetts
Boston—Lorentzen, G. A.
Holyoke—Newcomb, R. E. (J.)
Lowell—Dean, H. R.
Springfield—Carey, H. W. (J.)
Worcester—Bacon, W.
Minnesota
Duluth—Bjorge, O. B.
Minneapolis—Rollins, L. M.
St. Paul—Flowers, D. W.
New Hampshire
Hanover—Hayes, R. S.
Nashua—Morey, E.
New Jersey
Bayonne—McNinch, H. T.
Bloomfield—Barrett, G. E.
Franklin—Tillson, B. F.
Maurer—Woolson, C. G.
New York
Brooklyn—Danielson, J. W.
Ingalls, J. A.
Ishimura, S.
Wenzlik, R. H.
Ilion—Bishop, E. B.
Ithaca—Upton, G. B.
Johnstown—Way, W. F.
New York—Baumis, F. J.
de Groot, J.
Granger, D. M.
Latham, B. W.
Lightowler, G. R.
Newman, P. A.
Paradise, W. F.
Vershbinsky, D. M.
Rochester—Farnham, G. W.
North Carolina
Greensboro—Moore, J. S.
Ohio
Cincinnati—Alsfelder, F. P.
Walker, E. C.
Chalkley, C. R.
Cleveland—Hadlow, H. R.
Schubert, F. R.
Columbus—French, T. E.
Dayton—Best, W. E.
Lima—King, H. V.
Lorain—Spatz, R. L.
Pennsylvania
Ambridge—Hubbard, C. R.
Philadelphia—Koch, C.
Pittsburgh—Meigs, R. R.
Vansant, W. L.
Rhode Island
Pawtucket—Muir, L. S.
Tennessee
Memphis—Shea, T. F.
Texas
Amarillo—Mayer, E. R.
Fort Worth—Gage, W. P.
Virginia
City Point—Armstrong, E. R.
Washington
Pullman—Foster, D. E.
West Virginia
Follansbee—Reed, J. K.
Worthington—Beeson, A. C.
Wisconsin
Milwaukee—Schmitz, A. J.

SOCIETY MEETINGS

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the sections and student branches are urged to make every effort to get the complete reports of their meetings to this office as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. The reports of meetings in order to appear in the next issue of The Journal must be received in this office before the 18th of the month.

NEW HAVEN, JUNE 29

The last meeting of the season of the New Haven Section of the Society was held on June 29 at the Mason Laboratory. P. J. G. Reuter gave an interesting talk on the Diesel Motor, which was illustrated with pictures of Swiss machine shops in which Diesel engines are built.

PROVIDENCE, JUNE 28

A meeting of the Providence Engineering Society was held on June 28. Through the invitation of F. E. Winsor, chief engineer of the Providence Water Supply, more than 120 members of the society were taken around the proposed Scituate Reservoir which will eventually supply Providence and some of the neighboring towns and cities with water. The members were accomodated in twenty-five automobiles which were provided by the Water Supply Board.

Following a dinner at the University Club, the annual business meeting of the Society was held. The reports showed that in the past year the membership has doubled. The following officers were elected: Prof. J. Ansel Brooks, Mem. Am.Soc.M.E., *president;* R. W. Adams, G. A. Carpenter, W. T. Robertson, *vice-presidents;* A. E. Thornley, *secretary:* W. C. Kennedy, *recording secretary* and A. H. Whatley, *treasurer.*

Following the business meeting, Mr. Winsor gave an illustrated lecture on the Scituate water supply, detailing the faults of the present system. The speaker said that the source of the Providence water supply at the present time is very polluted, but that the water is reasonably safe because it is filtered. If anything should happen to the filters, however, the people of Providence would have to drink the contaminated water.

G. T. Seabury, an engineer of the Water Supply Board, told of the borings that are being made, particularly at the dam site at Kent, to determine the kind of dam which will be necessary at the outlet end of the reservoir. Borings are being made constantly at this site and at the site for the filters and other places where artificial structures are to be built. He said that they have bored 130 holes from 80 to 92 ft. deep, and have taken samples of the soil every five feet until they struck bed rock. Mr. Seabury also explained the various methods used in drilling and bringing up samples of the soil and the working of the diamond drills used in boring.

F. E. Waterman, another engineer of the Board, told of the problems that were met in determining the ownership of the land condemned by the city. Some of the deeds of the land dated back to 1795 and 1800, and it was very difficult to find an exact or accurate description of the bounds or extent of the parcels of land.

CIVIL ENGINEERS ANNUAL MEETING

The Summer Meeting of The American Society of Civil Engineers was held at Pittsburgh, June 27 to 30.

A notable feature of the meeting was the address of Clemens Herschel on the Advancement of the Profession by the Civil Engineer, which he introduced by a feeling allusion to the death of Dr. Corthell, president of the society, and to whose duties Mr. Herschel succeeds. Dr. Brashear, Past President of The American Society of Mechanical Engineers, addressed the opening session on the attitude of science to engineering.

Of much interest was the announcement of the ballot on the transfer of the society's headquarters from 57th St. to the building of the United Engineering Societies. An overwhelming preference was expressed by vote for the change of headquarters.

ELECTRICAL ENGINEERS ANNUAL MEETING

The thirty-third annual convention of the American Institue of Electrical Engineers was held at Cleveland, June 27 to 30. Professional Sessions were held on Industrial Power, Power Transmission, Protective Apparatus, Electrophysics, and miscellaneous subjects. Percy H. Thomas, Mem.Am.Soc. M.E., chairman of the Institute's Committee on Transmission, presented the report of this committee. J. T. Lawson, Mem. Am.Soc.M.E., was the joint author with N. O. Pollard of a paper on Experience in Recent Developments of Central Station Protective Apparatus.

H. W. Buck was elected president of the Institute for the forthcoming year. Mr. Buck is of the firm of Vielé, Blackwell & Buck, Consulting Engineers in New York, and is also known in connection with the installation of some of the great plants at Niagara Falls.

SOCIETY OF AUTOMOBILE ENGINEERS PROPOSE TO CHANGE NAME AND ENLARGE SCOPE

During the summer meeting of the Society of Automobile Engineers, held on a steamer on Lake Huron, Howard E. Coffin, Mem.Am.Soc.M.E., and a member of the U. S. Naval Consulting Board, and Henry Souther, Mem.Am.Soc.M.E., consulting engineer, Aeronautical Division, War Department, proposed that certain changes be made in the constitution of the S.A.E. so as to include in the field of activities of that society aeronautics, motor boats and tractors. On a motion made by Vice-President E. S. Foljambe, an amendment to the constitution was adopted as follows:

The name of the society to be changed to that of Society of Automotive Engineers, this name having been selected with the view of retaining the former initials.

The society to have affiliated with it automobile, aeroplane, motor boat, tractor and stationary internal combustion engineers.

The new society will have a president, a vice-president and four second vice-presidents, each of the latter in charge of one of the activities of the society.

The work of the new society will be conducted with the coöperation of the Government in the establishment of standards and in the furtherance of the Industrial Preparedness movement.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month. The notices appear in the Employment Bulletin in a form which indicates the classification.

POSITIONS AVAILABLE

These advertisements are placed by members of the Society or persons vouched for by members. The Society is pleased to act as a "clearing house" but is not responsible for results.

In forwarding applications, stamps should be enclosed for transmittal of applications to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed by the Society.

DESIGNER; on heavy machine tools and similar machinery; good opportunity for high grade designer with chiefly drawing office experience. Location Pennsylvania. 40.

SALESMAN with technical education as mechanical engineer to become head salesman of company manufacturing heavy capacity automatic scales for factory and warehouse uses; man between 30 and 40; position does not call for an engineer, but business to be transacted is almost entirely with engineers; one-third of time at factory in middle west, two-thirds in field. Salary liberal. 42.

ASSISTANT CHIEF ENGINEER—Young man who has had experience, or special study in the operation of a power plant, to assist in running a wood working factory of 1000 h.p.; knowledge of the design of exhaust steam heating on a large scale a desirable asset. Answer, stating age, past position and salary expected. 83.

DRAFTSMAN experienced in design of heavy machinery, rolling mills, etc. Location, Connecticut. 98.

FOREMAN of shop for manufacturing chemists. Location New Jersey. 104.

CHEMIST for firm of manufacturing chemists. Location, New Jersey. 105.

TEXTILE PLANT ENGINEER; one capable of studying textile operations with view of making improvements in machines or processes; who has had experience in similar lines, or a practical designer in connection with textile machinery. Salary $2,000 to $3,000, dependent upon ability and experience. Location, New England. 130.

DRAFTSMAN; thorough technical training with at least 5 to 6 years practical experience as draftsman and designer of heavy high speed machinery, such as steam turbines, centrifugal pumps and herringbone gears. Must be neat, quick and accurate and possess such characteristics as would justify his promotion to chief or assistant chief engineer in one to two years' time. Salary to begin moderate until ability is proven. Location, Maryland. 164.

DRAFTSMAN; for interchangeable parts on fine balances. Young man with tool making experience preferred. Eastern location. 180.

TOOL DESIGNER who is resourceful and can follow work through to completion. Technical man with practical shop experience. Location, Connecticut. 185.

DRAFTSMAN with blast furnace and rolling mill experience. Location, Pennsylvania. 187.

SALES ENGINEERS.—Young men between the ages of 25 and 30 years, of good appearance, graduates of some approved engineering college, preferably M.E. degree; would be expected to undergo a period of probation and training in the various offices of company before being given more responsible and higher positions in sales work. If a call cannot be made, application may be made by letter in the applicant's own handwriting, stating age, education, previous business training, if any, salary desired, etc. Location, New York. 205.

AGENTS to handle sales of products in own territory for firm specializing in manufacture of crushers, adapted for road building, contracting, mining, rock crushing, gravel plants, block and tile plants. 232.

SUPERINTENDENT FOR FACTORY engaged in the manufacture of oil and gasoline engines; must be familiar with modern methods of manufacture, active, tactful, a close student of human nature and a natural leader. Exceptional manufacturing men even though not actively engaged in gas engine work are encouraged to reply. Position offers a splendid opportunity for one who can qualify. Give complete experience. Apply by letter. Name confidential. 246.

MANAGER for firm in India manufacturing clay products, as drainage pipes, tile floors, bricks and wall tiles. Correspondence will be handled through New York firm. 250.

TOOL DESIGNERS and DRAFTSMEN. American or English. Location, near Philadelphia. 255.

ESTIMATOR, experienced in grey-iron and steel castings, pattern and machine work; a position calling first for accuracy. Location Maryland. 273.

TOOL DESIGNERS to take charge of tool drafting department in concern manufacturing small interchangeable parts; one with experience in tool designing for concerns making typewriters, adding machines, electrical apparatus, etc., preferred. In reply state age, nationality, former places of employment, experience and salary expected. 288.

ASSISTANT PROFESSOR IN EXPERIMENTAL ENGINEERING is desired to fill a vacancy in a large engineering school in Atlanta, Georgia, beginning the fall term in September. Applicants must have an engineering degree from some well recognized technical school and either teaching experience or extensive practical experience in experimental and research work. The work involves experimental work, steam, hydraulic and mechanical testing materials, refrigeration and other mechanical subjects. Give full details of education, post-graduate work and practical experience, including references. 293.

MEN EXPERIENCED IN HIGH CLASS GAGE WORK, with practical tool making experience, some organizing power and tact, to visit various plants and pass on gage work for Canadian concern. 320.

ASSISTANT SHOP ENGINEER familiar with wood-working machinery, to look after production side of work and upkeep. Location, Vermont. 327.

GRADUATE MECHANICAL ENGINEER with experience in development and research work, to take charge of experimental department of old established firm manufacturing carburetor equipment for automobile engines. 381. Also one or two assistants. 382.
Scientific soundness and familiarity with systematic methods are of more importance than experience with carburetors, fuels and engines, but both qualifications most desirable. Permanent positions.

YOUNG ENGINEER with experience of one or two years in electrical lines, wiring buildings and plants, motors, etc., for concern in Toronto, Canada. 384.

YOUNG GRADUATE METALLURGICAL ENGINEER for manufacture of steel castings and car wheels, located in middle west, desiring to create position of time study and efficiency engineer for entire plant; prefer graduate of western college. In writing give experience, age, physique, condition of health, denomination, married or single, with whom associated, college and branches of work, salary. 385.

YOUNG ENGINEER, preferably of class 1916, who is willing to start and learn the business from the selling end, of printing press company with headquarters in New York office. 386.

INDUSTRIAL ENGINEER, 22 to 25 years of age, willing to learn the business and make himself useful in the drafting and engineering side of concern of consulting and contracting engineers, sugar factories and equipment, marine work, etc. 387.

MECHANICAL INSTRUCTOR for college in California. Salary $1,000. 388.

MECHANICAL DRAFTSMAN for permanent position with well-known firm near New York City. Several years experience in the design of dynamo electric machinery preferred; must be responsible, accurate and rapid worker, capable of handling detailers and tracers. State age, experience, salary expected and give references. 392.

SEVERAL COLLEGE GRADUATES, of from one to five years experience in manufacturing, wanted by a New Jersey plant, to take positions in production department which is being developed. Salary

to start, $25 a week. Good future for the right man. In making application give full history and record. 395.

ESTIMATOR, young man, technical graduate who has had experience in foundry and pattern work and familiar with cast iron and cast steel, to take charge of estimating department for large foundry. Location Maryland. 397.

TECHNICAL GRADUATE, 1916 preferred, energetic and resourceful for general engineering work in connection with general sales office of concern building fuel economizers and located in New York. 398.

DESIGNER on automatic machinery. Location Brooklyn, N. Y. 400.

SALESMEN ON POWER PLANT EQUIPMENT—Consisting of boilers, engines, force draft blowers, pumps and elevators. Commission basis. 402.

HIGH GRADE ENGINEER, capable of designing and laying out power plants. Location, New York City. 407.

WANTED—by a Company introducing a modern system of management, men who have had both college training and practical experience. Location New Jersey. 408.

EXPERIENCED MAN ON TWIST DRILLS, one thoroughly familiar with twist drill making machines and able to assist in their design for new factory, to have charge of department as soon as started. 413.

SALES MANAGER, fully capable of taking entire charge of sales for old established manufacturing company. Preference will be given to one having experience in steam, plumbing, power plant and water works supplies; a good organizer of salesmen who has demonstrated his ability along these lines. In reply state full details of experience, age and salary expected. A good position with bright possibilities. 414.

DRAFTSMAN, experienced in tool and jig work, salary about $25, opportunity for advancement to right man. Work is on standard line. No war orders. Location Southern Ohio. 415.

SALES ENGINEER, mechanical engineer or salesman with equivalent ability, to sell small special tools direct to the manufacturer. A high grade position for a high grade man. To be considered applicant should give age, references, past experience, salary expected, and whether, or where now employed. 416.

PERMANENT POSITION, with established company developing an epoch making mechanical system, for young graduate engineer with a liking for research work of a practical, semi-commercial nature, preferably with a knowledge of physical chemistry; must be of a practical bent, and willing to begin at the beginning. A good future for a man who knows how to take advantage of an opportunity. Location near New York. 417.

YOUNG ENGINEER familiar with estimating detail and final costs. One familiar with machine shop and metal stamping practice; will afford opportunity for other constructive work in cost department just being organized by large corporation. 418.

HEATING AND VENTILATING DRAFTSMAN; position open in consulting engineer's office for one with sufficient experience and technical training to work out designs for high class installations. Applicants should state full particulars of training, age, experience and salary expected. Location New York City. 419.

INSTRUCTOR in machine shop in a western state college. Must have had shop experience and some technical education. Experience in teaching and ability to interest and instruct young men also essential. 420.

A LARGE PUBLIC INSTITUTION of the Middle Northwest is seeking the services of a strictly high class man who can conduct classes and give lectures on automobiles; must be a technical graduate, have had considerable practical experience and not afraid of work. 421.

DRAFTSMAN for metallurgical plant in process of construction; man should be thoroughly familiar with steel and general construction work. 425.

ENGINEER-SALESMAN capable of approaching with confidence architects and consulting engineers on the larger building operations in New York and vicinity for concern manufacturing steam and water specialties. 426.

TWO ASSISTANT SUPERINTENDENTS, ONE NIGHT SUPERINTENDENT, for concern in Missouri manufacturing special machinery and steel castings. Salary to start $150 to $175 a month according to ability. 428.

INDUSTRIAL ENGINEER, COST ACCOUNTANT.—A well established firm can offer exceptional opportunities for effective and interesting work to engineering graduates who have had substantial experience with modern industrial accounting, with special reference to manufacturing costs. In reply state age, education, experience, present and expected salary. 431.

SUPERINTENDENT FOR FOUNDRY employing 250 men, thoroughly experienced on medium and light castings, including gas engine cylinders; must know how to produce good castings with minimum loss and low cost, and possess tact and energy. Give complete details of experience and references and compensation expected. 432.

SALES ENGINEERS OR AGENCY desired for the following territories: Tennessee, North Carolina, Minnesota, North and South Dakota. Past record must show familiarity with boiler plant practice. Work can be handled by engineer, on commission basis, who is handling other lines. 433.

HEATING AND VENTILATING ENGINEER; position involves preparation of specifications, design and supervision of installations of heating and ventilating systems, for State Department of one of the eastern states. 434.

MEN AVAILABLE

Only members of the Society are listed in the published notices. Notices are not repeated in consecutive issues of the Bulletin.

Members sending in notices for the Men Available section are particularly requested in the future to indicate the classification under which they desire their notices to appear.

SUPERINTENDENT OF CONSTRUCTION for the far east. Associate, Japanese graduate of electrical and mechanical school in United States; varied experiences along mechanical and electrical engineering since 1903, now employed with railway company as power house designer, wishes to represent an American engineering company on construction work in Japan or China.—H-266.

ADMINISTRATIVE or EXECUTIVE position. Member technical and commercial training, at present employed, desires to become identified with manufacturing or industrial plant in responsible position. Varied experience in design and construction of machinery and buildings; remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines; familiar with the handling of men, drawing up contracts, purchasing equipment and material, modern methods of manufacturing and marketing product—H-267.

LABORATORY and EXPERIMENTAL RESEARCH ENGINEER for mechanical engineering; specialty heat and combustion, calorimetry, fuel economy.—H-268.

DESIGN, CONSTRUCTION or OPERATION of power plants; twenty-five years practical experience in mechanical and electrical engineering. At present employed—H.-269.

MANAGER, ASSISTANT, SUPERINTENDENT, EXECUTIVE or SALES ENGINEER. Associate, age 42, Lehigh University graduate in mechanical engineering; varied experience in mechanical electrical and civil engineering lines involving design, inspection reports, responsible charge of construction work, plant operation, management, purchasing, etc., in connection with power, lighting and industrial plants, electric railways, etc. Salary, $3,000.—H-270.

JUNIOR MEMBER, graduate mechanical engineer, at present employed as assistant to chief engineer, desires position with established engineering firm; desirous of specializing in costs and accounting; will consider salary secondary to opportunity. Available after September 1, 1916.—H-271.

MECHANICAL ENGINEER, Associate member, Stevens graduate, who is energetic, capable of taking initiative and has executive ability, with ten years' engineering experience in power plant work, boilers, stokers, etc., desires position in engineering capacity.—H-272.

MANUFACTURERS' REPRESENTATIVE or SALES ENGINEER; Member; age 37; 16 years' experience in the design of special machinery, compressors, engines, etc.; thorough knowledge of modern factory methods; wide experience in selling organization. Will consider offer as New England representative of a good product that can be developed by efficient and diligent business methods.—H-273.

MECHANICAL ENGINEER, 34, technical graduate, Member, assistant in engineer department; nine years' varied technical and executive experience with a large car building company; divided into designing tools and machinery, plant construction, freight and passenger car designing and estimating; sales engineer and valuation analyst. Desires change to aggressive company, preferably in same line of work and doing an export business.—H-274.

MANAGER, ASSISTANT MANAGER or CHIEF ENGINEER. Age 34. Experienced in the manufacture of water tube boilers and general plate construction as designer, estimator, chief engineer and manager. A good organizer and capable of filling any responsible position in this line of work. Would also consider position as sales engineer.—H-275.

GRADUATE M.E. Twelve years' varied experience. For past six years chief engineer in charge design, construction and maintenance of engineering work, also in charge City light and water department; one and a half years master mechanic of a Colorado sugar factory. One year operating in water and light company: four years' construction experience in turbine department of large company, desires to take up new position of responsibility—September 1st or October 1st. Salary $2,000.—H-276.

SALES ENGINEER, MANAGER or MANUFACTURER'S REPRESENTATIVE. Technical graduate, with present employers since graduation June, 1912, and now department manager. Experienced in sales work in Philadelphia territory; wants to hear from manufacturers of power plant apparatus. Location Philadelphia.—H-277.

SALES ENGINEER, American, age 33, thorough technical training, possesses executive ability, speaks Portuguese, Spanish and German, eleven years' experience in selling electrical and mechanical machinery, excellent references, desires position for Cuba, or as branch manager western part of United States. Thoroughly acquainted with intermountain and Pacific Coast territory.—H-278.

PRODUCTION ENGINEER, FACTORY MANAGER OF TOOLS AND METHODS. Member, wishes to correspond with well established concern. Nineteen years experience in several of the largest and well known concerns in this country and Europe, manufacturing small, and medium size accurate interchangeable parts, such as adding machines, typewriters, cash registers, watches and electrical mechanism. Natural mechanical and executive ability, together with broad experience in developing production of work as mentioned above. Location—Middle West preferred. All correspondence treated as confidential.—H-279.

EXECUTIVE, ENGINEERING or SALES, familiar with sale of oils and handling by pipe lines, motor trucks and ships. Ability to design and install pipe lines, power plant equipment, tanks, etc. Capable of handling accounts and cutting costs. Several years experience in conducting efficiency tests of power plant equipment, lubricants, air compressors and shop material. Technical graduate. Initial salary secondary consideration. Can handle men without friction and obtain results.—H-280.

EXECUTIVE or MECHANICAL ENGINEER, experienced in organization, design of special, elevating and conveying machinery, technical graduate, at present employed, desires interview with parties seeking reliable aggressive man for responsible position. Location New York or vicinity.—H-281.

DRAFTSMAN, technical man with three years shop and two years drafting experience; also one year on production and experimental work seeks position in or near New York City.—H-282.

EXECUTIVE; position desired by member, age 35, American, technical graduate; employed. Thirteen years experience in varied engineering work, mining, smelting, blast furnace and general steel plant work—operation, construction and design.—H-283.

CHIEF ENGINEER, Member, successful designer of automatic machinery, 20 years experience, desires charge of maintenance and operation of industrial plants. At present employed in executive position. Salary $4,000.—H-284.

WORKS ENGINEER, Cornell M.E., 1904, with experience on design of steam and gas engines, in power department of steel mill and on engineering force of large copper smelters, desires position with larger responsibility and a better future.—H-285.

UNIFLOW ENGINES. Mechanical engineer of reputation having long experience with poppet valve engines offers to introduce uniflow engines (patented) suitable for condensing and non-condensing work. Extremely simple and compact arrangement; several engines in actual operation.—H-286.

MECHANICAL AND STRUCTURAL DESIGNER now doing responsible work for $200 a month, must leave this class of work on account of eye strain. Will start for $100 a month with large firm as traveling salesman. American born; 35 years of age; single; technical education; fifteen years wide experience in engineering work in 10 cities of U. S. and 3 foreign countries. Now in Canada. Pleasing personality and good mixer, especially adapted for dealings with foreigners. Many references.—H-287.

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

American Gas Centenary, 1816-1916. *Baltimore, 1916.* Gift of Consolidated Gas, Electric Light and Power Company of Baltimore.

Boston. Metropolitan Water and Sewerage Board. 15th Annual Report, 1915. *Boston, 1916.* Gift of Board.

Cambridge (Mass.) Water Board. Annual Report April 1, 1914-April 1, 1915. *Cambridge, 1915.* Gift of Water Board.

Carnegie Foundation for the Advancement of Teaching. 10th Annual Report. 1915. *New York, 1915.*

——— Bulletin no. 9. *New York, 1916.* Gift of Foundation.

El Sistema de Taylor y su Critica, C. Montullo. *Barcelona, 1916.* Gift of author.

Measuring the Value of Coal. *New York, 1915.* Gift of Fuel Engineering Company.

National Marine Engineers' Beneficial Association. Journal of Proceedings. vol. 14. *Washington, 1916.* Gift of Association.

New York City. Board of Water Supply. Information for bidders, forms of proposal, contract, bond and certificates, specifications and drawings for the construction of the two gate chamber superstructures, balustrades and brick paving and miscellaneous work at Silver Lake Reservoir, Borough of Richmond. *New York City, 1916.* Contract 144. Gift of Board of Water Supply.

New York State. Department of Health. 35th Annual Report. vols. 1-2. *Albany, 1916.* Gift of Department of Health.

Putting Facts Behind Your Choice of Coals. *New York, 1916.* Gift of Fuel Engineering Company.

The Sanction of International Law. Amos J. Peaslee. Reprinted from American Journal of International Law, April, 1916. Gift of author.

Taxing Incomes of Foreign Investors in American Stocks and Bonds, Amos J. Peaslee. Reprinted from The Columbia Law Review, June, 1916. Gift of author.

Travelers Insurance Company. Year Book, 1916. *Hartford, 1916.* Gift of Company.

EXCHANGES

American Gas Institute. Proceedings. vol. 10, 1915. *New York, 1916.*

——— Membership list, year ending Aug. 31, 1915, corrected to Jan. 1, 1916.

——— Index to Proceedings, vol. 1-10, 1906-1915. *New York, 1916.*

Institution of Engineers and Shipbuilders in Scotland. Transactions. vol. LVIII. *Glasgow, 1915.*

Victorian Institute of Engineers. Proceedings. vol. XIV. *Melbourne, 1914.*

TRADE CATALOGUES

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. *June, 1915-May, 1916;* vol. 4, no. 1.

Gould Manufacturing Co. *Seneca Falls, N. Y.* Bulletin no. 120. Multi-stage centrifugal pumps. 1916.

Texas Co. New York, N. Y. Lubrication. *June, 1916.*

Thompson & Co. *Victoria, Australia.* Manufacture of modern machinery in Australia. 51 pp.

Walworth Mfg. Co. *Boston, Mass.* Walworth Log. *April-July, 1916.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

Abstracts of Current Decisions on Mines and Mining, reported from October to December, 1915. U. S. Bureau of Mines. Bulletin 118. *Washington, 1916.*

Die Abwässer aus der Kaliindustrie. Ergänzungsheft. J. H. Vogel. *Berlin, 1915.*

American Chemical Society. Directory. 1914. Gift of American Chemical Society.

Atlantic Gold District and the North Laramie Mountains, Fremont, Converse, and Albany Counties, Wyoming. U. S. Geological Survey. Bulletin 626. *Washington, 1916.*

Atlas of the State of New York, Julius Bien. *New York, 1895.*

The Authentic History of the United States Steel Corporation, Arundel Cotter. *New York, Moody Magazine & Book Co., 1916.* Gift of publisher.

The author admits a prejudice in favor of the corporation. It is an interesting contribution to industrial history.

By-Products Recovered in the Manufacture of Coke, W. H. Childs. *1916.* Gift of D. D. Berolzheimer.

Birliography on Valuation of Public Utilities to Dec. 23, 1915. *New York, 1915.* Gift of American Electric Railway Association.

Boston Society of Civil Engineers. Constitution and By-Laws and List of Members, *June, 1916. Boston, 1916.*

Business After the War, G. E. Roberts. *New York, 1916.* Gift of National City Bank.

The Caddo Oil and Gas Field, Louisiana and Texas. U. S. Geological Survey. Bulletin 619. *Washington, 1916.*

Car Builders' Dictionary. ed. 8, 1916. *New York, 1916.*

Carnegie Library of Pittsburgh. Index to the classified catalogue of the Technology Department. ed. 2. *Pittsburgh, 1916.*

Chlorine and Chlorine Products, G. Martin. *London, 1915.*

City Officials of the United States, 1916. Gift of Engineering News.

Commercial Fertilizer. Year Book, 1916. *Atlanta, 1916.*

Cotton Production in the United States. Crop of 1915. *Washington, 1916.*

Concrete Construction for Rural Communities, R. A. Seaton. *New York, 1916.*

Defenseless America, Hudson Maxim. *New York, 1915.* Gift of author.

Deposits of the Useful Minerals and Rocks; Their Origin, Form and Content, F. Beyschlag and others. vol. II. *London, 1916.*

Determination of Time, Longitude, Latitude and Azimuth. ed. 5. U. S. Coast & Geodetic Survey. Special Publication no. 14. *Washington, 1913.*

The Diesel Engine in Practice, J. E. Megson and H. S. Jones. *San Francisco, 1916.*

Dutch East Indies. Jaarboek van het Mijnwezen. 1914—Verhaudelingen, Eerste deel. With Atlas. *'s-Gravenhage, 1915.*

Effect of Motion Study Upon the Workers, Frank B. and Lillian M. Gilbreth. Reprinted from The Annals of American Academy of Political and Social Science, May, 1916. Gift of authors.

Electrical Contractor, L. W. Moxey, Jr. *New York, 1916.*

English-French and French-English Dictionary of the Motor Car, Cycle and Boat, Frederick Lucas. *London, 1915.*

The Etheridge Mineral Field. Queensland. Geological Survey. Publication 245. *Brisbane, 1915.*

Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface. *New York, Babcock & Wilcox Co., 1916.* Gift of publisher.

Fauna of the Chapman Sandstone of Maine. U. S. Geological Survey Professional Paper 89. *Washington, 1916.*

Financing an Enterprise, Francis Cooper. A manual of information and suggestion for promoters, investors and business men generally. ed. 4. *New York, 1915.*

Foreign Publications for Advertising American Goods. *Washington, 1913.* Gift of U. S. Department of Commerce.

Die Funkentelegraphie, H. Thurn. ed. 3. *Leipzig, 1915.*

Geology and Coal Resources of Castle Valley in Carbon, Emery, and Sevier Counties, Utah. U. S. Geological Survey. Bulletin 628. *Washington, 1916.*

Geology and Mineral Resources of the Southern Coal Field. Part 1—South Coastal Portion. With Maps and Sections. New South Wales. Memoirs of the Geological Survey. Geology no. 7. *Sydney, 1915.*

Geology and Underground Water of Luna County, New Mexico. U. S. Geological Survey. Bulletin 618. *Washington, 1916.*

Ground Water in the Hartford, Stamford, Salisbury, Willimantic and Saybrook Areas, Connecticut. U. S. Geological Survey. Water Supply Paper 374. *Washington, 1916.*

——— in San Joaquin Valley, California. U. S. Geological Survey. Water Supply Paper 398. *Washington, 1916.*

Handbook and Descriptive Catalogue of the Meteorite Collections in the United States National Museum. Bulletin no. 94. *Washington, 1916.*

Handbuch der Gastechnik, E. Schilling and H. Bunte. Vol. VIII. *Munchen, 1916.*

Handbuch der Physikalisch Chemischen Technik für Forscher und Techniker, Kurt Arndt. *Stuttgart, 1915.*

Hydraulics, R. L. Daugherty. *New York, 1916.*

Indiana—Report of a Geological Reconnoissance and Survey 1837 and 1838, D. D. Owen. *Indianapolis, 1839.*

International Engineering Congress. Transactions. Vol. XI—Miscellany. *San Francisco, 1915.*

Die Kaliindustrie und ihre Abwässer, Dr. Tjaden. *Berlin, 1915.*

Kansas. Geological Survey. vol. I. *Topeka, 1896.*

Kon. Instituut van Ingenieurs. Naamlijst der Leden, 1916. *'s' Gravenhage, 1916.*

Lathe Design, Construction and Operation, O. E. Perrigo. *New York, 1916.*

Leading Opinions Both for and Against National Defense, Hudson Maxim. *New York, 1916.* Gift of author.

Locomotive Dictionary. ed. 4, 1916. *New York, 1916.*

Manufacture of Organic Dyestuffs. Translated from the French of André Wahl, F. W. Atack. *London, 1914.*

Die Maschinelehre der Elektrischen Zugförderung, W. Kummer. *Berlin, 1915.*

Mechanical Engineers' Handbook, L. S. Marks. *New York, 1916.*

Messungen an Elektrischen Maschinen, Rudolf Krause. ed. 3. *Berlin, 1916.*

Microscopical Determination of the Opaque Minerals, Joseph Murdoch. *New York, J. Wiley & Sons, 1916.* Gift of publisher. Price, $2.00.

Treats of the technique of mineral examination by treatment with various reagents under the microscope. Ingeniously arranged tables are provided.—W. P. C.

Mineralogic Notes, Series 3. U. S. Geological Survey. Bulletin 610. *Washington, 1916.*

Motor Manual. ed. 15. *London.* Gift of Frank Gilliland.

National Parks Portfolio. *Washington, 1916.* Gift of Department of Interior.

Natural Gas Resources of Parts of North Texas. U. S. Geological Survey. Bulletin 629. *Washington, 1916.*

One Century in Business, 1816-1916. Peter A. Frasse & Co., Inc. History. *New York, 1916.* Gift of Company.

Oscillating Current Circuits, V. Bush. *1916.* Gift of Massachusetts Institute of Technology—Electrical Engineering Dept.

Panama Canal. An engineering treatise. Under the direction of G. W. Goethals. Vols. 1-2. *New York, 1916.*

Petroleum and Natural Gas Prospects at Roma. Queensland. Geological Survey. Publication 247. *Brisbane, 1915.*

Power Transmission by Leather Belting, R. T. Kent. *New York, J. Wiley & Sons, 1916.* Gift of Publisher. Price, $1.25 net.

Belting practice has changed greatly in the past fifteen years. The literature is buried in the transactions of engineering societies and in technical journals. Ths book seeks to gather this into a compilation of the greatest service to the user of belting.—W. P. C.

Predetermination of True Costs and Relatively True Selling Prices, F. A. Parkhurst. *New York, J. Wiley & Sons, 1916.* Gift of publisher. Price, $1.25 net.

Outlines a system of scientific records and forms to be used as a basis for determining costs, as used in several well-known manufacturing firms by the author. It is therefore based on actual experience. —W. P. C.

Preliminary Notes on a New Way of Converting Light into Electrical Energy, Theodore W. Case. Read before the New York Electrical Society, June 14, 1916. Gift of Geo. H. Guy.

Public Utilities Reports—Annotated 1916—B. *New York, 1916.*

Public Utilities Digest. Annual 1915. *New York, 1916.*

Schiffs-Dieselmotoren, William Scholz. *Hamburg, 1915.*

Society of Automobile Engineers. Transactions. Part I, 1916. *New York, 1916.*

Spirit Leveling in Louisiana, 1903-1915, inclusive. U. S. Geological Survey. Bulletin 634. *Washington, 1916.*

——— in Maine, 1899-1915. U. S. Geological Survey. Bulletin 633. *Washington, 1916.*

Standard Cloths, Structure and Manufacture, Roberts Beaumont. *London, 1916.*

Statik mit Einschluss der Festigkeitslehre, A. Schau. *Leipzig, 1915.*

Surface Water Supply of the United States, 1914, Part III. Ohio River Basin. U. S. Geological Survey. Water Supply Paper 383. *Washington, 1916.*

Tennessee—Sixth geological report to the 24th general assembly, Nashville, 1841.

The Three Position Plan of Promotion, Frank B. and Lillian M. Gilbreth. Reprinted from The Annals of the American Academy of Political and Social Science, May, 1916. Gift of authors.

Tonométrie, F. M. Raoult, *1900.*

Transportation Rates and Their Regulation, H. G. Brown. *New York, 1916.*

Tungsten and Molybdenum. Part I-II. Tasmania. Geological Survery Mineral Resources, no. 1. *Tasmania, 1916.*

U. S. Bureau of Census. United States Life Tables, 1910. *Washington, 1916.*

U. S. Patents on Wood Preservation, Jan. 1, 1880-Mar. 31, 1916. D. D. Berolzheimer. Gift of author.

Untersuchung des Wassers an Ort und Stelle, Hartwig Klut. ed. 3. *Berlin, 1916.*

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

Arranged in the Order of Their Appearance in the Survey.

Fuel Oil Installation on Florida East Coast Railway.
Fuel Expense Per Engine Mile, Coal and Oil.
Steel Scrap in Foundry Mixtures.
Strength of Bars with Steel Scrap.
Casting of Non-Ferrous Metals in Chill Moulds.
Chill Moulds.
Flow of Oil Through Orifices.
Flow of Viscous Fluids Through Pipes.
Painting of Iron and Steel.
One of Several Coats of Paint Compared.
Selection of Machines for Forging.
Multiple Mechanical Die Sinking.
Making Front Axles for Automobiles.
Elliott I-Beam Front Axles for Automobiles.
Heat Treatment of Drop Forgings.
Drop Forging Steel, Manufacture.
Sand Blasting of Forgings.
Small Powdered Coal Furnace Plants.
Upsetters.
Roll Pressures in Cold-Rolling Steel.
Sherardizing Process.
Hobbing High Prime-Number Spur-Gears.
Quenching Liquids Compared.
Dynamic Balance of Machines.
Noise of Operating Machinery.
Critical Speeds of Shafts.
Whirling of Shafts.
Diesel Engine and Steam Turbine Costs.
Santa Fe Type Locomotives.
Lateral Motion in Driving Wheels, Rigid Base Locomotives.
Superheaters on Locomotives.
Equalization of Long Locomotives.
Draft Channel Strength.
Steam Prime Movers, Efficiencies.
Double-Nozzle Gear-Type Turbines for Variable Loads.
45,000 h.p. Turbine, Etc.

Economy in power generation has always been a leading topic among engineers, but never so vital as now, when the approaching competition among nations is more and more emphasizing the necessity of attaining the highest efficiency in all departments of industrial life of a nation. In one field of industry in particular there are additional reasons for endeavoring to reduce the cost of power as much as possible, and that is in the central station field. There the necessity of meeting the growing cost of labor and raw materials without raising rates in a corresponding manner on one hand, and the constant supervision of and accountability to various public utility boards on the other, makes it particularly essential to keep down the unit cost of power as low as possible.

This can be achieved in one of two ways, dependent upon local conditions. The central station with very large loads can meet the difficulty by increasing tremendously the size of the unit, and in the present issue a brief description is given of some of the features of one of the largest power generating units in the world, Unit No. 3 at the Northwestern Station of the Commonwealth Edison Company of Chicago, rated at 45,000 h.p.

For small stations with widely varying loads, one way of reducing power cost is to introduce types of prime movers equally or nearly equally efficient at loads varying from about one-third to peak. The double-nozzle gear-type steam turbine described in the section Steam Engineering offers one of the solutions of the problem.

THIS MONTH'S ARTICLES

An abstract of an article describing the fuel oil installation and equipment on the Florida East Coast Railway gives, among other things, a comparative statement of fuel cost per engine mile with coal and oil.

In the section Foundry will be found a report of some practical results that have been obtained by the use of steel scrap in the different classes of castings produced in the foundry of a company making carwheels.

The casting of non-ferrous metals in chill molds is described, and a table is given showing the comparison of the physical properties of copper alloys cast in sand and permanent molds.

Two articles are abstracted on the flow of viscous fluids, one on flow of oil through orifices and the other on the carrying capacity of pipes for viscous fluids. In the first of these articles an interesting fact is disclosed, namely, that the discharge for a given orifice is always the same with a given pressure, provided the oil be at or above its critical temperature.

An abstract of an article on roll pressures in cold-rolling steel gives formulæ for the pressure used as a function of the projected area of the rolls in contact with the metal.

Oliver W. Storey presents a discussion of the sherardizing process, in which an attempt is made first to establish conditions insuring the uniformity of the product, and second to show how a maximum protection of iron may be obtained with a minimum expenditure of zinc dust. Among other things the writer shows that it is of great importance to maintain a uniform metallic content in the zinc dust, and also explains the fact, which seemed to be quite puzzling, that concerns which obtained very good results with sherardizing at first began to have trouble after having used the process for some time. It seems now that the cause of this was simply the enrichment of the dust by iron, which made it necessary to use a high temperature for sherardization, resulting in a coating less resistant to weathering.

A method of hobbing high prime-number spur gears is described by Will. O. Wynne. Curiously enough, the machine described, which permits of hobbing a gear with any number of teeth up to 1000, is actually simpler than the ordinary machine, which cannot hob high prime numbers.

C. D. Young, Mem. Am.Soc.M.E., shows by a number of tests that, providing proper care is taken in the handling of steel during the quenching process, water is preferable to oil as a quenching medium. He also recommends that in all specifications for forgings which are to be heat treated there be included a clause to govern the allowable amount of segregation.

In the section Mechanics, attention is called to the article on the whirling speed of shafts by W. M. Wallace.

Firing and Fuel

Fuel Oil Installation and Equipment

Description of the fuel oil installation and equipment on the Florida East Coast Railway, the most recent of the large systems to change from coal to oil fuel for its locomotives. This change was made only after considerable preliminary experience involving the conversion of some twenty-five engines from coal to oil burners.

The locomotive equipment used is characteristic of that employed on other large systems. A Clarke burner is used; the installation is fully described in the article. The fire pans are of the round bottom variety sloping from back to front in such a way that whatever surplus of oil may accumulate in the pan is drained out at the forward end and does not bring about danger from explosion. A course of brick is set on edge along the sides of the fire pan to protect the lower portions of the side sheets from the intense heat, and at the same time assist in sealing the pan at the point of its attachment to the mud ring.

Particular attention has been given to the matter of draft. Air is admitted at two points, through a damper at the front wall of the fire pan and through a second damper controlling the supply through the flash hole located about two-thirds of the distance from the burner back to the rear of the pan.

The perforations in the front wall of the fire pan covered by the first mentioned damper have inserted in each a 4-in. length of tubing. Air supply for combustion is received at this point during the operation of firing-up. After steam has been raised and the engine starts working this damper may be partly or entirely closed, and, further, air for combustion may be received through the second damper at the flash hole. This second damper is manipulated by means of a notched lever set in the floor of the cab.

Table 1 gives a comparison of the fuel expense per engine mile as between coal and oil for a period ending with the month of March, 1916, from which it is seen that a saving of about 18 per cent in the cost of fuel has been realized from the use of oil. (*Railway Review*, vol. 58, no. 26, p. 903, 4 pp., 6 figs. *a*.)

TABLE 1. COMPARATIVE STATEMENT OF FUEL COST PER ENGINE MILE, COAL vs OIL, FLORIDA EAST COAST RY.

		Cons. of Avg. Price.				
Coal—	Mileage.	Coal-tons.	Per ton.	Cost.	Miles run per ton.	Cost per mile run.
Forwarded.	1,304,663	71,524	$3.03	$216,722.97	18.24	$0.166114
March.....	237,920	13,667	3.07	41,957.69	17.41	.176352
Total & avg.	1,542,583	85,191	$3.04	$258,680.66	18.11	$0.167628
Oil—		Gal.	Gal.		Gal.	
Forwarded.	467,341	3,719,841	$0.017	$63,482.97	.126	$0.135830
March.....	115,591	991,367	.0168	16,654.97	.117	.144085
Total & avg.	582,962	4,711,208	$0.017	$80,137.94	.124	$0.137467

Foundry

Steel Scrap in Various Foundry Mixtures, G. S. Evans

Report of some practical results that have been obtained by the use of steel scrap in the different classes of castings produced in the foundry of the Lenoir Car Works of Lenoir City, Tenn., of which the writer is superintendent.

At first this Company used, in the manufacturing of car wheels, a mixture consisting of different grades of charcoal pig iron and scrap wheels, the mixture being made by fractural grading. A large percentage of the wheels had been rejected by the railroad inspector on account of either drop or thermal failures. A small percentage of scrap steel was then added in place of a portion of the No. 6 and 7 grades of charcoal pig iron, the mixture being figured on the analysis basis instead of by fracture. An improvement was noticed. By degrees the addition of steel was increased from 10 to 12 per cent. Now 10 per cent of scrap steel is regularly carried in the mixtures for general locomotive and car castings, the other components being 30 to 40 per cent pig iron and 50 to 60 per cent machinery and returned scrap. The writer found that in this mixture the use of steel closes the grain of the casting and increases the strength without affecting the chilling qualities sufficient to cause any trouble even in very thin sections. While the use of scrap steel in these amounts tends toward improving the quality of the casting, it does not, in the belief of the writer, give any distinctive characteristics to the metal that would warrant any claim for it other than that of being a good grade of machinery or chilled casting. With larger percentages of steel, and when properly melted, however, an iron is produced which apparently could not be obtained without the use of steel. Under ordinary foundry conditions such castings are more expensive to produce, are more efficient for certain specific uses, and consequently demand a higher price regardless of the name. In special light castings, which include light pipe fittings requiring high strength and great density, 30 to 40 per cent of scrap steel is used. An interesting discussion is presented on carwheel chillers. Until some three years ago when the writer began experimenting with special chiller mixtures he was of the opinion that the softer the chiller, the more adapted it would be to the service conditions, those of periodical expansion and contraction. Practical tests have shown, however, that the resistance of the metal to sudden expansion and contraction depends essentially neither on hardness nor the chemical constitution of the metal but upon its metallurgical structure.

Tests were made to determine the effects of the addition of steel on the strength and properties of test bars cast from irons of like analysis. It was found that the semi-steel iron shows an increase of 61.4 per cent in tensile and 23.9 per cent in transverse strength over the gray iron; the hardness as shown by the Brinell test is slightly greater in the case of the semi-steel but the "toolability" of both is approximately the same. The useful characteristics of semi-steel are its uniformity of structure throughout the whole section of a casting and freedom from paper chills; but correct cupola practice is very essential to the successful production of semi-steel. While there is no specific formula by which to melt it, as a general rule it is essential to use smaller cupola charges and greater total tuyere area than commonly. The writer found a charge of 150 lb. of metal per sq. ft. of cupola area and a tuyere ratio of 1 to 5 to give very satisfactory results in cupolas from 32 to 84 in. in size. (*The Iron Age*, vol. 97, no. 26, p. 1541, June 29, 1916, 5 pp., 27 figs. *dp*.)

The Casting of Non-Ferrous Metals in Chill Moulds, F. Johnson

After a brief discussion of the advantages obtainable with chill molds the author proceeds to the consideration of the molds themselves. Of the three materials suitable for these molds, gray cast iron and steel have been used and found satisfactory (the third is malleable cast iron). Cast-iron molds should be produced with a generous allowance for machining to the exact dimensions required for the production of a casting, and also for the removal of surface defects. The thickness of the walls of the mold depends upon its size.

For small castings the walls need not be more than 2 in. thick. Steel molds may be thinner.

Whether the parts of the mold form vertical or horizontal joints, strong clamps, of a simple type adapted to rapid tightening and loosening, should be provided. If the parts of the mold are hinged together, the hinges should work smoothly and easily. Strict attention should be paid to the venting of the joints, since if there is insufficient provision for the escape of air the casting will either be spongy or its surface spoiled by the presence of air pockets.

The composition of the iron for cast-iron molds is important. The iron should be tough and close-grained and free from blowholes. W. J. May recommends the following composition of iron sucessfully used for molds:

	Per cent
Combined Carbon	0.84
Graphitic Carbon	2.76
Silicon	2.02
Sulphur	0.07
Phosphorus	0.89
Manganese	0.29

The high phosphorus content is justified by May on the ground that the fluidity which it confers enables molds of

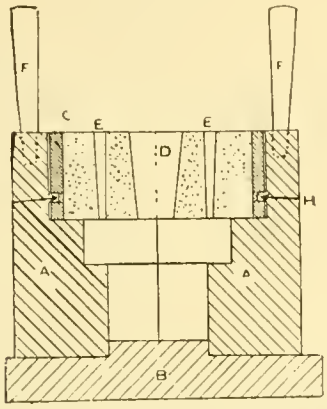

Fig. 1 Cross-Section of Permanent Iron Mold for Non-Ferrous Metals

sharper outlines to be produced. He also states, however, that an iron high in combined carbon would probably grow and become deformed under repeated heating. The presence of phosphorus, moreover, increases brittleness, and therefore a cast iron with a low phosphorus content is preferable, for even if sharp outlines are not obtained the surface can be machined.

To protect the mold surface and to facilitate the extraction of the casting, a coating is applied. Seal oil liberally mixed with fine plumbago appears to be as satisfactory as anything. In contact with the molten metal partial distillation of the dressing takes place, with the production of gaseous hydrocarbons which are trapped in the casting before they can gain egress from the mold. Just sufficient coating is required to form a gaseous envelope between the casting and the mold to give a clean surface to the former, to facilitate its extraction and to protect the surface of the mold. If carbonaceous coatings are considered undesirable, an emulsion of bone ash and water applied with a brush to the warm surface of the mold should prove satisfactory.

Steel cores appear to be preferable to sand cores in iron molds. The provision of a satisfactory gate for chill molds has introduced difficulties. Owing to the rapid chilling effect of the iron no marked constriction of space at the junction of the head with the casting can be allowed, as the setting of the metal is likely to take place here before the casting has solidified. By carefully diminishing the rate of pouring as the mold fills, this difficulty may be partly overcome; but still a considerable amount of metal is required for the head when formed in the mold itself. The writer tried to use a much smaller head, kept molten until after the solidification of the casting. To do this the gate was made in sand in a detachable ring placed on top of the mold, and kept firmly in position while pouring. The lower thermal conductivity of the sand enabled the small head to do all the feeding. A small riser was also added for the purpose of securing free egress of gas and air from the mold. In Fig. 1 the halves of the mold are indicated by *A*; *B* is the cast iron base and *C* the steel ring for

TABLE 2. COMPARISON OF THE PHYSICAL PROPERTIES OF ALLOYS CAST IN SAND AND PERMANENT MOLDS.

Composition	How cast	Yield point, tons per sq. in.	Breaking stress, tons per sq. in.	Elongation per cent	Reference
Copper, 85 per cent.; aluminum, 5 per cent...	Sand	4.3	18.1	75.0	Eighth report of the alloys research committee, 1907
Copper, 85 per cent.; aluminum, 5 per cent...	Chill	7.1	18.1	60.5	
Copper, 90 per cent.; aluminum, 10 per cent..	Sand	11.3	31.7	21.7	
Copper, 90 per cent.; aluminum, 10 per cent..	Chill	12.4	36.93	30.5	
Copper, 88 per cent.; aluminum, 10 per cent.; manganese, 2 per cent..	Sand	13.2	34.44	24.0	Ninth report of the alloys research committee, 1910
Copper, 88 per cent.; aluminum, 10 per cent.; manganese, 2 per cent..	Chill	16.8	37.0	25.0	
Copper, 56 per cent.; zinc, 41 per cent.; iron, 1.5 per cent.; tin, 0.9 per cent.; aluminum, 0.45 per cent., and manganese, 0.15 per cent.....	Sand	...	33.44	20.0	
The same alloy as given above.....	Chill	...	38.4	25.0	

sand. The gate is shown at *D*; *E E* are the risers and *F F* the handles. The small heads proved that the feeding was satisfactory. In one experiment the weight of the head represented only 8 per cent of the total weight of metal used. This method also has the advantage of securing a more effective elimination of dross, air and gas.

In producing brass castings in chill molds, the elimination of dross from the surfaces of the casting has proved to be the greatest difficulty. The position of the mold has some bearing on the problem. The best way to secure castings with smooth cleaning surfaces is to prevent ingress of all dross and oxide to the mold. A suitable flux which will dissolve zinc oxide is useful. The addition of aluminum to copper-zinc alloys has the effect of checking oxidation of the zinc, and no other deoxidizer has been proved to have such a marked influence in this respect.

To prove that dross was the cause of rough surfaces, the following experiment was made: A graphite crucible was

pierced at the bottom with a ¼-in. hole, and a ½-in. arc-lamp carbon was used to plug up the hole and act as a stopper. This crucible was heated to redness and placed in position over the gate of the mold. Molten metal was poured into the hot crucible, and when it was reasonably certain that all the dross had risen to the surface the stopper was removed and the clean metal from the bottom was allowed to teem into the mold. By this means castings were produced quite free from surface imperfections.

The superiority of the mechanical properties of chill castings over sand castings may be seen from the data collected in Table 2. (Paper read before the Birmingham, England, Branch of the British Foundrymen's Association, abstracted through *The Mechanical Engineer,* vol. 37, no. 958, p. 429, June 2, 1916, 3 pp., 3 figs. *pd.*)

Hydraulics

Flow of Oil Through Orifices

Data of measurements of flow with fuel oil, power distillate,

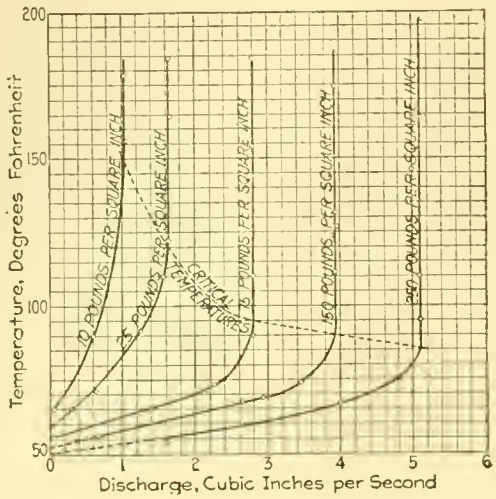

Fig. 2 Discharge of Steam Cylinder Oil at Different Temperatures

and Kansas crude under different pressures and with different sized orifices, made last year at the State University of Iowa. The experiments were made at a constant temperature of 70 deg. fahr., with six pressures ranging from 10 to 350 lb. and five orifices ranging from 0.0232 to 0.0807 in. diameter. Additional tests in which the temperature was varied were made on heavy steam-engine cylinder oil.

The most interesting results were obtained with the steam cylinder oil. Observations were made in which the temperature was varied from 50 to 200 deg. fahr. using the 0.063 in. orifice and pressures from 10 to 250 lb. It was found that at each pressure there was a temperature above which the discharge became independent of the temperature and below which the discharge dropped off at an increasing rate with a decrease in temperature. These critical temperatures decrease as the pressure increases. Fig. 2 shows the relation between discharge and temperature of this heavy oil.

The discharge per second above the critical temperature is in all cases nearly the same as the discharge for the other oils at 70 deg. fahr. This would point to the fact that, no matter what kind of oil be used, the discharge from a given orifice with a given pressure will be always the same if the oil be at or above its critical temperature. (From thesis by G. P. Anthes, *Power*, vol. 44, no. 2, p. 58, July 11, 1916, 2 pp., 5 figs. *e.*)

The Flow of Viscous Fluids Through Pipes, W. K. Lewis

Investigation of the carrying capacity of pipes for liquids other than water, of interest because of the lack of any published figures on this subject.

Previous investigations have shown that at low velocities viscous liquids move in straight lines parallel to the axis of the tube, but when the velocity is sufficiently increased the lines of flow become distorted, the filament forming violent eddies of constantly changing form and position. From this the author deduces that at least two different laws must govern the flow of fluids, the one above and the other below the critical velocity, with the possibility of a third for an intermediate state. Poiseuille's law would be the one to use below the critical point, since his formula applies entirely to straight line motion. For flow above the critical point, the author suggests an equation derived from observation of the formulæ for flow of steam, air and water above the critical point. This formula is

$$P = \frac{f\rho l V^n}{gr}$$

(notation at end of abstract) and it is surprising to find that they all have approximately the same constant f and also nearly the same value of n.

For the expression of pressure drop, the author suggests a general equation

$$P = \frac{(Ky + C)V^n}{d^m}$$

for all sizes of pipes with varying velocities and different degrees of internal roughness (the constants doubtless vary). The author shows that flowing liquids of all viscosities, when in sinuous motion, follow substantially the same equation, differing only in the coefficient of that equation; that is, the flow of any liquid in sinuous motion may be expressed as a constant times some function of velocity length and radius, this function being independent of the viscosity.

For estimating the carrying capacity of the pipe for viscous liquids, the author suggests the formula

$$f = f_w\ (0.955 + 0.045\ z)$$

where f_w is the hydraulic coefficient for the flow of water through a pipe, f that of any liquid, and z is the relative viscosity of the liquid in question to water. The best way to determine z is to measure the relative time of efflux of the liquid and water through the same capillary tube. The writer experimentally confirms the accuracy of this formula by data up to viscosities of twenty-fold that of water. Up to this point the equation term for viscosities in the different formulæ is small, but for very high viscosities such as are encountered in heavy mineral oils, glycerin, etc., this term becomes very great. In fact the writer doubts the validity of this formula for high viscosities.

Liquids of even moderate viscosity flowing under low heads follow viscous motion unless the pipes be very large. As long as the motion is viscous, doubling the size of the pipe increases the velocity four-fold and the discharge sixteen-fold for the same pressure drop.

Liquids flowing through pipes flow either in straight-line

motion, in which case they follow Poiseuille's formula,

$$P = \frac{8\mu l V}{g r^2}$$

or in sinuous motion, the pressure drop being represented by

$$P = \frac{f l \rho V^2}{g r}$$

The flow will follow that formula which requires the higher pressure drop, the higher radius, or gives the lower velocity, as the case may be. Both formulæ must therefore be employed, and the result chosen according to the above rule. To obtain the coefficient f of the formula for sinuous motion: look up, in suitable hydraulic tables, the value of the coefficient for water flowing in the same size pipe at the same velocity, and multiply this coefficient by the expression $(0.955 + 0.0452z)$ wherein z is the viscosity relative to water of the liquid flowing.

These formulæ have been experimentally substantiated only for use in pipes up to 2 in. in diameter and for the flow of liquids of viscosity (relative to water at 20 deg.) of 20. They are probably safe for use in larger pipes and at higher viscosities, but more exact expressions for these conditions must be determined by further experimentation.

Nomenclature

P = pressure drop in grams/cm². or lb./sq. ft.
μ = { coefficient of absolute viscosity in sec. dynes/cm². or sec. poundals/sq. ft.
l = length of the pipe in cm. or ft.
r = radius of pipe in cm. or ft. (d = diameter)
ρ = density of the fluid
V = mean velocity in cm./sec. or ft./sec.
f = hydraulic frictional coefficient.

(*The Journal of Industrial and Engineering Chemistry*, vol. 8, no. 7, p. 627, July, 1916, 6 pp., 4 figs. *eA.*)

Machine Shop

The Painting of Iron and Steel, James Scott

The paper is based on the fact discovered on the Continent (The Journal, 1912, p. 637) that a single coat of paint resists the rust of the metal more than either two, three or four coats. From this the writer comes to the conclusion that it may be possible to not only economize in paint but to obtain better results by this less expensive method.

Although paints do not appear to possess much structure when viewed by the naked eye, the pigments of which they consist are revealed very definitely upon magnification. In some cases the granules are exceptionally minute, uniform and equally distributed. Frequently, however, they are either initially coarse, or coalesce into groups which practically become enlarged nodules. In many specimens the actual speck-like pigment is accompanied by semi-crystalline particles of apparently large dimensions either hard or soft, or a mixture of the two kinds, and upon these objects depends to a great extent the success or failure of the paint to be properly protective. The nature of the solvent is also important and operates with much influence in regard to the pigment itself.

The writer covered glass slides thinly with even coats of various paints, and then sent reflected light up through them on the assumption that what is seen on the glass is the same formation as when it is over the metal, unless indeed the irregularities are increased, thus helping to understand what happens. The author gives several plates depicting films of various kinds. The one reproduced here in Fig. 3 is a view of a black varnish paint containing a fair proportion of spirit "turps," the presence of which produces a very different modification explained subsequently.

A wholly spirituous paint or varnish resolves itself into a gyrating mass of comparatively large globules owing to the extreme mobility of the solvent. The granules are rolled over most remarkably, and arranged alternately into a central spot in each globule, and swished to the contours where they meet others adjoining and form large angular patterns. These movements keep up until the solvent has evaporated, and then the granules subside and coalesce into overlying flaky films. The point to note is that as the globular collections of pigment granules are disposed of they produce bold hexagonal designs with intervening clear spaces. Air and moisture can find their way underneath the flakes, and when the latter harden there remain little tunnels level with the plane of the metal.

The outer surface of paint dries first so that the resultant film thus formed tends to press down upon the softer under part and force it into available cavities, thereby filling them with pigment and rendering them fairly impervious.

In actual practice the following happens: A moderately

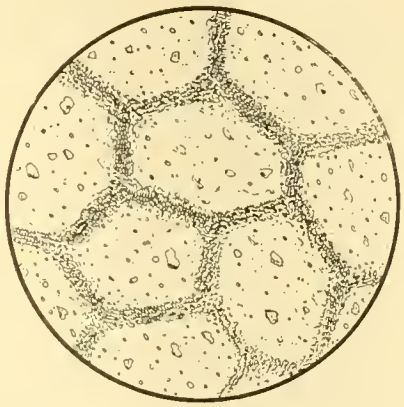

Fig. 3 A Portion of Black Quick-Drying or Spirituous Paint, About 1/24 In. Wide. Comparatively Large Mobile Globules Shift the Pigment Granules into Various Patterns, Beneath Which Slender Tunnels Form

thin layer of paint is applied. It dries with open spaces around its larger granules; then there are tiny cellular cavities where free oil globules or air have been present, narrow under grooves, and scattered particles of fairly large size. To all appearances it becomes hard, firm and intact, but really it is not so. Upon adding another coat to this first one, it is partly redissolved; the fresh substance soaks rapidly through the spaces of the first layer and resoftens the under parts. It also dissolves the soluble granules and thus opens up for itself an extra number of passages. The second coat apparently dries, but in reality it has made an increased amount of porosity. Each additional coat must be supposed to produce the same effect until finally when we think there is a thick, firm water-proof layer, it is really slenderly honeycombed from top to bottom with intercommunicating pores as invisible as those in an egg shell, and yet as free as the latter in admitting air and vapor. On the other hand, if a fairly thick single coat of paint is laid and undisturbed by too much brushing, the fine pigment granules and the larger particles sink to the bottom and the solvent flows above them and during gradual oxidation prevents the formation of the empty spaces. (*The Railway Engineer*, vol. 37, no. 437, p. 133, June 1916, 2 pp., 3 figs. *edp*).

Third Annual Convention of Drop Forgers

Brief abstracts of papers presented at the third annual convention of the American Drop Forgers' Association held in Philadelphia, Pa., June 9 and 10, 1916.

Of these addresses the following are of general interest to mechanical engineers: R. T. Herdegen read a paper on the selection of proper machines for making forgings, in which he pointed out the necessity of the selection of machine units suited to the particular job in question as a means of securing minimum costs. He considered three types of machines, board drops, steam drops and upsetting machines, and gave examples to show a minimum cost job for each type with figures including die cost, material, direct labor and the complete overhead charges.

Jules Dierckx in a paper on multiple mechanical die sinking pointed out the advantages of mechanical sinking of dies on the Keller machine.

J. F. Zwicker gave an interesting and detailed description of his method of producing the Elliott type I-beam section

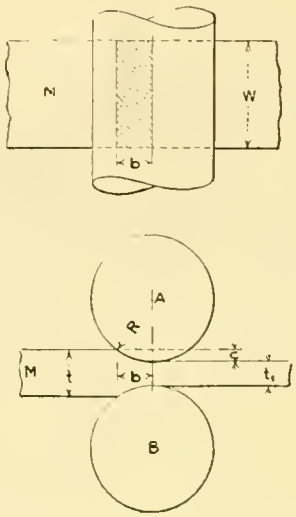

Fig. 4 Diagram of Rolls Acting on Metal

front axle for automobiles, as used in the Overland car. The discussion of this paper brought out the feasibility of thin forging alloy steel flanges; according to Mr. Zwicker's experience this is possible on a 7½ in. diameter flange 5-16 in. thick, gathered from 1½ in. stock, this case being the wheel flange on the rear axle.

W. C. Peterson presented a series of personal investigations on different methods of heat treatment of drop forgings, with particular reference to automobile forgings. He told of tests on the structure of the same forgings made under a varying number of blows and pointed out the advantage in granular structure and tensile strength secured by a large number of blows.

H. N. Taylor's paper on the manufacture of drop forging steel dealt with the method of rolling billets into bars, with a view to eliminating pipes and seams, as applied to carbon-steel forging stock produced by his company.

W. C. Lytle, in his paper on sand blasting of forgings, described the methods of cleaning forgings by pickling, tumbling and various types of sand apparatus, including the barrel type, the cabinet type, hose type and table type. During the discussion the purposes of sand blast for uncovering defects was taken up. The difficulty in cleaning alloy steel forgings by the sand blast process were said to be overcome by the use of No. 5 round chilled-steel shot. A member told of the installation of wire brushes at his hammers at the Buick plant for the purpose of uncovering defects prior to completing the forgings.

A. A. Holbeck (Sources of Heat for Forging Furnaces) described the operation of a powdered coal plant adapted for small furnaces, with distribution of coal by air in galvanized pipes. As small a fuel consumption as 10 lb. per hour per furnace is possible with this system; the temperature of combustion is 3400 deg. and the final cost with coal at $3.00 per ton is equivalent to fuel oil at 1½ cents per gallon.

F. O. Andrews illustrated the recent developments in the use of upsetters by showing a forged spiral beveled gear blank in which the teeth had been produced in a total of three operations on an upsetter.

During the executive session a resolution was passed unanimously placing the members of the American Drop Forgers' Association on record as holding themselves in constant readiness at all times to serve this country with their trade, knowledge and equipment for any necessary military defensive action the Government may require from them. (*American Machinist*, vol. 44, no. 25, p. 1082, June 22, 1916, 2 pp., *g*.)

Roll Pressures in Cold-Rolling Steel, Wm. K. Shepard and George C. Gumer, Mem.Am.Soc.M.E.

Report of an investigation carried out in the Mason Laboratory of Mechanical Engineering at the Sheffield Scientific School of Yale University into the pressures required to cold-roll annealed hot-rolled steel and unannealed steel that had been partly cold-rolled.

One grade of steel was used in all of the tests,—0.10 per cent. carbon and under.

The article describes the methods of conducting the tests and presents the results in the form of tables and curves, the latter being plotted with the pitch in inches as abscissae, and pounds pressure for a strip one inch wide as ordinates. The curves either have a slight curvature, usually in the early part, or practically follow the straight line law. When rolls of different diameters are used, the pressure will, it is believed, depend on the projected areas of the rolls in contact with the metal (the meaning of this term is shown in Fig. 4).

When a piece of metal 1 in. wide is being rolled between the rolls A and B from a thickness t to t_1 in., the projected area of the rolls acting on the metal will be equal to b, the sectioned area in the top view. For a strip of metal w in. wide the projected area will be w times that for a 1 in. width. The per cent rolling will equal $(t - t_1)/t$. From Fig. 4 it is seen that the projected area b for any pinch $t - t_1$ on a 1 in. strip can be found from the relation

$$b = \sqrt{R^2 - (R - C)^2}$$

where R = radius of the rolls and $C = (t - t_1) \div 2$. The writer has calculated the values of the projected areas of various rolls from 5 to 20 in. acting on a strip of metal 1 in. wide for different amounts of pinch. When the values so obtained are plotted on logarithmic cross-section paper, it is seen that there is a straight-line relation between the projected areas and the different pinches of each size of rolls. The ratios of these projected areas of different size rolls to the projected areas of 5-in. rolls for three pinches, are given in a separate table. (*American Machinist*, vol. 44, no. 26, p. 1117, June 29, 1916, 4 pp., 6 figs. *e*.)

The Sherardizing Process, Oliver W. Storey

Discussion of the sherardizing process, mainly from the point of view of securing the maximum of protection of iron with the minimum expenditure of zinc dust. This question has become now of particular importance because of the spectacular rise in the price of zinc.

The exact compositions of the alloys of zinc and iron are not known. The solubility relations of the two metals have been studied by Wologdine and von Vegesack, but their results are not entirely in accordance. This makes the exact nature of the alloys formed in sherardizing of some doubt. Several investigators have made a study of the zinc-iron alloys formed in the sherardizing process but came to different conclusions. They have found the iron content to vary from 9 to 30 per cent, and the coating to consist of from one to four layers of different zinc-iron alloys.

The writer has determined to a limited extent the effect of temperature on the iron content of sherardized coatings. The analyses were made on coatings of approximately the same thickness with the same time of deposition, while the concentration of zinc in the dust determined the temperature necessary to secure a given thickness of coating. Unfortunately it was impossible to secure accurate temperature measurements.

The metallic content of the zinc dust varied from 18 to 42 per cent. The variation in temperature necessary for these extremes was about 65 deg. cent., the higher metallic content requiring the lower temperature. The data obtained with intermediate metallic percentages showed that the iron content of the sherardized coating is proportional to the temperature used, the rate of deposition being constant. This explains the variation in iron percentages reported by earlier investigators, as no investigation of the sherardized coating with reference to its structure can be considered complete without a knowledge of deposit conditions. The higher the temperature of deposition the higher the percentage of iron in the alloy, providing the rate of deposition is the same.

The author discusses also the sherardizing of copper, and thinks that copper and zinc form two definite compounds at sherardizing temperatures, CuZn and $CuZn_2$, while no others are formed. Further, from the results obtained in sherardizing copper he concludes that the higher temperature results in a higher copper content in the coating and the alloys formed are in definite layers, each having a definite composition corresponding to an intermetallic compound.

From this the author proceeds to a discussion of the theory of sherardizing. He finds that the so-called vapor theory is not without objections. He found much trouble in the sherardizing of large pieces of flat work in non-revolving boxes; if the dust was not in close contact with the entire area those parts which were not touched by the dust were not sherardized. The sherardizing process should not become confused with the vapor coating process, in which much higher temperatures are used.

The writer compares the behavior of zinc with that of other metals, and finds that sherardizing may be carried out with various metals, especially antimony, at temperatures used ordinarily in sherardizing with zinc dust. He further points out that zinc at the sherardizing temperature is more or less plastic and can be easily welded or joined to other metals in the same manner; and that iron, platinum and other metals may be welded together well below their fusing temperature. This welding action is aided by the formation of the intermetallic compounds. By analogy with other active metals, zinc will unite with iron, copper, nickel and other metals below its melting point because of the affinity of the metals involved as shown by the intermetallic compounds formed.

The iron in the sherardized coating has an important effect on its *weathering properties*. The writer has found that coatings containing high percentages of iron withstand weathering poorly. The amount of iron in the zinc dust used is also important. If the zinc dust used is high in iron, 2 to 4 per cent, the dust clinging to the coating will turn red when it becomes moist. The writer has found that some manufacturers were unable to turn out as good a coating at the end of the year as when they first installed the process. When the process was new the metallic content of the zinc dust was high, while the iron content was negligible. As the zinc dust was used the metallic content dropped and the iron content of the dust increased due to various causes. The temperature required for sherardizing had to be increased, and as a result the coating became less resistant to weathering.

To obtain the best possible results in service corrosion tests, the sherardizing process has been studied in detail at the General Electric Company. By studying the process in detail the practice was standardized. It was found that in order to secure complete control of the process it was necessary to have complete temperature control and an unvarying quality of zinc dust. Electric heating was found to give the best results.

The zinc dust used consists principally of the so-called "sherardizing zinc," a granulated zinc with an addition of a small proportion of "blue dust" or oxide. It contains from 80 to 92 per cent of metallic zinc. It would be impossible to run "blue dust" with this high metallic content due to its caking. With such a high metallic content the temperature regulation has to be close. The temperature used is about 365 deg. cent.

From time to time the zinc dust is run through a magnetic separator which prevents an undesirable accumulation of iron. A study of their data on sherardizing shows that the specific gravity of the coat, under a certain set of conditions, varies from 1 at 35 per cent of metallic zinc in the dust to 6.75 at 80 per cent. This shows that the coatings obtained under the usual sherardizing conditions are more or less porous, or contain occluded oxides, etc. The specific gravity has a decided influence on the resistance of the coating to corrosion. By means of the salt spray test it was found that only a coating with a density of at least 6.75 would stand up satisfactorily. This means that, if the sherardizing is done with a dust containing less than 80 per cent, the salt water spray test will be unsatisfactory, due to the porosity of the coating.

The article discusses further corrosion tests on sherardizing, removal of zinc dust from coated articles, zinc dust control, and the testing of sherardizing. Of practical importance are the following conclusions arrived at by the author: Sherardizing when carried out properly gives a coating that is highly resistant to corrosion. Sherardizing should be carried out at the lowest temperature economically possible to secure a low iron content in the coating. A zinc dust having a high metallic content will give the best coating. The copper sulphate test gives good results for daily furnace control tests. (*Metallurgical and Chemical Engineering*, vol. 14, no. 12, p. 683, June 15, 1916, 9 pp. *ptcl.*)

Hobbing High Prime-Number Spur-Gears Without Special Mechanism, Will. O. Wynne

The usual clause in almost any description of a modern gear-hobbing machine is "with the exception of prime

numbers." The author describes a method of construction of a machine for hobbing any number of teeth up to 1000. The method is based on the following consideration: Although the prime number cannot be factorized it can be separated into two numbers one of which is less than 10 and the other divisible by 10, the sum of the two forming the prime number. While nothing in the nature of a dividing plate can be adopted in the hobbing machine, the addition and subtraction of continuous motions are easily dealt with by a differential gear and this is what is used in the first place to enable one to cope with the prime-number problem. It is well to remember that although high prime number spur gears may not be in general demand, the introduction of reduction gearing for turbines has rendered the production of high prime-number helical gears almost imperative in order to avoid synchronism and to distribute wear.

The author shows the application of his method to a gear hobbing machine with and without a differential gear, and shows that high prime-number spur gears can be produced on an ordinary gear-hobbing machine without special gearing.

Among the methods of handling this problem the following is of interest because of its comparative simplicity: Any prime number up to 1000 is within 5 of a number which will factorize into factors less than 100; therefore if the driving gear

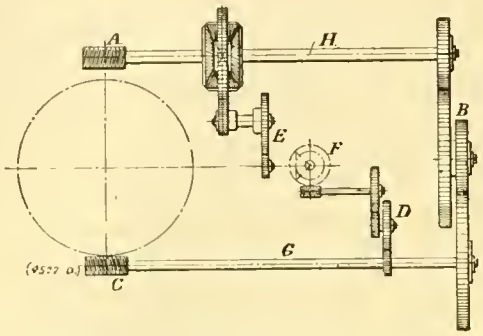

Fig. 5 Hobbing Machine with a Differential Gear in the Hob Drive

can be arranged so as to cut within 5 of the required number and the differential gear used to put on or take off up to 5 revolutions per revolution of the work, then any number up to 1000 can be dealt with.

In Fig. 5, where the worm drives the table through feed gears, E are the spiralling gears leading to the differential gears and so to A. There is no reason whatever why the gears E cannot be arranged of ratios which will impart 1, 2, 3, 4, or 5 additional revolutions to A, or take away that number of revolutions from A for one revolution of the table, altogether independent of the dividing gears B. Assume that it is necessary to cut 617 teeth. The dividing gears are then arranged to cut 620 teeth and by means of the differential gear three revolutions are taken off from the hob per revolution of the table. The spiral lead does not now come into the question at all.

$$\text{Ratio of change gears} = \frac{60}{620} = \frac{24}{80} \times \frac{20}{62}$$

$$\text{Feed gears to screw} = \frac{20}{50} \times \frac{15}{60}$$

Assume equal wheels at E. Let table make one revolution, then revolutions at A with dividing gears B and shaft H stationary =

$$1 \times \frac{60}{1} \times \frac{20}{50} \times \frac{15}{60} \times \frac{1}{15} \times \frac{2}{1} = 0.8 \text{ revolution}$$

Thus equal wheels at E will impart 0.8 additional revolution to A per revolution of table. But it is necessary to subtract 3 revolutions. Therefore, an adverse purchase of gears at E of $3 \div 0.8 = 90 \div 24$ must be introduced, taking care that the direction of rotation of the differential gear is such as will subtract from the motion of H, controlled, if necessary, by an intermediate at E.

$$\text{Dividing gears} = \frac{24}{62} \times \frac{20}{80}\text{; spiralling gears adverse} = \frac{90}{24}.$$

Again, let the table make 20 revolutions.

$$\text{Rev. of } H = 20 \times \frac{60}{1} \times \frac{80}{24} \times \frac{62}{20} = 12{,}400.$$

Revolutions subtracted from H by differential gear in 20 revolutions of table =

$$20 \times \frac{60}{1} \times \frac{20}{50} \times \frac{15}{60} \times \frac{1}{15} \times \frac{90}{24} \times \frac{2}{1} = 60$$

Total revolutions of A = 12,400 — 60 = 12,340. Number of

$$\text{revolutions of hob per revolution of work} = \frac{12340}{20} = 617.$$

It must be pointed out that with the method used the feed enters into the calculations, because, although in itself it bears no important relation to the motions which are operating to produce the spur gears, the gears which lead up to the feed screw form part of the train which is either taking off the spiral from the prime-number gear (in a method described in the article), or, in the method shown above, takes from the hob three revolutions during the one revolution of the table.

An interesting fact is that in the arrangement described which can cut any number up to 1000, less gearing actually is necessary than on a machine arranged to produce the usual limited range. (*Engineering*, vol. 101, no. 2634, p. 591, June 23, 1916, 2 pp., 4 figs. *d.*)

Oil versus Water for Quenching Forgings, C. D. Young.

Data of an investigation made to show the difference between the physical properties of a large forging quenched in water and those of a smaller forging quenched in oil.

The results obtained indicate that there is an advantage in the use of water as a quenching medium, providing proper care is taken in the handling of the steel throughout the process.

The forgings used for this experiment consisted of two 10-in. locomotive driving axles having a center bore 2 in. in diameter extending the entire length. Both axles were from the same melt of steel, and preliminary chemical analysis indicated the same chemical composition. Results of tension tests in which comparison is made with respect to the distance of the test specimens from the axis of the axle, and with respect to the location of the test specimens along the length of the axle, show that the average results are more nearly uniform in the latter case than in the former. This may be due to segregation, as it was found by chemical analysis that the carbon content was not uniform throughout the section. This leads the author to recommend that in all specifications for forgings which are to be heat-treated there be included a

clause to govern the allowable amount of segregation; otherwise it may be expected that extreme segregation will be found, as in the case of the specimens described in the article. (*The Iron Age*, vol. 97, no. 26, p. 1546, June 29, 1916, 2 pp., *el.*)

Mechanics

The Dynamic Balance of Machines, Chas. L. Clarke

The article is in the form of a statement from the consulting engineering department of the General Electric Company, and gives a brief exposition of the fundamental principles of mechanics as related to the phenomena of dynamic balance, as well as the reasons why the question of dynamic balance is becoming more and more important. The writer points out that on top of the refinement in balancing necessary for engineering reasons comes a growing insistence on a condition of reasonable quietude in relation to the operation of machines, which may be expressed as proceeding from a condition of nerves—people are getting more "touchy"; their perceptive faculties for noise and vibration are more acute and more easily upset than formerly; there is jolt and jar and clangor enough without adding to it when avoidable, and with the rapidly increasing use of machines in the home and business places, no noise or vibration of distracting amounts should enter with them, while in the factory where line shafting and belts have been supplanted by motors, the continuous purr of the former must not be replaced by an annoying high-pitch tremble or deep rumble coming from ill-balanced motors. Other things being equal the quiet machine will get the market.

The following is given as practical advice:

When a machine is apparently badly out of balance do not be in haste to condemn it. Look into the conditions of its use and see whether they may not reasonably be so modified as to cause the apparently undue out-of-balance to disappear else it may prove to be largely oneself, from the all-around technical and also commercial point of view, that is in reality out of balance. (*General Electric Review*, vol. 19, no. 7, p. 649, July, 1916, 3 pp. *g.*)

The Critical Speeds of Shafts, W. M. Wallace

Discussion of the whirling speed of shafts, based not on mathematical methods of investigation but on data obtained from actual tests.

The writer objects to an exclusively mathematical method of reasoning. He states that in actual tests he noticed that, for shafts loaded as is usual in actual machines, the whirling frequency was never far removed from the vibration frequency of the shaft when not rotating. The slight difference between the two is due to the gyroscopic action of the masses forming the load on the shaft. This action tends to increase the frequency at whirling. In practice it is usually very difficult to detect this difference, partly because it is very small, but chiefly because other factors such as the effect of the length and play of the bearings are of far greater importance. In the usual mathematical treatment it is this gyroscopic action which looms large while the bearings and other effects are neglected.

If the attached masses are sufficiently eccentric to produce an appreciable whirl when on the critical speed, then the shaft whirls through a range of speeds, and it is not easy to detect exactly when the whirling commences or ends. In fact in practice with actual materials all sorts of things happen. Some shafts do not whirl at all, but have two distinct critical speeds not far removed from each other and on each of which the shaft vibrates transversely. In one case a horizontal loaded shaft freely supported at its ends was driven by a horizontal belt on a pulley mounted in the shaft between the two supports and at a short distance from one support. To limit the deflection of the shaft when at the critical speed, a cast-iron ring encircling the middle of the shaft was firmly attached to a stand. On speeding up a speed was reached at which the shaft commenced to hammer the ring in a vertical direction. At a slightly higher speed this hammering ceased and the shaft ran steadily through a short range of speeds, until it commenced hammering again, but this time in a horizontal direction. At higher speeds the shaft ran quite steadily. If by a whirl is meant the motion of the center of the section in an approximately circular path then that shaft did not whirl. It is not necessarily true either that the true critical speed for a shaft is at the arithmetical mean of the speeds at which whirling commences and ceases respectively. This serves to throw some light on the fact that the critical speed of a motor or turbine when speeding up differs slightly from that observed when running down.

The distortion of the true whirl may be also caused by variations in the elastic qualities of the material of the shaft for bending in different planes, but this is very rarely uniform for a rod or turned shaft.

The author derives his expressions for the critical speed by introducing a term indicating the stiffness of the shaft, which is done through the use of an expression for strain energy

Fig. 6 Vibrations of a Massless Cantilever

in the shaft in terms of the deflection of the shaft under static loading.

Consider a massless cantilever EA, Fig. 6, with the load W at one end supported horizontally by a prop under the load. On suddenly removing the prop, the load falls through a distance y to its statical position of rest C, where it has acquired a velocity v such that $Wv^2 \div 2g = Wy \div 2$. Although the load loses potential energy Wy in falling from A to C, half of this is stored as strain energy in the cantilever. Continuing its downward journey, it comes to rest at B where $CB = CA$. Now v is the velocity of a point in the equivalent circular path of radius y and is, therefore, equal to $2\pi y \div T$ where T is the periodic time. Hence:

$$\frac{Wy}{2} = \frac{4\pi^2 y^2}{2g\ T^2}, \text{ or } T = \sqrt{\frac{Wy^2}{g\ Wy}}$$

With the number of masses on the cantilever at different points, since the sum of the potential energies in the extreme position is equal to the sum of the kinetic energies in mid-position, we must have

$$T = \sqrt{\frac{\Sigma Wy^2}{g\Sigma\ Wy}}$$

All this would apply to a shaft supported at the ends or in any other manner, and since in most cases the whirling time is practically equal to the time of vibration this gives a simple rule for expressing it. The critical or whirling speed is then expressed in revolutions per minute by

$$N = \frac{30}{\pi}\sqrt{\frac{g\ \Sigma\ Wy}{\Sigma\ Wy^2}}$$

the quantity y in the terms $\Sigma\ Wy^2$ and $y\ \Sigma\ Wy$ is the deflection of the shaft at the point at which any load W is applied when statically loaded by the particular systems of load.

The gyroscopic action of the masses attached to the shaft may induce a stiffening couple on the shaft and thereby increase the frequency at which whirling commences. In most cases it is insignificant. In fact the writer's experience shows that in practice so many factors operate to lower the frequency that one welcomes a slight tendency in the opposite direction to balance matters a little. However, if the attached masses have large radii of gyration R about the axis perpendicular to the shaft, and are so situated that a considerable amount of angular momentum is imparted to them when the shaft vibrates, the more correct expression for the whirling frequency is

$$N = \frac{30}{\pi} \sqrt{\frac{g\ \Sigma\ Wy}{\Sigma\ Wy^2 - \Sigma\ Wk^2\ \theta^2}}$$

where θ is the angle that the deflected shaft makes with the line of centers at the point of application of the load. In actual practice it is unnecessary to estimate the gyroscopic term, since, as the author shows, it affects actual results by only a fraction of one per cent.

The large difference between the actual and the theoretical whirling frequencies is due in the writer's opinion to an inaccurate estimate of the length of the vibrating shaft. This is an extremely important factor as the frequency varies as $L^{3/2}$. When a shaft is supported at the two ends only the length should be taken to the extreme outer ends of the bearings for the usual clearances allow of an appreciable deflection of the shaft at the middle of the bearings. (*The Engineer*, vol. 121, no. 3155, p. 495, June 16, 1916, serial article, not finished.)

Power Generation

Diesel Engines vs. Steam Turbines for Mine Power Plants, Herbert Haas

Cheap power is essential to large-scale mining and metallurgical operations, particularly where fine grinding of large tonnages has to be resorted to as is the case with an increasing number of mines treating disseminated copper ores or low grade gold ores. As many of our most important mines are located in sections where neither cheap coal nor water power is available, and the price of oil fuel is increased by long hauls, the Diesel engine will become a prime mover of increasing importance, especially in the Southwestern States where an ample supply of cold water for condensing purposes is unusual and local climatic conditions interfere in securing the high vacua essential to high turbine efficiency.

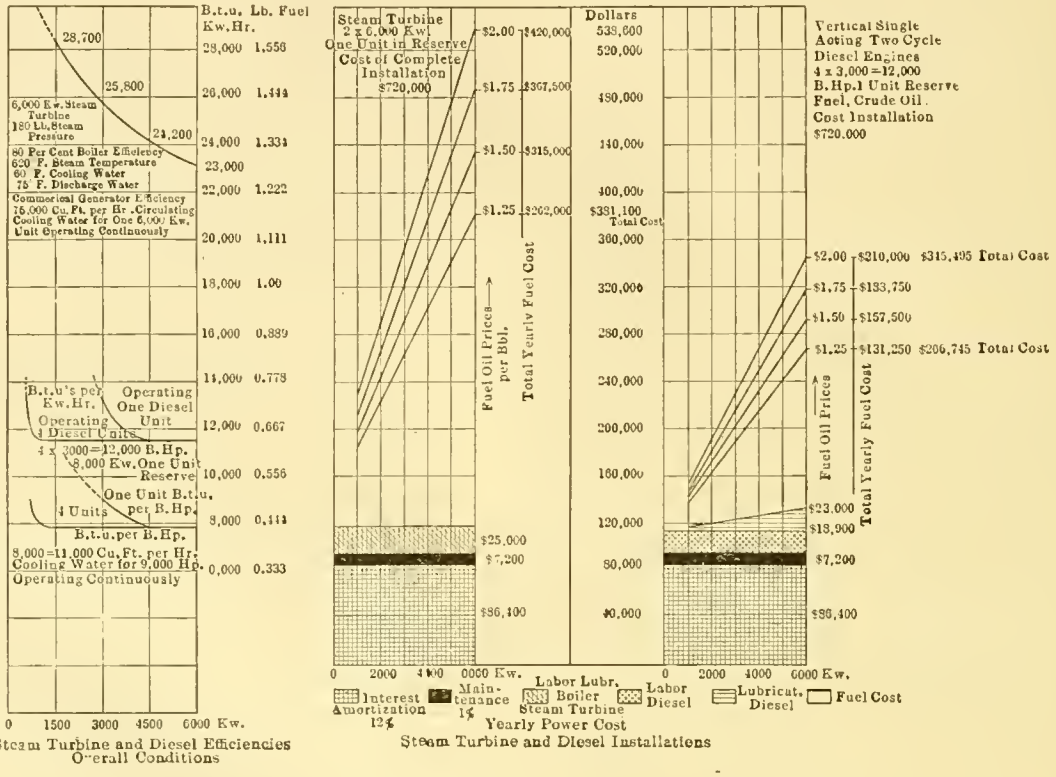

Fig. 7 Comparison of Steam Engine and Diesel Engine Efficiencies and Costs

About twelve times as much water will be required for condensing purposes with steam turbines under general conditions as is needed for jacket-cooling of 2-stroke cycle Diesel engines; 4-stroke cycle Diesel engines require only 1/20 of the cooling water.

Another condition favoring the use of Diesel engines is the high load factor at which most mine power plants operate. The influence of load factor on the cost of generating power is shown in Fig. 7.

The author compares the cost of the power with, on one hand, four 3000 b.h.p. Sulzer Diesel engines direct-connected to alternators and exciters, and on the other hand with two 6000 kw. steam turbines. (The author gives the reasons favoring the selection for purposes of comparison of two 6000 kw. steam turbines and four 3000 kw. Diesel engine generating sets.) The results the author finds are that, with outputs of 70,000,000, 52,500,000, 35,000,000 and 17,500,000 kw.-hr. per

year respectively, a kw.-hr. will cost from 1.0257 for the highest output to 1.6291 cents for the lowest output with steam turbines, and from 0.6045 to 1.0856 cents with Diesel engines.

In general the selection of either type of prime mover will be governed by the following economic conditions:

(1) Fuel is of chief influence on the total cost where both B.t.u. price and load factor are high. By B.t.u. price is here meant the cost for a given number of B.t.u, say 1,000,000, all fuel prices being reduced to this standard of comparison.

(2) Interest and redemption are of chief influence on the total power cost with low B.t.u. price and low load factor.

(3) Steam power will remain the cheapest power wherever waste heat gases are available, as for instance gases from reverberatory smelting furnaces.

(4) Up to capacities of 1000 h.p., steam turbines can compete with Diesel engines only in special cases, such as supplying exhaust steam for heating purposes. For such small units, particularly for greatly varying loads, high-grade reciprocating steam engines are preferable.

In comparing prices of different kinds of fuel such as gas, coal or liquid fuels, it is well to reduce all fuel prices to a common basis of absolute cost for 1,000,000 B.t.u. This, together with the knowledge of the thermal efficiencies of different prime movers, will enable one to arrive at the absolute fuel cost of each per brake horse-power-hour with different kinds of fuel. When a supply of liquid fuel is available, the sound economic application of steam turbines and Diesel engines is determined by fuel prices and load factor. The author gives a diagram (Fig. 8) showing at a glance whether a steam turbine or a Diesel engine power plant is in place with the given fuel price and load factor. The power costs represented by the curves include capacity costs and fuel costs but not operating labor. The latter is about the same for either type of plant, except for very large steam turbine plants which require less operating labor than Diesel engines. The curves marked *quarter load* cover fuel costs for ¼ kw.-yr., or 2,190 kw.-hr., and the same capacity charges as for full load; to arrive at the cost per kw.-yr. (8,760 kw.-hr.) at quarter load, the amount shown in dollars must be multiplied by 4.

The curves for steam turbine plants are based on 12 and 16 per cent efficiency (overall of the entire power plant); the higher figure is secured only with large units in sizes from 10,000 kw. upward.

The cost for lubrication is considerably higher for Diesel plants than for turbine plants, and amounts to from $2.00 to $4.00 per kw-yr., depending on the type of lubricating system used and the care of oilers. In turbine plants this greater expense for Diesel engines is partly balanced by the large amount of water required for condensing, which is 12 to 20 times greater than the supply needed for cooling Diesel engines. Only in plants with units in excess of 6000 kw. have turbines decided advantages over Diesel engine plants. (*Bulletin of the American Institution of Mining Engineers*, no. 115, p. 1171, July 1916, 13 pp., 6 figs. *cp.*)

Railway Engineering

Santa Fe Type Locomotives for the Erie Railroad

Description of two of the most recently developed types of heavy non-articulated locomotives, in each of which, though they are designed for the same service, certain important deviations have been incorporated. An important detail of one of these designs is the provision for lateral motion in the driving wheels, a feature of design not heretofore attempted and put into practice in the so-called "rigid wheel base" locomotive.

The application of lateral motion driving axles and boxes to these locomotives was made for the purpose of reducing the rigid wheel base to that which is in common use on locomotives of smaller capacity, and at the same time securing the advantages of the 10-coupled wheel arrangement with the resulting increased capacity of the locomotive. The driving and rigid wheel-base dimensions of these engines are, respectively, 22 ft. 6 in. and 16 ft. 6 in., well within the figures used on a very large number of Mikado and consolidation locomotives.

The lateral box arrangement consists of two independent

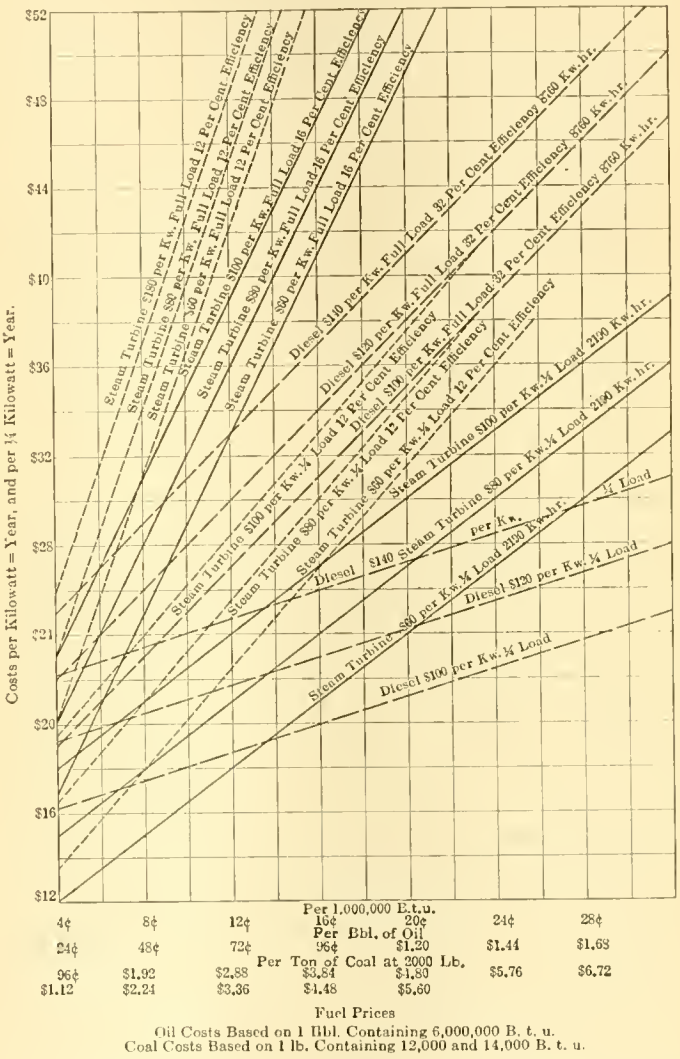

Fig. 8 Diagram Showing Comparative Costs of Steam Turbine and Diesel Engine Plants at Given Fuel Price and Load Factor

driving boxes, whose transverse lateral centers are about on a line with the inside of the main engine frames. When the boxes are deflected by a side movement of the first pair of driving wheels from their normal central position, they and the bridge casting move laterally in reference to the member carrying the springs. This movement deflects the inverted rockers, which offer a definite resistance against the motion. The spring and equalizer work, however, is not shifted from its normal position when the boxes are deflected laterally.

The operation of the lateral motion axle should be considered in connection with the engine truck which is, on this engine, of the inverted rocker type having a resistance of 50

per cent against the initial movement, while the resistance of the lateral device at the first driver is 20 per cent. These resistances are so chosen in relation to the weight coming upon each centering device, that the lateral resultants at the engine truck and the first driver are about the same in amount.

The resistance of the lateral motion box is proportioned with the idea of providing enough initial resistance so that, for any ordinary road service on tangent track or road curves, the first driver will remain in normal position and deflect only when passing through turn-outs and yard curves. The action of the rockers provides a limit to the lateral pressure which can be placed upon the first driving wheel flange, the excess lateral pressure being transferred by the deflection of the boxes to the second pair of drivers. This divides the work of guiding the engine through curves between the truck and the first and the second drivers, instead of between the truck and the first pair of drivers only as in the ordinary 10-coupled locomotive.

The same article describes Baldwin 2-10-2 Santa Fe locomotives for the Erie railroad, with straight boiler 96.25 in. in diameter and a superheating surface of 1389 sq. ft., the latter composed of 48 elements. In this design the Gaines arch is replaced by a combustion chamber which has the effect of increasing the plate heating surface of the fire-box end by 63 sq. ft. (*Railway Review*, vol. 58, no. 24, p. 817, June 10, 1916, 6 pp., 9 figs. *d.*)

The Modern Superheater and Its Performance, S. S. Riegel

The paper describes the application of superheaters especially to locomotive use. The writer points out that as there are now over 16,000 superheaters of the so-called fire-tube type in service in the United States and Canada, this may be called standard equipment on American railroads. At first considerable trouble was experienced with the headers and cracks developed between the unit seats in the lower faces of the headers. This was overcome by a later design providing free movement of the several parts, the so-called loose finger design. Another recent improvement in the American superheater is the substitution of a welded return bend for the old cast-steel form known as the torpedo end.

For the maintenance of a permanently tight connection between the unit and header, the header bolts must have a high elastic limit of about 70,000 lb. and an ultimate strength of over 100,000 lb. per sq. in. This problem has been solved by the use of a special material.

The conversion of existing locomotives to superheater locomotives is discussed mainly from an economic standpoint. In general, the modernizing of existing engines by the application of superheaters has permitted the railroads to keep pace with increased demands, as the change from wood to steel equipment, heavier rails, more exact service, etc. During the year 1915, out of 3667 superheaters applied in the United States and Canada more than 2000 were used on old engines, and as a matter of fact locomotives are today superheated which would not have been considered three years ago. A comparatively recent development is the superheating of switch engines.

As to lubrication, the writer states that it is not sufficient to have lubricators which work uniformly, but drifting steam must be used under automatic control. Results without drifting steam are usually unsatisfactory. The superheater in the present form is very sensitive, but with proper handling and maintenance is giving very satisfactory results. The author advises the use of some instrument like the pyrometer for the proper determination of the amount of superheat in the steam when more reliable records are required.

He concludes by questioning whether the type of superheater so universally used is one which will endure, or if it is to be superseded by a more durable and more efficient type. (*Central Railway Club*, vol. 24, no. 3, p. 137, May Meeting, 1916, 8 pp. *g.*)

Equalization of Long Locomotives

Discussion of the subject of the equalization of long locomotives presented as a report of a committee of which William Elmer, Mem.Am.Soc.M.E., was chairman, before the convention of the American Railway Master Mechanics' Association at Atlantic City, June 20, 1916. The report gives a brief review of early locomotive invention, and then proceeds to develop formulae from which to devise systems of equalization for locomotives of the less complicated types now in use.

The methods followed in working out the actual equalization of the various classes of locomotives depend on the type. The simplest form of wheel base is 0-4-0 or four-wheel switcher. In order to allow the wheels to follow the irregularities in the track without materially changing the loads on the journals, it is necessary to adopt the so-called three-legged stool principle. This involves designing the spring rigging so that the engine frames and all parts attached to them shall be carried on the fundamental points of support commonly called the three point suspension. The author derives formulae for the loads carried by each of the springs at their supports.

The author next discusses locomotives of the 0-6-0 type having six driving wheels and no truck and derives formulae for this case. In the eight and ten driving wheel locomotives with no truck, the spring hangers have to be anchored to the frames between the drivers between which the center of gravity of the spring-borne parts comes. If this point is overlooked there will be danger of some of the wheels not carrying enough weight in case the springs or spring hangers are not properly made and a derailment may occur. He discusses next locomotives of the Mogul, consolidation, decapod and American types, and derives the proper formulae as to loads on supports for each one of these types. From these formulae the weight distribution of any properly designed locomotive can be accurately determined. The writer points out that there are locomotives in service in this country in which the spring rigging has not been properly designed, and these locomotives require constant attention to see that the different axles carry the proper weight. (*Railway Review*, vol. 59, no. 1, p. 12, July 1, 1916, 4 pp. *tm.*)

Draft Gear Committee's Tests on Draft Channels

Abstract of the report of the Draft Gear Committee presented at this year's convention of the Master Car Builders' Association, reporting data of tests made to determine the maximum end force that could be put on the end frames of freight cars without overstraining them. The tests were made at the laboratory of the Union Draft Gear Company, equipped with a 15,000-lb. pendulum hammer so arranged that it can be raised to any desired height and allowed to drop against a 30,000-lb. car that runs on a straight level track.

The method of testing was to mount some form of draft gear and place the car so that the top of the hammer stood against the improvised coupler shank with the pendulum ham-

mer at its lowest point. The hammer was then raised to a desired height by means of a large electric magnet, and the recording drum started with the pencil in contact with the paper. The hammer was dropped and in this way any movement of the car was recorded on the paper, these records being checked by a 10 in. Berry strain gage.

Seven sets of channels were tested, five ordinary and two heavy sets, all 12 in. deep; the five had a weight of 25 lb. per ft. and the two heavy ones a weight of 40 lb. per ft.

The data are presented in the form of tables and curves. It was found that the maximum end force on the 25-lb. channels is approximately 600,000 lb. but that a force of approximately 450,000 lb. will cause the channel to be overstrained. On the heavier channels the maximum of the channel capacity was not reached because the lugs sheared at about 850,000 lb. The overstrained point on the heavier channel was found, however, as lying probably a little over 700,000 lb. It was further found that if a draft gear in a car goes solid before all the energy is absorbed or transmitted to the next car, the pressure is transmitted to the underframe immediately. It took only about 5000 ft-lb. of energy to do it in this case.

It is the opinion of the Draft Gear Committee that a draft gear is needed that will absorb enough of the energy to keep the pressure down below the elastic limit of the sills. The Committee calls attention to the fact that ten rivets were sheared off in two of the tests and that a longer lug with more rivets in it should be provided by the Association in the M. C. B. lug.

(As the *Railway Review* points out in an editorial [June 24, p. 921] a very great saving can be made by using a draft gear of greater ability to do the work rather than increasing the weight and strength of the car end frames so that both the lading and superstructure have to suffer. (*Railway Review*, vol. 58, no. 25, p. 864, June 17, 1916, 4 pp., 6 figs. *eA*).

Steam Engineering

Efficiencies of Steam Prime Movers, Prof. F. O. Ellenwood, Mem.Am.Soc.M.E.

The writer discusses various conceptions of efficiency of steam prime movers, giving in every case attempted definitions of the terms and side by side equivalent terms used in engineering literature, with references to published works where these terms are so used.

The article covers the subjects of the Carnot efficiency, efficiency of the Rankine cycle, and also the Indicated Thermal Efficiency, Brake Thermal Efficiency and Combined Thermal Efficiency, with their equivalents. The discussion comprises also the various efficiency ratios, such as Indicated Efficiency Ratio, Brake Efficiency Ratio and Combined Efficiency Ratio. Fig. 9 gives a bird's-eye view of the terms suggested by the author and their relation to one another. It also serves to show how the three words, *indicated*, *brake*, and *combined*, when applied to the two bases, *thermal efficiency* and *efficiency ratio*, give, without any tax on the memory, a definite and concise expression for each of the six important efficiencies commonly required in engineering practice. The author considers it unnecessary to introduce a term for expressing the relation between the net work of the Rankine cycle and the net work of the Carnot cycle for the same temperature limits (various writers have used for it such terms as *relative efficiency* and *type efficiency*). At the end of the article a brief bibliography is given. (*The Sibley Journal of Engineering, Cornell University*, vol. 30, no. 9, p. 288, June 1916, 6 pp., 1 fig. *te*).

Some Errors in Steam Tables

Some very elaborate and convenient steam tables issued of late years have as their basis certain experimental work carried out in Germany. To the belief of the writer, the compilers appear to have adopted the results of these experiments without sufficient criticism of the methods employed, with the result that their tabulated values of total heats and specific volumes of steam are mutually inconsistent.

The author sees this inconsistency in the following: When steam is expanded adiabatically, the work done can be estimated in two ways. It is equal to the area of the indicator diagram $\left(\frac{144}{J}\int V dp\right)$, and also to the difference between the total heats of the steam in its initial and final conditions. Hence if the tables are correct the two should equal each other, but as a matter of fact this does not hold if the quantities in-

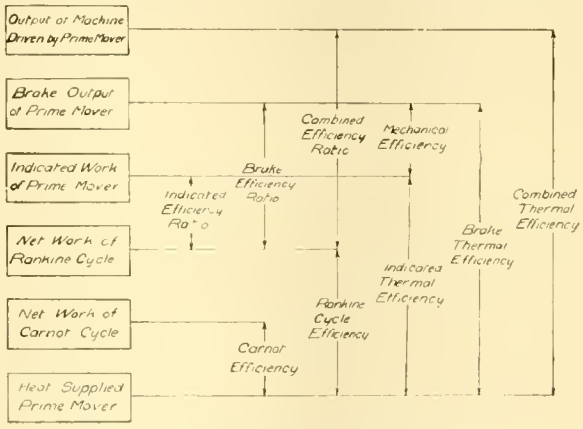

Fig. 9 Diagram Showing the Relation of the Efficiencies of Steam Prime Movers

volved be abstracted from tables based upon the experimental work referred to, as the author shows in examples. He comes to the conclusion that the absolute values of the total heat tabulated are probably materially in error. The author does not specifically mention the tables in which he found these errors. (*Engineering*, vol. 101, no. 2632, p. 545, June 9, 1916, 1 p. *g*.)

High Turbine Economy at Poor Load Factors

High turbine economies have usually been difficult to obtain in small stations operating at poor load factors, because a sufficient number of differently rated generators is not usually installed to permit the operation of such a combination that each machine will carry its full rate of load under all conditions. The introduction of double-nozzle gear-type steam turbines offers one solution to this problem by making it possible to operate these units at almost as high economy below rated load as at full load.

The article gives data of the operation of two small central stations, one at Dowagiac, Mich., and the other at Hoopeston, Ill.

The generating equipment at the Michigan station includes a two-nozzle Westinghouse turbine designed for 150 lb. pressure and 7400 r.p.m., geared 8 to 1 to a 150-kw. three-phase,

60-cycle, 1150-2300-volt, 900-r.p.m. belted-type generator. The turbine operates condensing. The 300-kw. Westinghouse units at Hoopeston are designed for 150 lb. throttle pressure and run 6000 r.p.m. non-condensing. The efficiency is practically the same at one-quarter and one-half load as it is at three-quarters and full load. The nozzles of the turbine at Dowagiac are set to carry equal loads, while in the Hoopeston plant they are set to carry one-third and two-thirds of the total respectively. Because of dissimilar requirements, different adjustments are used at these two plants. At Dowagiac the load is practically fixed. The steam pressure is maintained at 125 lb., which reduces the capacity of one nozzle from 75 kw. at 150 lb. to approximately 60 kw. so that the turbine may be operated with one nozzle at nearly full load, and at any time the capacity of the turbine when operating with one nozzle can be increased to 75 kw. by boosting the steam pressure without resetting the nozzle. This is particularly so as the economy is practically the same at 125 as at 150 lb. steam pressure. At Hoopeston the one-third, two-thirds setting makes it possible to operate the 300-kw. units at almost full-load economy on practically all loads.

The article gives the guaranteed steam consumptions in the form of a table and data on performances in the form of curves. (*Electrical World*, vol. 68, no. 2, p. 66, July 8, 1916. 3 pp., 7 figs. *d.*)

Unit No. 3 at the Northwestern Station, Thomas Wilson

Description of a compound turbine with its auxiliaries installed in the latter part of 1915 in the Northwestern station of the Commonwealth Edison Company of Chicago. The turbine of this machine, which has high and low pressure elements mounted in tandem on the same shaft but in separate casings, is rated at 45,000 h.p. Steam at 230 lb. pressure and 200 deg. fahr. superheat, or at a temperature approximating 600 deg. fahr., is supplied to the turbine. Within the steam chest there are 14 steam admission valves, all under the control of the governor and delivering steam to the upper half of the first stage. There are also four overload valves, each opening simultaneously with one of the last four admission valves. These valves through a series of nozzles discharge steam from the first into the fourth stage. Fig. 10 shows diagrammatically the steam and water piping. Circulating water for the condenser is drawn from the intake tunnel by a 48-in. double suction tri-rotor pump driven directly by a 650-h.p. Curtis non-condensing turbine at 1500 r.p.m. With the pump working at its rating and the condenser at its normal capacity, 72 lb. of water would be supplied per pound of steam. The tremendous size of the installation can be seen from the fact that in a day of 24 hours a total of 74,880,000 gal. of circulating water would be delivered.

Entering the condenser the steam comes in contact with the preheating feed-water tubes, giving up part of its heat before passing into the condensing space proper. The air and condensate are taken from the condenser through a single outlet by a turbo air pump on the same shaft as the circulating pump.

The condensate passes from the heater to the turbine-driven boiler feed pumps, of which there are two and which discharge to the economizers located above the boilers. (*Power*, vol. 43, no. 25, p. 866 June 20, 1916, 3 pp., 5 figs. *d.*)

Lucerne Mines Power Plant, Warren O. Rogers

Description of 12,000-kw. capacity steam turbine plant supplying electrical energy to a group of mines at the Lucerne Mines, Lucerne, Pa. The interest of the plant lies in the fact that bone fuel varying in heating value from 8500 to 12,000 B.t.u. and containing from 20 to 35 per cent of ash is used in the furnaces. The average water evaporated per pound of fuel is about 7½ lb.

The ashes from the furnace ash pits are wetted down and loaded directly into empty coal cars run into position for receiving them.

To burn the bone fuel successfully forced draft is necessary (about 150 tons of fuel are burned each 24 hours). The draft is supplied by two 11-ft. diameter, 5 ft. 3 in. wide semi-inclosed fans, each driven by a 13-in. x 16-in. horizontal engine at a maximum speed of 225 r.p.m. An air pressure of from 2 to 2½ in. of water is maintained.

There are two 3000-kw. turbines of an older design and one

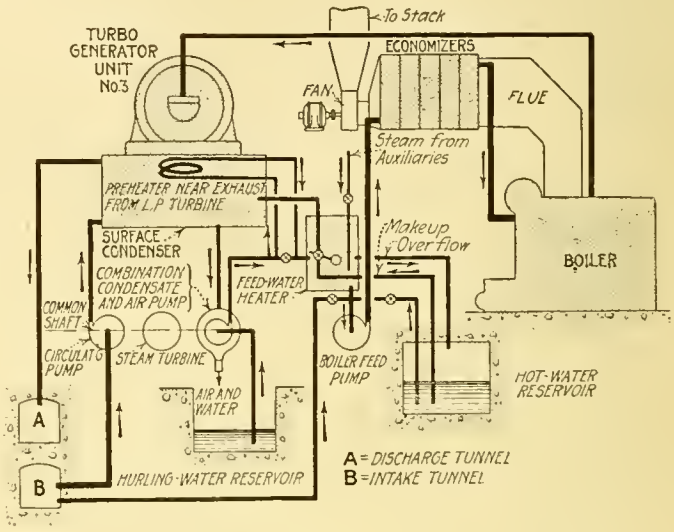

Fig. 10 Diagrammatic Sketch of Steam and Water Piping of the 45,000-h.p. Turbine Installation at the Northwestern Station, Chicago

6000-kw. unit new. Significantly, the new unit having a capacity equal to the other two machines occupies practically the same floor space, and when running with a 5000-kw. load will save the steam that can be generated by one of the 500-h.p. boilers over what would be consumed if the same load were being carried by the two smaller units. (*Power*, vol. 44, no. 2, p. 42, July 11, 1916, 4 pp., 4 figs. *d.*)

Steam Power Plants for Aeroplanes, Robert Cramer, Mem.Am.Soc.M.E.

Description of the Winslow boiler, a watertube boiler of the circulating type, constructed entirely of steel tubing. It consists of a number of individual sections, each connected at the bottom to a common mud drum, and at the top to a common steam drum.

Operating pressures in the Winslow boiler have been frequently carried to 600 lb. per sq. in., and in special cases as high as 1500 lb. (*Journal of the Aeronautical Society of America*, vol. 1, no. 3-4, p. 28, March-April 1916, 4 pp., 4 figs. *d.*)

Classification: *c*, comparative; *d*, descriptive; *e*, experimental; *g*, general; *h*, historical; *m*, mathematical; *p*, practical; *s*, statistical; *t*, theoretical; *A*, special merit.

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ESTABLISHING A STANDARD OF MEASUREMENT FOR NATURAL GAS IN LARGE QUANTITIES

By FRANCIS P. FISHER, BARTLESVILLE, OKLA.

Member of the Society

THE original business of natural gas handling and selling was confined to the discoverer, or owner, taking the gas from his own wells through his own pipes to various purchasers, and supplying them, in consideration of certain fixed monthly payments, with all the gas they could use. This eliminated the whole problem of gas measurement.

Some twenty years ago this simple and effective solution became impossible because of its extravagance, and the familiar domestic meter of the artificial gas business was slightly modified to take care of the domestic and small industrial consumer of natural gas. The operation of these meters is based on actual displacement from alternate filling and emptying chambers, and is comparatively simple. Where properly cared for and installed, these meters have given continuous measurements well within the commercial limits of required accuracy over long periods of time.

The discovery of new gas fields has been practically a continuous process, and many fields were opened up in the vicinity of towns previously piped for artificial gas. In time, selling contracts were made between the owners of gas wells and the artificial gas companies already equipped to serve domestic consumers, the sale of gas being effected at the town border. Also, large industrial consumers were connected up to gas lines and took gas in quantities too large to measure by the standard type of meter, leading to suggestions of many devices for taking care of the measurement of these larger quantities.

Today, approximately two and a half million people in this country make or receive a monthly settlement based on the measurement of natural gas. The gas must be handled from its original location in the gas-bearing rock strata to its point of consumption without being seen or weighed. The basis on which the gas changes ownership at various periods during its handling consists of indications on dials and charts of various apparatus; and in numerous cases where the faith of one or both parties in these indications is insufficient, the quantity of gas which has changed owners must be settled by arbitration and compromise.

AVAILABLE MEANS OF MEASUREMENT

While very accurate, the large wet meters used for station meters at the producing plants of artificial gas companies, by reason of size, cost and care required for operation, were not adapted to the much larger quantities of lower-priced gas handled in the new industry. The measuring devices suggested to meet this problem, up to within the last three or four years, were of three general classes: *a* proportional meters; *b* pitot tips in ordinary pipe lines; and *c* calibrated tubes containing pitot tips.

The proportional meter is simple and ingenious in principle. The gas passing through this meter is divided automatically into a large and a small channel, each having a definite ratio of resistance to the gas flow, so that the quantities of gas passing through the two channels have a fixed ratio, varying from 1/50 to 1/200 according to the size of the meter. The smaller quantity is measured by an ordinary domestic meter with a multiplying dial register.

If the gas to be measured had been a clean, pure, perfect gas, it is probable that proportional meter records would have been satisfactory. However, to the initial mechanical difficulties of devising such a meter were added difficulties caused

SYNOPSIS

This paper deals with the methods employed by a company operating over 1200 miles of pipe lines in the mid-continental gas field, in establishing a standard of measurement for natural gas in large quantities.

After pointing out the commercial importance of such a standard, the author describes the various available means of measurement—proportional meters, pitot tips in ordinary pipe lines, calibrated tubes containing pitot tips, the Thomas meter, the orifice meter, etc., stating their respective advantages and shortcomings. He then takes up a specific problem of loss in the system mentioned, and in selecting a point of attack, chooses the large-capacity measurements with orifice meters as promising quicker results for a given amount of work, and for the reason that such meters do not involve delicate mechanism or the employment of complex formulae.

Some serious inconsistencies which developed after the first two months' operation were attributed to fundamental error of some kind in the principle employed, and the basic assumptions of the method were accordingly subjected to verification in several ways, the quantity of gas metered being taken as equal to the sum of the gas lost by leakage, the gas added to or taken from line by change of pressure, and the gas compressed.

All of the orifice calibration work has been compiled and plotted in a chart which gives the velocity coefficient for all sizes of pipe on a basis of ratio of diameter of orifice to diameter of pipe, and the author believes that the fair curve through the plotted points gives values that may be safely applied to any practicable size of pipe line; they are now actually in use on the system in question.

In the course of the work it was found necessary to develop a differential recording gage to eliminate certain operating difficulties, the outcome being a special type of mercury float gage, particulars of which are given in the paper.

It has been found impossible to obtain accurate measurements with a pulsating flow of gas, this being particularly true when the pulsations are rhythmic, as in the vicinity of compressor stations. As numerous attempts to measure under such conditions have been unsuccessful, efforts are now being directed toward the elimination of pulsation, and one device which seems promising is described.

In the discussion, the attitude and regard for scientific accuracy displayed by the author's company were commended, and attention was called to the fact that two independent sets of investigations as to the variation of natural gas from the laws of perfect gases are now in progress. The hope was expressed that some body, such as the Society, working in conjunction with the Bureau of Mines, the Bureau of Standards, the state universities and others, would correlate the work of various investigators and establish uniformity in the constants or coefficients, in the types of apparatus to be used in the determination of specific gravity and measurement of gases, and in differential pressure-recording instruments.

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by dust and sand from the rock formation, water, salt, oil and gasoline from the wells, dirt left in the pipes when the line was laid and small bits of debris from the same source, including occasionally portions of carcasses of animals that ventured into the lines during construction, and in winter time, quantities of hoar frost forming on the inside of the pipe line, and moving along with the gas whenever the temperature rose sufficiently to loosen the frost from the pipe. The number of competent men in this country today, trained to adjust and calibrate these meters, is wholly inadequate to secure a continuous and satisfactory record of the gas to be measured. The best condition for proportional meter operation is in the distribution plant, a long distance from the fields, where the gas has passed many drips and cleaning devices and is comparatively clean. The most unpropitious location is in the fields close to the wells.

The pitot tube furnishes a more certain and dependable method of measurement of very large quantities, and has been widely used in various forms. There are two general types of installation: The first consists of inserting pressure and velocity tips in the ordinary pipe line through a tap made for the purpose, assuming an average velocity at a given distance from the circumference (taken at various values by different

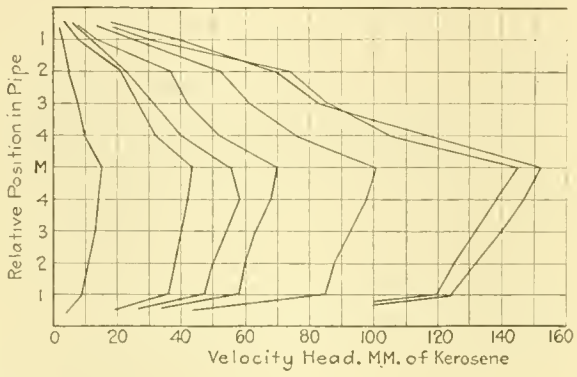

Fig. 1 Pitot Tube Traverse, 8-In. Pipe

writers). The quantity of gas passing is measured by observing the difference of pressure between static and velocity tips, and calculating the quantity passed by the fundamental pitot tube formula $V = \sqrt{(2gh)}$. The fundamental weakness of the formula is that a different and unknown coefficient should be applied to each individual installation to take care of the slight variation from nominal diameter and the effect of roughness of the pipe. The coefficient is also modified by irregularity of velocity in the same zone, shown by the erratic results obtained in different pipe traverses where the velocity tip (or both tips) is stationed progressively at regular intervals across the diameter of the pipe, and observations plotted to show the variations in velocity at different distances from the center. (See Fig. 1.)

The second and more refined form of installation of the same instrument—for many years considered the standard for large-quantity measurements—consists of tubes of polished brass carefully compared with similar standardized tubes and the coefficients determined by experiment. This instrument has been fully described by Thos. R. Weymouth[1] and B. C. Oliphant.[2]

[1] Measurement of Natural Gas, T. R. Weymouth, Trans. Am.Soc.-M.E., vol. 34, p. 1091.

[2] Proc. Nat.Gas.Assn. of America, vol. 4, p. 212.

These tubes at their best are capable of giving very close results. They are calibrated by experiment individually, and each one, therefore, is liable to have a coefficient varying slightly with the personal equation of the man making the test. In actual practice the tubes are occasionally found not to run harmoniously in tandem on the same quantity of gas. Only recently have satisfactory differential gages been devised for recording automatically the observed differential pressures used in the formula for computing the quantities. It was, therefore, found necessary to have these meters installed at regular 24-hr. operating points and the gage readings recorded generally at 15-min. intervals by observers, thus bringing another personal equation into the result. The long piping usually installed from these tubes to the observing station would show a material effect on the indication from small leakages. In many cases also it was found that sand or salt lodged against the velocity opening, partially or wholly closing the exposed tip, again affecting materially the indication without the knowledge of the observer. In one case a small tin can hung itself neatly over the velocity tip and put an important measuring station temporarily out of commission.

MORE RECENTLY SUGGESTED MEANS OF MEASUREMENT

In the last few years additional standards of measurement which promise a distinct advance have been proposed. The Thomas electric meter[1] operates on the most ingenious principle of imparting a small quantity of heat to the gas electrically, and maintaining a constant temperature increase between the incoming and outgoing gases. The quantity of gas is directly calculated from the quantity of heat supplied, as measured by the electrical input necessary to furnish the heat. This meter has the great advantage of being theoretically accurate without a specially calibrated coefficient, and also of working independent of the pressure at which the gas passes, giving in effect a measurement of mass. The question arises, however, as to the adequacy of available data on the specific heat of gas of widely varying composition and with daily changes in specific gravity. Its installation involves considerable expense per unit as compared with other types.

The so-called orifice meter is another comparatively recent suggestion. This well-known principle of flow of fluid through a thin-edged orifice is very simple of application to pipe lines, and seems to give promise of good results; but there has been great difficulty in securing recording gages delicate enough to retain their accuracy and rugged enough to keep in continuous operation under severe field conditions,—occasionally withstanding excessive pressures, either forward or backward.

The venturi meter has also been applied to some large and important measurements. The comments above apply practically to the venturi meter with the exception that the range is somewhat wider, the cost of installation is considerably heavier, and a true formula is more complex.

The rotary station meter, quite generally adopted in artificial gas plants, has also been applied recently to a comparatively few installations.

Very delicate and complex apparatus that has proved successful for steam meters in expert hands is wholly impractical under the rough conditions of natural gas measurement.

With the meter difficulties enumerated, for many years most of the gas companies did not attempt a complete measurement of the gas produced from their own wells until it reached the

[1] J. C. Wilson, Proc. Nat.Gas.Assn. of America, vol. 6, p. 219.

point of consumption and sale. But, while the extravagance of the ultimate consumer has been soundly and properly eliminated by selling him gas in measured quantity, the loss of gas between the producing wells and the consumer remains hidden, owing to difficulties of measurement.

Due to various causes, however, in many fields the tendency in recent years has been towards the separation of the ownership of the wells from that of the great pipe-line systems connecting the producing fields with ultimate markets. This has raised an imperative call for field measurement, involving financial settlement, for large quantities of gas taken at the wells. The result is that the comparison of the amount of gas purchased and sold has been forcibly emphasized by its financial aspect, with very surprising results in many cases, showing enormous unaccounted-for losses of gas.

To avoid the difficulty of large quantity measurement, many contracts for sales have been made with separate distribution companies having pipe-line systems, where the supplying company takes a percentage of the domestic meter sales. Thus, the losses in towns themselves were not generally realized. Instances have developed where from 35 per cent to an extreme of 80 per cent of all gas entering town distributing systems appears as unaccounted for in meter sales, and some large pipe-line systems have discovered overall losses approximating 50 per cent of all gas entering the system. In fact, it was discovered recently that losses in excess of 25 per cent are the general rule rather than the exception.

A SPECIFIC PROBLEM OF LOSS

Some three years ago the writer became associated with the reorganized management of a natural gas piping system in the Mid-Continent field, comprising something over 1200 miles of main lines with corresponding field and distributing plants. In the course of investigations preparatory to outlining a general policy, there was discovered between purchase and sales a loss of gas which seemed wholly unreasonable and the elimination of which would be the shortest and most effective road to early increase of earnings.

The total loss could be made up from losses from six possible causes:

1 Leakage of field lines
2 Leakage of main lines
3 Leakage in distribution systems
4 Errors in large-capacity meters
5 Errors in domestic meters
6 Errors in estimates of unmeasured gas

The first step in eliminating this waste was to provide an accurate gas measurement at strategical points, for segregating the leakage so that the repair work could be made efficient. Manifestly, the first problem was that of large-capacity meter installation, and with part of our losses possibly due to meter inaccuracy, the first step was the establishment of a definite standard of accuracy in meters. The work done to establish this standard has been continued by a technical staff for approximately two and one-half years at considerable expense. It has now passed the second phase of installing measuring stations to segregate and locate definitely the remaining leakage losses.

Meanwhile, repairing of the most evident weak places and reduction of 95 per cent of our purchase and 75 per cent of our larger sales to standard bases, have reduced the unaccounted-for losses about one-half, and we are prepared to get after the more difficult remainder with more efficient tools and better promise of quick results. The matter of critical study of domestic meters, believed to be the final step in this campaign, is reserved until other corrections and improvements are initiated and in operation.

POINT OF ATTACK

In selecting a point of attack, the large-capacity measurements were chosen as promising quicker results for a given amount of work. The small-capacity meters as now operated are more reliable, but the number is so great that improvement through checking these meters would necessarily be slow.

In connection with large-capacity measurement, a catalog of the weaknesses and objections to all known and available methods has been given earlier in the paper. It was determined that the relative objections be weighed and one of the systems chosen as a standard to be developed to a closer de-

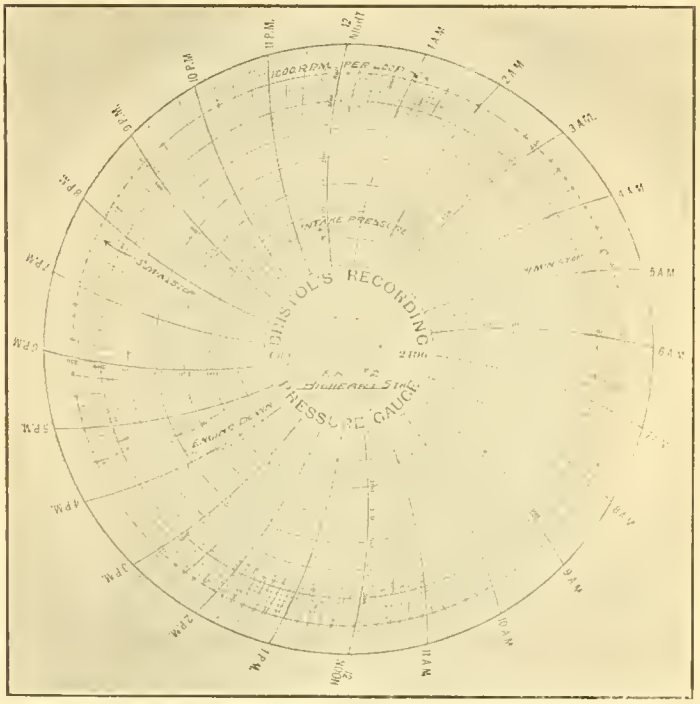

Fig. 2 Chart of Revolutions of Compressor and Intake Pressure

gree of accuracy than heretofore available. The method chosen for development was the orifice meter, in the belief that the objections to the existing types could be overcome at less cost and more simply than in any of the others. Further consideration was the absence of delicate mechanism, and the simplicity of the formula. There is no question but what any one of the other methods of measurement is capable of an equal degree of refinement, but the present paper is chiefly concerned with the work actually done on this one type of meter.

In order to give the work a sound foundation, it was considered necessary to establish a standard of reference entirely independent of existing meter indications, and a 250,000-cu. ft. capacity artificial gas holder at Joplin, Mo., was taken as a reference quantity. This part of the work has been described concisely and accurately in a paper presented to the Society in December, 1915, by E. O. Hickstein. Some 500 standardized flows were made, covering a period of nearly a year, for establishing a wholly independent and authoritative coefficient which could be relied on in actual service. This work was con-

fined to various-sized orifices in 8 and 10-in. pipes, inasmuch as the quantities to be measured first were large and would necessitate such installations.

In the meantime, while these calibrations were being made, the manufacturers of differential recording gages were urged to perfect and deliver recording differential gages having a range of zero to 50 in. water pressure, and operated by an iron float in a mercury U tube. These gages were finally perfected and delivered about the time of the completion of the Joplin tests, and about twenty of the most important installations were made in rapid succession.

ORIGINAL CONSTANTS CALLED IN QUESTION

With the results of these installations, after the first two months' operation some serious inconsistencies appeared which were attributed to fundamental error of some kind in the principle being employed. We considered it necessary at once to verify the following basic assumptions not previously experimented on.

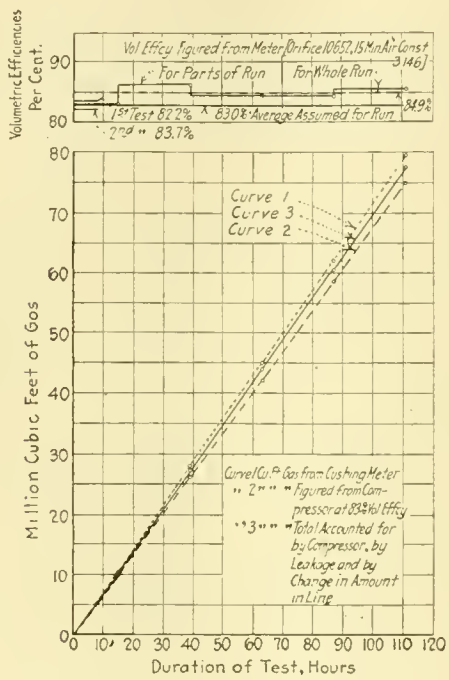

FIG. 3 CURVE SHOWING NET RESULTS OF PUMP STATION DISPLACEMENT TESTS

First Assumption. Coefficients determined by experiments with differentials of 4½ in. of water or less, representing velocities of less than 100 ft. per min., are constant with velocities up to 300 ft. per min., represented by differentials up to 50 in. of water, which were utilized in actual service.

Second Assumption. Coefficients determined at atmospheric pressure are constant and unchanged by static pressures up to 365 lb. absolute.

Third Assumption. Coefficient determined with air at point of saturation is applicable to natural gas by applying correction for specific gravity.

Fourth Assumption. Natural gas is a perfect gas, having pressure and volume relations according to Boyle's law.

The work of verifying these assumptions was undertaken in three ways. The first was by a careful comparison under operating conditions of orifice meter registration with a calibrated compressor displacement.

WORK TO ESTABLISH CONSTANTS

There was available at Bigheart, Okla., a compressor station consisting of three duplex units of about 950 h.p. rating twin-tandem gas engines, each driving two double-acting compressor cylinders with poppet valves, only one engine being used in the test.

Fifty miles distant, near the north end of the Cushing field, was located a measuring station with a 10-in. orifice meter containing a disk with 6½-in. opening. The dimensions of the intervening lines are:

Nom. Diam., In.	Actual I.D.	Area, Sq. In.	Area, Sq. Ft.	Length	Capacity, Cu. Ft.
18 O.D.	17.375	237.10	1.646	42,091	69,300
16 O.D.	15.375	185.66	1.289	79,823	102,900
10 I.D.	10.192	81.585	0.5661	6,747	3,822
12 I.D.	12.250	117.860	0.8185	84,549	69,190
12 O.D.	1 .4316	102.636	0.7125	28,947	20,630
			Tota Cu. Ft.		265,742

The first factor to be determined was the leakage. The line was filled to about 300 lb. and closed in. After the pressure had equalized, the pressures were carefully taken at half-hour intervals until the pressure reached 270 lb. Then the compressors were started and the pressure reduced to 230 lb. After the pressure was equalized again, the pressures were taken as before. In this way the leakage was determined at a number of points, approximately 280, 225, 165, and 115 lb., giving the same results that would have been obtained by allowing the whole volume of gas to leak out. Fig. 4 gives a graphical representation of the pressure log during the leakage test. Fig. 5 was derived from Fig. 4 by plotting to a large scale and drawing a fair curve through the resulting points to eliminate errors in gage readings. Then the rates of drop at various pressures were plotted. To determine rate of leakage at any pressure, multiply line volume by drop in pressure per hour and divide the result by 14.41, which will give the cubic feet of gas leakage per hour.

After determining the leakage as shown in the curves in Figs. 4 and 5, one of the compressor units was carefully overhauled to secure good valve and packing ring conditions. An automatic counter equipped with indicating chart was mounted on the secondary shaft with a pressure spring automatically recording the intake pressure of the compressor cylinders, tracing a line on the same chart. This gave a chart as shown in Fig. 2, in which the outer loops each represent 1000 revolutions. The line was filled and shut in at both ends and allowed to equalize. The compressor was started and the intake pressure held constant by regulating a gate on the station intake. Fifteen-minute readings were taken on all gages and thermometers. The total and intermediate numbers of revolutions of the compressor were taken from a revolution counter. The line pressure being taken at the start and finish of the test, the volume of gas taken from the line would equal the initial pressure minus the final pressure divided by 14.41,

the result multiplied by the line volume. From this the leakage was deducted, leaving the volume of gas taken by the compressor. With the proper temperature corrections, the volume of gas taken by the compressor divided by the cylinder displacement during test, equals volumetric efficiency. Two reliable tests were made, and the average of the two results was taken as the final figure. The results of two such runs were as follows:

	August 4, 1914	August 5, 1914
Time of Start	8 : 35 : 30 a.m.	8 : 52 : 15 a.m.
Time of Stop	12 : 09 p.m.	1 : 10 p.m.
Duration of Test	213½ min.	258 min.
Average Intake Pressure, lb. per sq. in	121.5	122.3
Average Intake Temperature, deg. fahr	81	81
Revolutions during Test	22,445	27,085
Average rev. per min	105	105
Cylinder Displacement per Revolution, cu. ft	13.496	13.496
Cylinder Displacement for Test, cu. ft	2,859,543	3,447,034
Average Line Temperature, deg. fahr	80	79.5
Correct Line Pressure { Start, lb. per sq. in	258.25	289.75
Correct Line Pressure { Stop, lb. per sq. in	127.75	129.50
Drop in Line Pressure during Run, lb. per sq. in	130.50	160 25
Rate of Leakage at Average L.P., lb. per hour	0.98	1.01
Drop of Pressure due to Leakage, lb. per sq. in	3.43	4.34
Drop in Pressure due to Pumping Out, lb. per sq. in.	127.0	155.91
Effective Drop in Atmospheres	8.81	10.82
Volume of Line, cu. ft	265,742.0	265,742.0
Gas Taken from Line by Compressors, cu. ft	2,344,643.0	2,875,328 0
Corrected to Intake Temperature, cu. ft	2,345,544.0	2,886,829 0
$\frac{\text{Gas from Line}}{\text{Compressor Displacement}}$ = Vol. Efficiency	82.2%	83.7%

Average Volumetric Efficiency = 83.0%

Following this determination gas was drawn through the measuring station, and under test conditions the compressor and meter were operated in tandem for 111 hr. divided into 5 periods. In this test all conditions at Bigheart were practically the same as during the volumetric efficiency test. The Cushing end of the line was opened and the line filled until

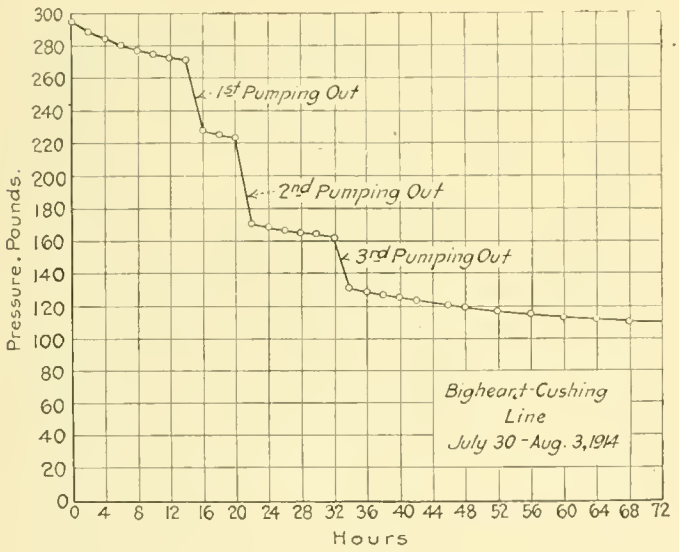

Fig. 4 Pressure Log During Leakage Test

the pressure at Bigheart was above 125 lb. Then the engine was started, and after running conditions were constant the test was started and continued for 5 days. Half-hourly readings were taken at both ends of the line. With the exception of the first period, the results were worked up in twenty-four hour periods. Figures for a typical period are as follows:

THIRD PERIOD OF RUN

4:00 p.m., August 8, to 4:00 p.m., August 9, 1914.

Leakage and Change of Line Pressure during Test:

Bigheart 167 lb. to 178 lb. = 11 lb. increase

Cushing 210 lb. to 218 lb. = 8 lb. increase

Assumed average increase = 10 lb.

Cushing average Pressure 214 lb.

Bigheart average Pressure 173 lb.

41 lb. $41 \times \frac{2}{3} = 27.4$.

173 + 27 = 200 lb., assumed average Line Pressure.

Rate of Leakage at 200 lb. from Test Curve = 0.97 lb. per hour or 23.3 lb. per 24 hours.

Volume of Line = 265,742 cu. ft.

$\frac{10 + 23.3}{14.41} \times 265{,}742$ = 613,000 cu. ft. metered but not compressed.

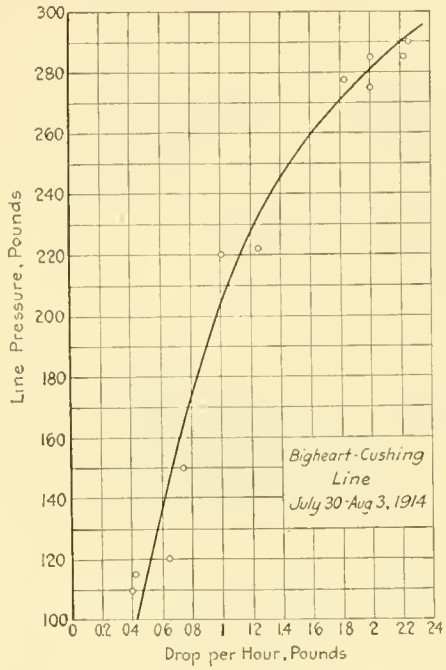

Fig. 5 Pressure Log During Leakage Test

COMPRESSOR CALCULATIONS

Average Intake Pressure, 123 lb. Average Intake Temperature 82° F.

Displacement per Revolution = 13.496 cu. ft.

Revolutions during Test = 151,899. R.P.M. = 105 3.

$151{,}899 \times 13.496 \times \frac{122.5 + 14.41}{14.41}$ = 19,420,000 cu. ft. displaced at 100% Volumetric Efficiency.

Average Volumetric Efficiency from Test = 83%.

19,420,000 × 0.83 = 16,120,000 cu. ft. of Gas pumped at 14.41 lb. and 82° F.

16,120,000
613,000

16,733,000 cu. ft. = amount of Gas accounted for at 14.41 lb. and 82° F.

METER CALCULATIONS

15-Minute Air Coefficient at 14.41 lb. and 60 deg. = 3.146 per M.

Specific Gravity of Gas during Test = 0.714

$\frac{3.146}{\sqrt{(0.714)}}$ = 3,725 = 15-Min. Coefficient for Gas at 14.41 lb. and 60° F.

Average Meter Temperature = 82° F.

Sum of Extensions for Test = 2240.551.

2240.551 × 2 = 4481.102, extensions for 15-Min. Coefficient.

3.725 × 4481 = 16,690,000 cu. ft., Quantity that would pass meter with a meter temperature of 60° F.

16,690,000 × √(520/542) = 16,350,000 cu. ft. of Gas at 14.41 lb. and 60° F. with Meter Temperature of 82° F.

$16{,}350{,}000 \times \frac{542}{520}$ = 17,045,000 cu. ft. at 82° F.

COMPARISON

$$\begin{array}{r} 17{,}045{,}000 \\ 613{,}000 \\ \hline 16{,}432{,}000 \end{array}$$

$$\frac{16{,}432{,}000}{19{,}440{,}000} = 84.6\%, \text{ Volumetric Efficiency of Compressor as shown by Meter.}$$

$$\frac{17{,}045{,}000}{16{,}733{,}000} = 101.8\%$$

The object of this test is to account for the gas metered by the Cushing meter through orifice No. 10,652, using the meter coefficient determined by the Joplin experiments and the recording pressure and differential gages that are in use at the Cushing station. The factors entering into the comparison, for a certain interval of time, are: quantity of gas metered; quantity lost by leakage; quantity put into or taken out of

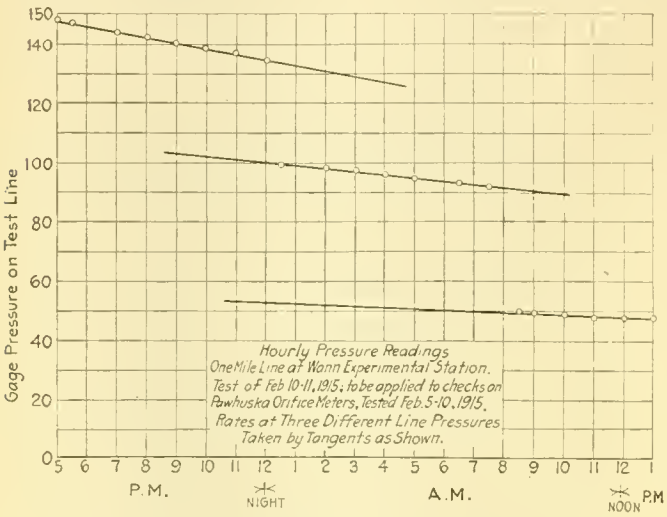

FIG. 6 HOURLY PRESSURE READINGS IN WANN TESTS

line by change in line pressure; and quantity taken from line by compressors.

$$\text{Quantity of gas metered} = \left\{ \begin{array}{l} \text{Gas lost by leakage} \\ \text{Gas added to or taken from line by change of pressure} \\ \text{Gas compressed} \end{array} \right.$$

All gages and thermometers used were calibrated.

The final result of this comparison is illustrated graphically by Fig. 3, in which the net result of a comparison of the compressor station with the orifice meter shows a constant difference of approximately 2 per cent. Following this test a continuous comparison was carried on by checking monthly totals to secure information as to the consistency of this agreement over a long period of time. At other points these monthly checks were carried on by means of the pipe-line flow formula proposed by Thos. R. Weymouth in a paper read before the Society.[1] For instance, during the month of June, 1915, the amount of gas through the Cushing-Bigheart line compared day by day showed a total compressor station displacement of 377,110,000 cu. ft., using the same volumetric efficiency found by the test. The total orifice meter reading for the same period was 382,480,000, an excess of $1\frac{1}{3}$ per cent. A check of another orifice meter measuring gas through a line consisting of 5.59 miles of 8-in. inside diameter and 9.23 miles of 10-in. inside diameter line gave a flow, by Mr. Weymouth's formula for drop in line pressure, of 333,420,000; and the orifice meter gave totals for the same month of 338,900,000 cu. ft., an excess of $1\frac{1}{2}$ per cent. The pressure in the last two comparisons ranged from 200 to 290 lb. Leakage allowances were made in each case on the same basis as referred to and shown in Fig. 5, for one of these lines.

WANN DISPLACEMENT TESTS

The pump-station and line-flow checks gave approximate corroboration in certain specific instances of the value of the coefficient determined at Joplin, but it was admittedly necessary to get a verification covering as wide a range of pressures and differentials as possible. For this purpose we chose a section of line running from Caney, Kan., to a point near Wann, Okla., which was not in use at the time, and was located so that it could be filled with gas at any time up to a pressure of 250 lb. The dimensions of this line were:

1 From Wann-Portland to 12-in. gate, 1 mile west, 1/23/14.

5,236 ft. of 12-in. ($11\frac{1}{2}$ in. I.D.)	$\times$ 0.7213 =	3,776.73 cu. ft.
286 ft. of 10-in. I.D.	$\times$ 0.5476 =	156.61 cu. ft.
48 ft. of 8-in.	$\times$ 0.3474 =	16.67 cu. ft.
Total volume between 12-in. and 8-in. gates	=	3,950.01 cu. ft.

2 From Wann-Portland to 18-in. gate, $3\frac{1}{2}$ miles west.

2,554 ft. of 18-in. ($17\frac{5}{16}$ in. I.D.)	$\times$ 1.6347 =	4,175.00 cu. ft.
18,554 ft. of 12-in. ($11\frac{1}{2}$ in. I.D.)	$\times$ 0.7213 =	13,383.00 cu. ft.
286 ft. of 10-in.	$\times$ 0.5476 =	156.61 cu. ft.
48 ft. of 8-in.	$\times$ 0.3474 =	16.67 cu. ft.
Total volume between 18-in. and 8-in. gates	=	17,731.28 cu. ft.

3 From Wann-Portland to 18-in. gate at Caney, Kan., station.

17,776 ft. of 18-in. ($17\frac{5}{16}$ in. I.D.)	$\times$ 1.6347 =	29,058.4 cu. ft.
Total of No. 2	=	17,731.28 cu. ft.
Total cu. ft. in line	=	46,789.68 cu. ft.

There were three gates on the line, so located that the latter could be used as a reservoir having a computed volume of either 46,730, 17,670 or 3,950 cu. ft., according to the size of the meter to be tested. Careful leakage tests were run on the various sections of this line. Figs. 6 and 7 show the leakage on the smallest division at different line pressures. In making these leakage tests, care was taken to seal the gates at each end of the section in use and drain the line beyond the gate at each end through an observed opening to prevent unknown leakages in, or out, through the gate valves. This station was connected up as shown in the diagram, Fig. 8, so arranged that gas from this reservoir was allowed to escape through three orifice meter flanges in tandem, one 8-in. and two 10-in. It was then led through a reducing valve manipulated by an operator, and through a section of line about 300 ft. long to a large discharge chamber, Figs. 9 and 10. This chamber consists of an initial space containing a series of conical baffles to break up eddies in the current, and a second chamber of larger dimensions with an additional baffle having at the outlet end a large flange for conveniently changing the outlet plate. These plates had a central orifice through which gas was discharged to the air by a head in the discharge chamber, maintained as near an absolute constant as possible for giving a test run. This head was observed at one-minute intervals by a sensitive inclined draft gage, and a second similar draft gage attached to the same line was near the man who regulated the reducing gate. This manipulation was carefully controlled to maintain this head as nearly uniform as possible.

[1] Problems in Natural Gas Engineering, Trans. Am. Soc. M.E., vol. 34, p. 185.

It was the aim to maintain a uniform rate of flow from start to finish of each run, although with a wide variation in pressure and differential on the orifice meters in series. Temperatures were taken at each succeeding point on the line and corresponding corrections made. This work was continued from June 20 to the end of September, 1914. Nearly 1200 determinations of coefficients were made. For the purpose of showing the factors taken into consideration, a portion of the complete record of a typical day's run on September 27, 1914, is here given. The disks installed in the flanges that day were:

Flange A. Disk 10,503, 5-in. orifice in 10-in. line
Flange B. Disk 10,402, 4-in. orifice in 10-in. line
Flange C. Disk 8,409, 4-in. orifice in 8-in. line

Table 1 gives the observed data for determining the amount of gas escaping from the reservoir in the six successive runs, and the specific gravity of the gas in each instance.

The following is a key to the symbols used as summaries of readings and calculated values, as tabulated in Table 2, in regard to the Wann displacement tests.

Column number	Symbol	DESCRIPTION
1	h	Observed differential drop in in. of water, across meter orifice disk
2	P_c	Gage reading (P), corrected to calibration
3	P_a	Corrected gage reading, lb. absolute
4	$\sqrt{(hP)}$	Calculated square root of the product of h and P_a
5	R_1	Calculated rate flow, expressed in cu. ft. per 15 min., at average line temperature and standard barometric pressure B of 14.41 lb. per sq. in. This value is based on the average rate of displacement and corrected for variations in prover temperature
6	T_p	Observed temperature of gas at prover
7	T_m	Observed temperature of gas at orifice meter
8	R_2	Calculated value of R_1 reduced from average line temperature to observed orifice meter temperature
9	C_m	Calculated 15-min. meter constant, for gas at temperature T_m. Found by dividing R_2 (column 8) by $\sqrt{(hP)}$ (column 4)
10	C_g	Cm corrected to 60 deg. fahr.
11	C_a	Calculated 15-min. meter constant, for air at standard condition of 14.41 lb. per sq. in. absolute, and 60 deg. fahr.

Table 2 gives the actual observations for determining the meter constants. The significant results of this series of observations is column 11 giving the air constant for each of the disks tested.

A study of the results of this work led to the belief that assumptions 1 and 2, *ante,* were not perfect, and that it would be necessary to provide means for using a variable factor instead of a constant heretofore applied on orifice meters.

Inasmuch as the number of records to be computed in ordinary operation is so great, the considerable clerical labor involved could not be put in the hands of technical men, and it was deemed advisable to devise a slide rule which could be continually used with a variable factor in accordance with the pressure and differential shown at different points on the chart.

Fig. 11, developed in collaboration by Prof. P. F. Walker, is a series of curves showing results of the entire tests segregated as to differential and pressure, with a view to the determination of the available factor to be used if a variable coefficient should become necessary.

QUESTION OF AN IMPERFECT GAS

Assumption 3, *ante,* that the coefficient determined for air would apply for gas, and assumption 2, in part, that coefficient determined at low pressure would apply for high static pressure, were called in question in a paper read by Prof. P. F. Walker before the Society.[1] It was therefore deemed necessary to pursue the work suggested by him at that time to a conclusion, which could be used as a basis of calculation. In consultation with Professor Walker it was decided to inaugurate simultaneously analogous experiments in the University of Kansas laboratory and at the Wichita Natural Gas Company's laboratory in Bartlesville. Independently and simultaneously, S. S. Wyer, of Columbus, and Robert F. Earhart, working in the laboratories of the Ohio State University, were conducting similar experiments. Up to the present time the findings in these three series of tests are somewhat diverse and not yet ready to submit. The final conclusion of this re-

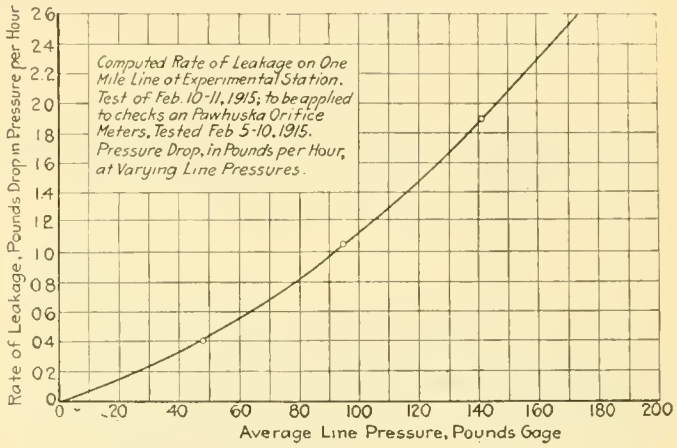

FIG. 7 COMPUTED RATE OF LEAKAGE IN WANN TESTS

TABLE 1 READINGS AND RESULTS OF DISPLACEMENT CHECKS

Small and Large Provers in Tandem with Three Meter Orifices (Nos. 10,503, 10,402 and 8,409)

September 27th, 1914. 12-in. Gate, one mile west of station, shut. Computed Volume, 3,950 cu. ft.

(Barometer, 29.60 In. Hg. Specific Gravity of Gas, 0.696)

No. or Size of Prover Orifice	Time, Start and Finish	Duration of Test, Min.-Sec.	Corr. Line Pressures, Start and Fin.	Quantity in Cu. Ft. at Line Temperature				Temperature of Line	Avg. U Tube, In.	Avg. Prover Temp.
				Gross for Entire Test	Leakage for Test	Net for Entire Test	Net for Fifteen Min.			
3605	1:22:00 1:05:35	16-25	218¾ 71	40,490	350	40,140	36,690	70	4.43	72
3005	2:06:00 1:45:55	20-05	225¾ 71¾	42,190	420	41,770	31,200	70	4.17	75
2705	3:42:45 3:10:55	31-50	230¼ 3	62,250	570	61,680	29,060	68	4.19	77
16 in.	4:54:15 4:46:20	7-55	220 30½	51,920	140	51,780	98,170	68	2.74	65
12½ in.	5:36:50 5:23:05	13-45	214¼ 13¼	54,930	230	54,700	59,670	66	2.76	66
12½ in.	6:08:30 5:53:10	15-20	207¾ 13¾	53,160	240	52,920	51,790	65	2.04	63

[1]Physical Laws of Methane Gas, Trans. Am.Soc.M.E., vol. 36, p. 781.

search will be of great importance to the natural gas industry, and will determine finally the necessity for a variable coefficient in orifice and pitot meter determinations.

PROBLEM OF SPECIFIC GRAVITY

A very important factor hitherto unmentioned is that of specific gravity. Below are given gravity determinations in three different fields taken at several months' intervals, and a series of simultaneous gravities in seven different fields:

North Osage Gravities		Cushing Gravities		Lot 51	
Jan., 1914	0.585	May, 1914	0.640	Mar., 1915	0.597
Sept., 1914	0.635	Nov., 1914	0.6995	May, 1915	0.603
Nov., 1914	0.653	March, 1915	0.7505	Oct., 1915	0.627
April, 1915	0.647	Oct., 1915	0.695		

Simultaneous Gravities

Sycamore Field	0.5765	Pawhuska Field	0.630	Chilocco Field	0.6925
Local Iola Field	0.590	Augusta Field	0.666	Sedan Field	0.765
Humboldt Field	0.601				

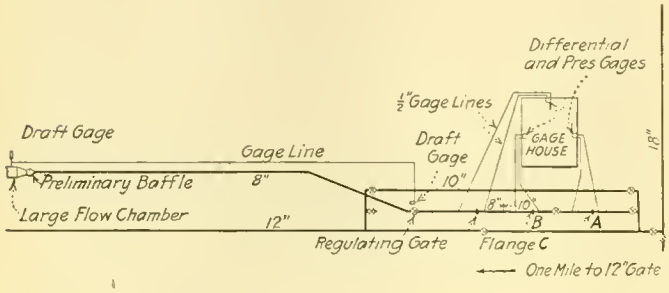

Fig. 8 Wann Testing Station Connections

In actual practice, gravity determination of gas at a given purchase meter frequently affects a correction in the monthly settlement of from $3000 to $8000, as compared with the gravities taken a month or two previous, or an estimated gravity such as is frequently used. The method of determining this specific gravity with diffusion instruments is rather a delicate manipulation. Even with experienced operators results are liable to vary with the same sample, and it is of great commercial importance to eliminate this uncertainty. It was, therefore, considered necessary to develop a type of gravity determining apparatus which would give approximately accurate and consistent results in the hands of inexperienced and unskilled manipulators, and finally, at the suggestion of W. C. Baxter, a method was proposed using apparatus shown in Fig. 12. The principle involved is simple, consisting of an indicating balance with a beam carrying opposed weights of widely different volume. This balance is enclosed in a chamber with observation glasses at the ends. The balance is adjusted to equilibrium with the chamber filled with air. The air is then completely expelled by a flow of gas and the gas pressure increased in the chamber until the balance is again at equilibrium. The specific gravity is determined by the relative absolute pressure of air and gas necessary to secure the same buoyancy, as shown by indicating balance. The apparatus, even in the crude form shown, seems to be quite sensitive enough to improve materially our gravity records and to involve the personal equation to but a slight degree.

NEW TESTS WITH AIR AT ERIE

A subsequent series of calibrations was run in 1915 to supplement the large capacity meters previously developed by the addition of a series of relatively small capacity meters in 6-in. and 4-in. pipe. The reference quantity chosen for this work was a small holder located at the testing plant of the Metric Metal Works, Erie, Pa., which was courteously loaned to the company's technical staff for the purpose. Check tests were

TABLE 2 WANN DISPLACEMENT TESTS, SEPTEMBER 27, 1914

Large Prover in Tandem with Three Meter Orifices. One Mile of 12 in. Line Used

Disk No. 8,409; Flange C

1 h	2 P_c	3 P_a	4 $\sqrt{(hP)}$	5 R_1	6 T_p	7 T_m	8 R_2	9 C_m	10 C_g	11 C_a
12 in. Orifice: B = 29.60 in.; Line Temperature 66°; Average Prover Temperature 66°; Average Flow, 59,670 Cu. Ft.; Gravity of Gas, 0.696										
11.20	197	211.50	48.62	59,440	70	69	59,790	1.229	1.219	1.017
12.05	185	199.50	49.01	59,560	68	69	59,910	1.222	1.212	1.011
12.82	175	189.50	49.25	59,610	67	68	59,850	1.215	1.206	1.006
13.97	162½	177.00	49.70	59,670	66	68	59,910	1.204	1.195	0.997
15.02	147½	162.00	49.30	59,730	65	68	59,970	1.214	1.205	1.005
16.71	132½	147.00	49.53	59,790	64	67	59,910	1.208	1.200	1.001
18.40	119¼	133.75	49.53	59,790	64	67	59,910	1.208	1.200	1.001
20.14	108	122.50	49.65	59,790	64	66	59,790	1.204	1.197	0.998
22.73	96	110.50	50.10	59,790	64	66	59,790	1.193	1.186	0.989
27.72	75¾	90.25	49.97	59,790	64	66	59,790	1.196	1.189	0.992
38.61	51½	66.00	50.42	59,790	64	66	59,790	1.185	1.178	0.982
46.05	41½	56.00	50.73	59,790	64	66	59,790	1.178	1.171	0.976
Small Prover in Tandem with Three Meter Orifices. One Mile of 12 in. Line Used Disk No. 8,409; Flange C										
No. 3605 Orifice; B = 29.60 in.; Line Temperature, 70°; Average Prover Temperature, 72°; Average Flow, 36,690 Cu. Ft.; Gravity of Gas, 0.696										
3.81	207¼	221.75	29.03	36,580	75	74	36,860	1.268	1.252	1.044
4.22	191¼	205.75	29.41	36,620	74	74	36,900	1.252	1.236	1.031
4.47	182¼	196.75	29.61	36,620	74	73	36,830	1.243	1.228	1.024
4.63	176	190.50	29.68	36,650	73	73	36,860	1.242	1.227	1.023
4.95	162	176.50	29.52	36,690	72	72	36,830	1.247	1.233	1.028
5.25	153¼	168.00	29.88	36,690	72	72	36,830	1.241	1.227	1.023
5.74	143¼	158.25	30.11	36,730	71	70	36,730	1.220	1.208	1.008
5.92	136	150.50	29.80	36,760	70	70	36,760	1.232	1.220	1.017
6.34	125¾	140.25	39.80	36,800	69	70	36,800	1.232	1.220	1.017
7.49	108¾	123.25	30.39	36,830	68	70	36,830	1.212	1.200	1.001
8.08	100	114.50	30.39	36,830	68	70	36,830	1.212	1.200	1.001
9.56	82	96.50	30.37	36,870	67	70	36,870	1.214	1.202	1.003

also taken with 8-in. and 10-in. pipe-line orifices; in all about 130 determinations were made, covering the orifices tabulated on the next page.

Table 3 gives data for determination of leakage in the holder and lines. This gives a leakage correction factor for these tests. Table 4 gives the dimensions of the holder. Table 5 is a recapitulation of the derivation of the formula used in determining the air constant in this series of tests. Table 6 is a specimen sheet showing a summary of determinations made on various orifices in 6-in. pipe. The following is a key to the tabulation employed in Table 6 on page 689:

KEY TO TABULATION IN TABLE 6

1st Column.	Heading: Number of Disk	
2nd Column.	Feet Drop of Holder	Each foot drop is equivalent to displacement of 200 cu. ft.
3rd Column.	Time in Sec.	Taken by stop watch.
4th Column.	T_h	Temperature of holder air, deg. fahr.
5th Column.	T_f	Temperature of flowing air, deg. fahr.
6th Column.	H	Differential across disk, inches of water.
7th Column.	P	Absolute pressure, in lb. per sq. in. on inlet side of disk.
8th Column.	C_a	Fifteen-minute air constant for disk.
9th Column.	C_v	Velocity coefficient, per cent.
	P_h =	Holder pressure (lb. per sq. in., absolute).

ORIFICES USED IN ERIE TESTS

No. of Disk	Size of Pipe, In.	Size of Orifice, In.	No. of Disk	Size of Pipe, In.	Size of Orifice, In.
4051	4	0.506	6204	6	2.002
4071	4	0.755	6302	6	3.003
4103	4	0.996	6401	6	4 000
4123	4	1.250	8101	8	1.010
4154	4	1.500	8205	8	2.006
4174	4	1.754	8304	8	3.006
4205	4	1.997	8451	8	4.500
4223	4	2.251	8506	8	5.005
4251	4	2.504	10151	10	1.500
4301	4	3.002	10302	10	3.007
6101	6	1.002	10451	10	4.502
6151	6	1.502	10601	10	5.999

PRESENT STATUS OF COEFFICIENT

All the orifice calibration work, up to and including the Erie tests, has been compiled and reduced to a basis shown in Figs. 13 and 14, showing the velocity coefficient for all sizes of pipe plotted on a basis of the ratio of diameters of orifice to diameters of pipe in Fig. 13, and on a basis of the ratio area of orifice to internal area of pipe opening in Fig. 14. This shows the degree of variation under the conditions of the different tests, and the solid black line is an averaging line on which coefficients for actual use at the present time are based.

It is the belief of the author that this value may be safely applied within the limits of accuracy shown by the curve to any practicable size of pipe line without further question. The number of experiments which are incorporated in it, and the great variety of conditions under which it has been developed, have practically eliminated any personal equation of observational error of any individual test or series of tests.

TABLE 3 LEAKAGE TEST, AUGUST 7, 1915

The readings and calculated results given here show Leakage Test made to ascertain rate of leakage from holder, so proper allowance could be made. This test was started about noon on a Saturday and ran until early Monday morning.

Time

Start	11:30 a.m.	Aug. 7, 1915.
Finish	7:00 a.m.	Aug. 9, 1915.

Readings	Temperature of Holder, Deg. Fahr.	Reading of Tape
Start	70	26.0
Finish	71	25.85

Leakage (without any allowance for change of temperature during test): 0-15 ft. drop in 43½ hr. This is equivalent to 0.0115 cu. ft. per min. Leakage (with temperature corrections made): 0.0130 cu. ft. per min.

TABLE 4 CALCULATED VOLUME OF HOLDER, AUGUST 10, 1915

Measured Diameter of Holder Top (Outside).
16′ 0.5″; 16′ 0.1″; 15′ 11.8″; 15′ 11.9″; 15′ 11.7″;
16′ 0.1″; 15′ 11.7″ and 16′ 0.0″

Average	15′ 11.975″
Allowance for thickness of metal, 2 thicknesses of No. 16 gage iron,	0.125″
Inside Diameter,	15′ 11.850″
or 15.988 ft.	

Calculated area = 200.76 sq. ft., which means that one foot drop of holder displaces 200.76 cu. ft. The nominal capacity is 200 cu. ft. per ft. drop; the actual capacity is therefore ⅜ of 1 per cent above the theoretical.[1]

Measured Circumference of Holder

Near Top	50′ 3¾″
Near Middle	50′ 4″
Near Bottom	50′ 4½″

[1] This error of ⅜ of 1 per cent in holder capacity is ignored in the calculation of all tests given in this report. It exactly counterbalances an error of ⅜ of 1 per cent in stop watch.

When the exact data are available as to the factor which must be applied to Boyle's Law for gases of differing composition, it is now apparent that the observational points slightly off the curve in Figs. 13 and 14 will be brought still closer to agreement, and we shall have then the necessary data to apply intelligently a variable coefficient if it is found desirable. With the slide rule mentioned earlier, it would be no more difficult to make routine meter calculations with a variable than with a constant coefficient.

TABLE 5 DERIVATION OF GENERAL FORMULA FOR CALCULATING HOLDER TESTS ON ORIFICE METER DISKS

Subscript "o" means standard conditions of pressure and temperature, i.e., 60 deg. fahr. and 14.41 lb. per sq. in.

Subscript "h" means actual conditions of air or gas in holder. This will vary from day to day, even for the same holder.

Assuming Flow Temperature of 60 deg. fahr.

$$Q_o = C_a\, hP \text{ for air} = \frac{C_a}{6}\, hP \text{ for gas.}$$

At any Other Flow Temperature T_f,

$$Q_o = \frac{C_a}{6}\, hP \frac{520}{T_f} \quad Q_h \times \frac{520}{T_f} \times \frac{P_h}{14.41} = Q_o$$

$$Q_h \times \frac{520}{T_h} \cdot \frac{P_h}{14.41} = \frac{C_a}{6}\, hP\, \frac{520}{Tf}.$$

$$C_a = Q_h \frac{T_f G}{hP} \frac{P_h}{Th} \frac{520}{14.41}.$$

In this general formula derived above, there are substituted special values for reducing quantity and time of test, giving

$$C_a = 284.6 \frac{\text{Tape Difference (in ft.)}}{\text{Number of Sec.}} \frac{P_h}{T_h} \frac{T_f}{hP}$$

RECORDING APPARATUS

It was found necessary to develop a differential recording gage to eliminate certain operating difficulties which resulted in loss of record over considerable proportion of the time for most of the meters in service. The difficulties to be eliminated were:

a rupture of spring from overload in spring type gages

b erratic calibration in spring type gages

c retarding of indicating needle by stuffing-box friction in all types.

d loss of mercury through leakage in mercury float type recording gages, resulting in derangement of zero level of mercury and false reading

e loss of mercury through stuffing box, same type gages and same difficulties.

f blowing over of mercury into pipe line with strong flow of gas in same type of gages.

All these difficulties resulted in loss of record from the time any of the enumerated troubles occurred until a trained attendant could again visit the station and restore the gage to normal condition.

A type of mercury float gage was suggested by H. O. Ballard, superintendent of lines for this company, and has been gradually developed step by step to overcome the various difficulties enumerated. This gage (Fig. 15) is so built that when the gas pressure exceeds the range of the gage the mercury level in the concentric manometer leg drops below the opening at *a*, Fig. 15, and a free flow of gas is permitted without violently disturbing the body of mercury, so that when the pressure again drops within the limits of the gage the fluid returns to normal registering position and the operation of

Fig. 9 Outflow Chamber with Separate Orifice Plates

the gage goes on correctly. The stuffing box is far from the mercury body, and a large chamber above the mercury with a baffle at the top prevents the splash of the mercury through to the outlet pipe. A small automatic check is inserted in the line, close to the gage, which will allow a gentle flow of gas but shut off with any violent current in either direction by the raising of a light ball to the "choke" position. There is also installed a small mercury separating chamber on the high-pressure line to prevent loss of mercury by a back flow.

A convenience for eliminating occasional error caused by using the wrong pressure chart with a given differential record consisted of installing the pressure spring in the same apparatus and concentric with the stuffing box of the differential gage, so arranged that differential and pressure records appear on the same chart, using one color of ink for the pressure and another for the differential. This reduces the number of clocks required and allows the installation to be made with simpler piping.

LIMITATION AS TO RANGE

All large-capacity gas meters have maximum capacity limits which must be made sufficient to take the greatest flow to be measured. The minimum limits are not so definite.

In all the types enumerated the accuracy deteriorates at the minimum limits. In the orifice meter the degree of accuracy is apparent on inspection of the chart, for the reason that the resulting percentage of error occasioned by falsely estimating the position of the differential line becomes a much greater factor in the result as the total differential pressure diminishes. In other words, an error which in a 10- or 12-in. differential might be negligible, would be an important factor of a 1-in. differential. As a result, with our 50-in. range recorders, we consider the practical limits of capacity to have a ratio of about one to four.

We keep a supply of all size orifices on hand and make frequent changes to keep the gages operating at their most accurate range. Some installations have hour-to-hour variations which run beyond the limits of this ratio, and to avoid

TABLE 6 SUMMARY OF ERIE TESTS ON 6-IN. ORIFICE METER DISKS

August, 1915

1	2	3	4	5	6	7	8	9	
Date, 8-17-15: Barometer, 29.4 in. P_h = 14.63.									
6302	6	231.0	531	529	4.645	14.57	0.5677	72.8	73.0
6302	6	232.7	531	529	4.56	14.57	0.5692	73.0	
6302	6	253 5	531	529	3.86	14.54	0.5676	72.8	
6204	4	367.9	531	529	5.17	14.59	0.2253	65.0	
6204	3	292.2	531	529	4.37	14.57	0.2313	66 6	
6204	3	317.5	531	529	3.685	14.55	0.2315	66.9	
6204	4	365.5	531	529	5.17	14.59	0.2252	65.0	
6204	3	276.2	531	529	5.115	14.59	0.2255	65.0	
6204	3	290.5	532	531	4.43	14.57	0.2312	66.9	
6204	1	94.7	532	531	4.855	14.58	0.2256	65.3	
6204	1	95.6	532	531	4.61	14.58	0.2294	66.4	
6204	1	94.6	532	531	4.74	14.58	0.2293	66.4	
6401	8	166.1	532	530	3.12	14.52	1.286	92.7	93.0
6401	8	169.7	532	530	2.98	14.51	1.291	93.0	
6401	8	194.3	532	530	2.26	14.49	1.296	93 3	
6401	8	165.6	532	530	3.13	14.52	1.289	92.9	
6151	1.450	239.8	532	531	5.295	14.59	0.1239	63 6	64.0
6151	1.343	240.6	532	531	4.465	14.58	0.1243	63.8	
6151	1.135	240.4	532	531	3.19	14.52	0.1245	63 9	
6151	1.070	240.5	532	531	2.84	14.51	0.1245	63 9	
Date, 8-18-15: Barometer, 29.4 in. P_h = 14.63.									
6101	1	384.2	528	527	5.29	14.60	0.05345	61.6	61.9
6101	1	425.0	528	527	4.35	14.56	0.05331	61 6	
6101	1	470.4	529	528	3.55	14.53	0.05326	61 6	
6101	1	556.9	529	528	2.54	14.48	0 05332	61 6	
6101	1	652.0	529	528	1.815	14.45	0.05397	62.3	
6204	1.7	154.6	530	529	5.19	14.60	0 2278	65 7	
6204	1	94 6	530	529	4.69	14.58	0.2306	66 7	
6204	1	98.6	531	529	4.30	14.57	0.2306	66 7	
6204	1	105.1	531	529	3.715	14.55	0.2325	67.4	
6204	1	111.7	531	530	3.28	14.54	0.2330	67.5	
6204	1	121.6	531	530	2.765	14.52	0.2334	67 6	
6204	1.2	165.7	531	530	2.165	14.51	0.2326	67.4	
Date, 9-2-15: Barometer, 29.6 in. P_h = 14.71.									
6204	6.3	573.0	532	530	5.16	14.71	0.2278	65.7	
6204	3.5	356.0	532	530	4.05	14.67	0.2305	66 7	
6204	2.0	235.0	532	530	2.99	14.60	0.2325	67.4	
6204	1.4	202.4	532	530	1.99	14.58	0.2323	67.3	
6204	1.0	195.8	532	530	1.09	14.55	0.2313	67.0	
6204	1.2	199.7	532	530	1.49	14.56	0.2333	67.7	
6204	1.2	245.5	532	530	1.00	14.55	0.2315	67.1	
6204	1.2	219.6	532	530	1.235	14.56	0.2331	67 6	
6204	1.4	267.4	532	530	1.12	14.55	0.2345	68 0	
6401	7.9	161.4	535	533	3.14	14.63	1.304	93 9	
6401	7.7	158.0	535	533	3 12	14.63	1.301	93 7	
6401	6.8	156.8	535	533	2.505	14.61	1 296	93 3	
6401	6.3	172.0	535	533	1.82	14.59	1.285	92.6	

the cost of constant attendance of an operator a convenient apparatus has been devised for automatically changing from one size orifice to another without personal attention. The installation in the pipe line consists of a large revolving plate, pierced by several orifices of different sizes, which may be shifted to come in succession concentric with the pipe. This apparatus is actuated by an automatic shifter deriving its power from the pressure of gas in the line and controlled by a diaphragm operated by trip valves so that the disk will

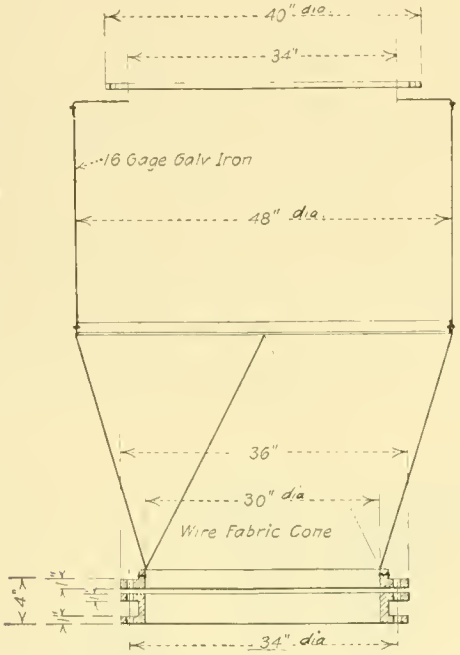

Fig. 10 Outflow Chamber with Separate Orifice Plates

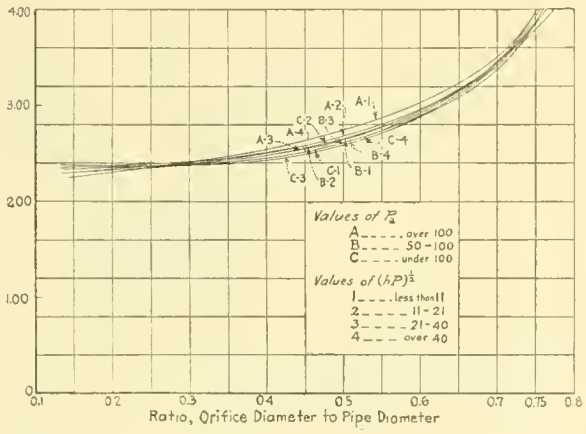

Fig. 11 Curves Analyzing Wann Coefficients

be shifted to the next larger orifice when the maximum differential reaches a predetermined value, say 40-in., and will be shifted to the next smaller orifice when the differential reaches a minimum predetermined value, say 4 or 5 in. This shift makes a sudden and unmistakable jump in the chart, which is readily interpreted. Whether or not it will be necessary to use a third pen on the chart which will trace a line indicating which orifice is in service, will be determined by actual operation.

PULSATION OF FLOW

One problem at present unsolved is obtaining correct measurement with a pulsating flow. This is particularly true where the pulsations are rhythmic, as in the vicinity of compressor stations with reciprocating compressor pistons. An orifice meter early installed at such location failed to check with the station or with meters some 17 miles away on the same line. In endeavoring to locate the difficulty a series of recording gages was installed, both with and without devices for damping out the pulsations in the lines leading to the gages. There were finally connected in parallel a spring recording gage, a mercury float gage of the type originally installed, a Ballard recording gage as described above, and a water U tube. These gages were all calibrated in unison, and agreed very well under condition of steady flow. When the compressor station was started the gages took widely varying positions; some dropped

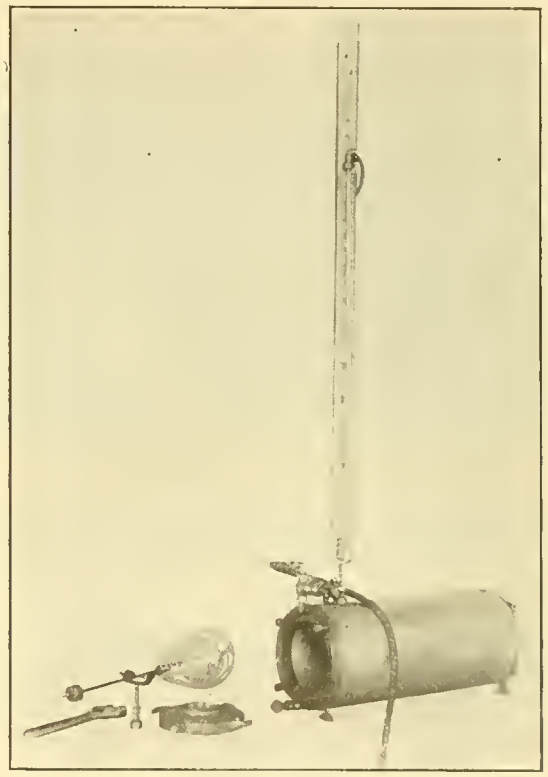

Fig. 12 Baxter Gravity Apparatus

down to half their former reading despite the increased flow, one took a negative reading as though the flow were reversed and the water column took a wholly indeterminate condition of churned foam; some of the gages moved about in an erratic way and others gave steady indications, but wholly unrelated to the quantity of gas. A proportional meter installed in tandem at this point gave over a period of months a record erratic and irreconcilable as compared with pump station displacement, line-flow formula or meters 17 miles away operating on the same gas with steady flow.

Similar disturbances in the accuracy of the record are occasioned by irregular pulsations resulting from the action of fluid in the line. Disturbances are particularly serious when occasioned by irregular or imperfect action of automatic pressure regulators in the vicinity of the meter. After many unsuccessful attempts to solve the problem of measuring under these conditions, our efforts are now bent on eliminating pulsa-

tion. One attempt is shown in Fig. 16, where a device was installed ahead of a compressor station with the idea of dividing the gas into about 20 different streams and make each stream traverse a path of different length so that the wave motion from different parts of the cycle would be made to interfere at the point where the gas was again brought to a common line. This was almost successful, and it is believed that by a little further calculation and change of arrangement to secure more perfect interference a measurement at this point may be secured.

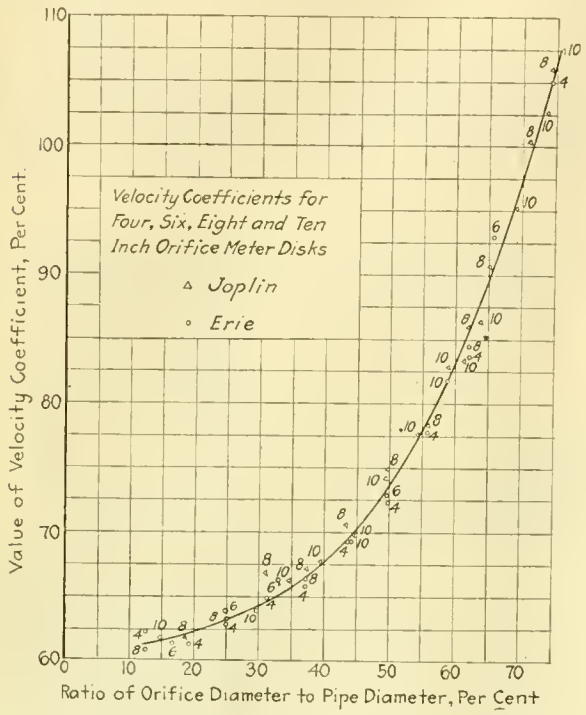

Fig. 13 Velocity Coefficients for Orifice Meter Disks Based on Ratio of Diameter

Pulsations due to fluid and imperfect regulators are obviously questions of simple correction, by separators, drips and mechanical repairs.

CONCLUSION

In conclusion the writer wishes to acknowledge the loyal, able and enthusiastic service of the technical staff entrusted with carrying out these experiments, particularly Mr. E. O. Hickstein, Jun.Am.Soc.M.E.

Much of the apparatus referred to has been suggested by members of this staff, as follows: *a* Fundamental concentric U tube recording gage, Mr. H. O. Ballard; *b* Gravity apparatus and safety device for recording differential gage, Mr. W. C. Baxter; *c* Automatic orifice shift, Mr. J. P. Fisher, Mem. Am.Soc.M.E.

Many incidental developments and improvements should be attributed to others who took important part in the work. Acknowledgment is especially due to Prof. P. F. Walker, Mem. Am.Soc.M.E., for very hearty and enthusiastic coöperation in reviewing data and visiting and inspecting experimental conditions. Further acknowledgment is also due to the many excellent papers that have appeared on measurement of natural gas referred to at various points through the paper.

Particular acknowledgment is due to Mr. Alfred J. Diescher, who has supported the work of arriving at a more sound basis of measurement. This support has not only consisted in generously approving the considerable cost of the work but also in taking an enlightened and detailed interest in the progress throughout, and adopting a broad policy that the truth in regard to measurement, whether favorable or unfavorable from a financial standpoint, should be adopted without coercion or pressure.

DISCUSSION

MR. WELCH CALLS ATTENTION TO NECESSITY OF STANDARDIZING COEFFICIENTS

W. M. Welch (written).[1] There is one feature in connection with this paper which I would like to call to the attention of the Society, and that is the necessity of standardizing the coefficients to be used in the measurement of natural gas. In the natural gas fields there is a wide divergence in the constants or coefficients used. At the present time, engineers throughout the country are working independently on these problems, such as Weymouth and Cooper in Pennsylvania and West Virginia, Wyer and Biddison in Ohio; Fisher in Oklahoma, Paine and Moeller in California, and numerous others. All of these men are connected in some way with producing or

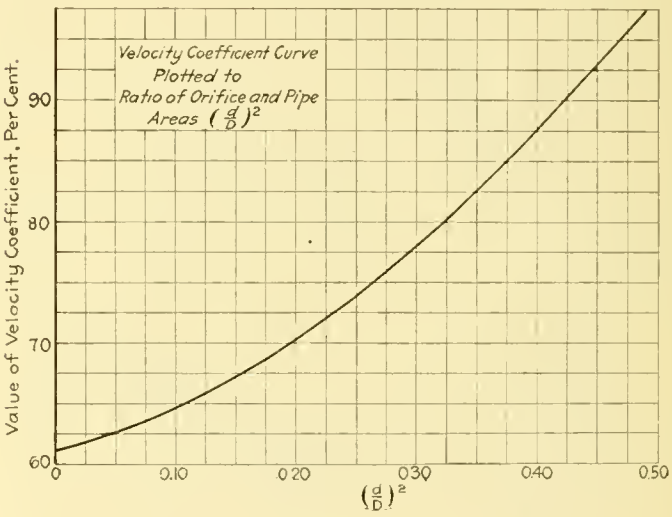

Fig 14 Velocity Coefficients for Orifice Meter Disks Based on Ratio of Area

distributing companies, either as regularly employed or consulting engineers. In addition to these, the Bureau of Standards in Washington is conducting experiments, and the Bureau of Mines, under Burrell, in Pittsburgh is also conducting experiments on Boyle's Law and general work in connection with the measurement and gravity of gases. Also, the state universities of Ohio, Kansas, Wisconsin and elsewhere are working in connection with these subjects. The work being done by these various investigators leads to the use of different coefficients, and where a money consideration resulting from the purchase or sale of gas is dependent upon the coefficient, the matter becomes very important from a commercial standpoint, and much confusion and possible litigation may result from the unsettled condition and uncertainty. It would seem that some effort should be made by some body such as this

[1] 506 Custom House, San Francisco, Cal.

Society, working in conjunction with the Bureau of Mines, the Bureau of Standards, the state universities and others, to correlate the work and establish uniformity in the constants or coefficients, in the types of apparatus to be used in the determination of specific gravity and measurement of gases, and in differential pressure-recording instruments. It is to be hoped that Mr. Fisher's paper will produce some tangible results along these lines.

MR. HILL DISCUSSES PAPER IN LIGHT OF HIS OWN EXPERIENCE

D. M. Hill (written).[1] I am more familiar with the type of orifice meter consisting of a plate ⅛ in. thick with flat edges, and with pressure connections made at the flange 1 in. either side of the plate. The static pressure connection is made from the downstream side of the orifice.

From very careful tests of this type of meter with standardized pitot tubes, it has been established that for differentials up to 100 in. of water the orifice coefficient is constant. I believe, therefore, that the variation of the coefficient with increasing differential, of which Mr. Fisher speaks, is due to the location of the pressure connections at 2½ times the pipe diameter on the inlet and 8 times the pipe diameter on the outlet side of the orifice. By using flange connections a larger differential for a given flow is obtained. This helps somewhat

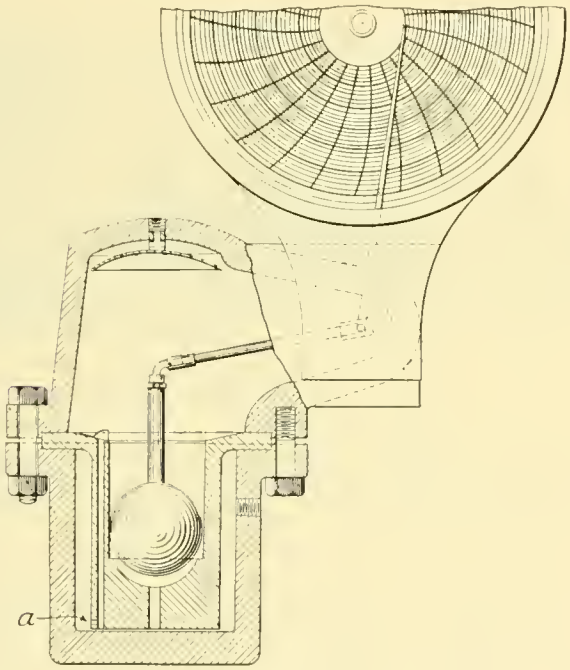

Fig. 15 Ballard Differential Gage

in low flows, where the chances for error are great, due to gage inaccuracies.

I fail to see how the correction to Boyle's Law will bring the observational points closer to the curve in Fig. 13, inasmuch as both the Joplin and Erie tests were performed under the same pressure conditions, and the points are about evenly distributed above and below the curve.

The device which Mr. Fisher has described for automatically changing from one side of the orifice to another without personal attention is most ingenious. I would like a little more information as to how the sticking of the plate against the gasket and the friction against the flange was overcome without permitting serious leakage of gas past the plate. In practice, it has been found that after an orifice plate has been in service for some time, it frequently sticks to the gasket, even with the flange spread apart with jack screws.

[1] Equitable Gas Co., Pittsburgh, Pa.

PROFESSORS GOSS AND WALKER COMPARE ACCURACY OF EARLY AND PRESENT PRACTICE

W. F. M. Goss. It is evident that our practice in dealing with natural gas is rapidly improving. Fifteen years ago gas companies were not much concerned with errors of one per cent in measuring gas. I recall a pipe line in Indiana which, in the declining days of the gas field in that state, was found to be delivering a million feet of gas per day as shown by consumers' meters, while the compressor displacement in the field, 45 miles away, showed that six million feet of gas were being delivered into the line. The line was reported by the field inspectors to be in good condition.

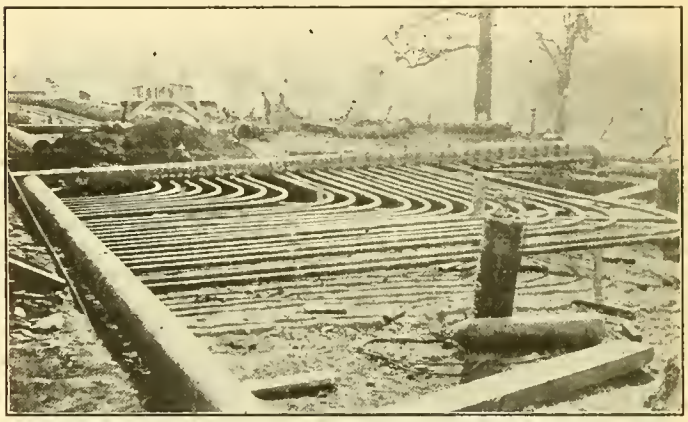

Fig. 16 Pulsation Equalizer

Shortage in the supply of gas soon made it necessary to find out what was becoming of the difference between the six million feet going in and one million feet coming out. Measurements taken along the line revealed a steady decline in the quantity of gas passing different sections of the pipe. Differences were accounted for only on the assumption of leakage. The condition of this pipe line was not exceptional, but probably rather typical of practice in the Indiana field during the brief period when cities were supplied through long pipe lines. When the supply of gas was abundant and the amount delivered sufficient for consumption, there was little concern for what leaked out on the way.

All this, it will be noted, is in striking contrast with the attitude displayed by Mr. Fisher's excellent paper.

P. F. Walker. The conditions in the mid-continental field are not so dissimilar from those which Dean Goss has just cited, except for certain differences in the character of the gas, or, rather, in the character of the substances, mainly vapors and sometimes actual liquids, carried with the gas, and the advancement of the art since the Indiana days. About five years ago I was making investigations of the pipe line conditions for the Kansas Natural Gas Company, the company supplying Kansas City and other towns in Eastern Kansas and Western Missouri. There were three compressor stations on the line, one receiving the gas from the fields, the second, 40 miles away, a step-up station, and the third, 40 miles further, a second step-up station. The piston volume displacement of the sta-

tions fell off, but not, perhaps, more than 8 or 10 per cent each time, the loss, of course, in the main, being due to leaks or to uncharted small users along the lines.

It has been a great pleasure to me to note the attitude and the regard for scientific accuracy displayed by Mr. Fisher's company. When it became necessary to investigate the variation of this gas from the laws of perfect gases, and in spite of the fact that such an investigation seemed almost sure to cause variations disadvantageous to the company, the officials asked us to find out the truth if possible. Two independent sets of investigations as to the variation of this gas from the laws of perfect gases, one by the company and one at the Kansas State University, are now in progress.

The mid-continental gas carries a large amount of matter foreign to gas and gas measurement. At places it is absolutely necessary to take out some of the lighter oils and gasolines in order to avoid danger. A very good grade of gasoline is being manufactured at points along the company's lines. The trouble with the Thomas meter is that its action is based upon the amount of heat required to heat a given

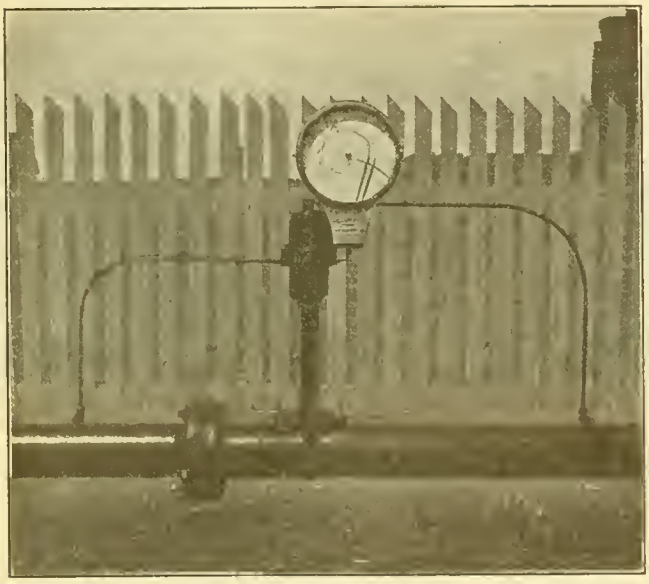

Fig. 17 Present Standard Setting for Orifice Meter

amount of the substance during a given rise in temperature. With the impure gas the specific heat is an extremely variable quantity, and even though the specific heat were known, many of the heavier condensible vapors would probably have been removed before the gas reached its destination, so that the measurement would not be the one required. Moreover, the rock and sand in the gas would destroy so delicate an instrument as the Thomas meter. I do not wish to criticise the Thomas meter, which is a particularly fine instrument, but merely to point out that it is not applicable in this field.

MR. VOORHEES REQUESTS ADDITIONAL INFORMATION

Gardner T. Voorhees said that he was particularly interested in the coefficient of flow through orifices because of investigations of his own in refrigeration. He suggested that in addition to the information given in the summary of tests to determine the volumetric efficiency of the compressor, the temperature of discharge at the pressure taken and the diameter and stroke of the compressor be given, as he wished to compare with a formula evolved by him for the volumetric efficiency of ammonia compressors, based on the outlet and inlet temperatures, the results obtained with natural gas.

P. F. Walker pointed out that the table referred to was a minor element in the investigation, but gave some results which were gratifying in regard to the exactness with which the meter coefficient measured up with the values determined by another test.

THE AUTHOR REPLIES TO POINTS RAISED IN THE DISCUSSION

The Author. The instance of which Professor Goss speaks, where six million feet of gas was put into the line to maintain one million feet 45 miles away, was, of course, a very serious case, but by no means unique. Similar conditions have gone on unsuspected in many fields during the early history of the business, for lack of any reliable means of checking gas at the input end.

Mr. Hill refers to a statement (and to Fig. 11) in the original paper as to the variable coefficients at different values of the differential. This statement should perhaps have been modified by the statement that the total variation from a constant of these differentials at the various values was relatively small and has never been taken into consideration as a commercial factor, but merely in some of the theoretical work it was considered that a law might be found governing these slight variations.

In plotting distances of the outlet pressure tap from the orifice flange as abscissae against the differentials as ordinates for various constant rates of flow, it is seen that the recovery of static pressure beyond the orifice with the decrease of velocity, while practically negligible at 1 in. differential, becomes noticeable at higher differentials, and that with the point of observation spaced at 8 diameters there is full recovery and practically a horizontal line on differentials up to and exceeding 50 in., which is the highest used in our work.

In answer to Mr. Hill's further query, no gaskets are used in the orifice-shifting device, but leakage of gas is prevented to an absolutely satisfactory degree of "tightness" by the pressure of accurately ground brass surfaces against accurately ground steel surfaces, the surfaces being kept in contact by springs. The average differential that is used as a maximum, at which the disks are shifted, is about 40 in., at which pressure the leakage through such ground joints is a negligible factor compared with the quantities of gas flowing.

One advantage of using these points of observation ($2\frac{1}{2}$ in. and 8 in.) of the differential is to give orifices which can be used satisfactorily with a wider range between maximum and minimum flow quantities. It also does away with the possibility of the serious effect of violent eddy-currents at the point of expansion beyond the orifice where these changes of energy from dynamic to static pressure are taking place.

I would like to further acknowledge Mr. Hill's criticism of the paragraph dealing with Boyle's Law and Fig. 13, as I find that the points referred to in that paragraph, which were largely observations at Wann at high pressures, have been in some way omitted from the sheet from which the curve was drawn.

Fig. 17 shows what we now consider our standard setting, in which fittings are largely eliminated by the use of oxy-acetylene welding, and the meter is raised out of the ground for convenience in handling and changing disks and eliminating water or fluid from the line adjacent to the meter disks.

DEVIATION OF NATURAL GAS FROM BOYLE'S LAW

By ROBERT F. EARHART,[1] COLUMBUS, OHIO, and SAMUEL S. WYER, COLUMBUS, OHIO

Non-Member Member of the Society

SYNOPSIS OF THE PAPER AND DISCUSSION

THE magnitude of the natural-gas compressing and measuring problem, and known data regarding probable deviation of natural gas from Boyle's law, are summarized in this paper.

Tests were made by the authors in the laboratory of the Department of Physics, Ohio State University, Columbus, Ohio, on eight representative natural-gas samples from various parts of the United States, to ascertain by accurate volumetric measurement whether or not these natural gases did deviate from Boyle's law, and if so, under what conditions. The apparatus used and methods followed are illustrated and described in detail. The data obtained are given in tabulated and graphical form.

These data show:

That all of the observed deviations of natural gas from Boyle's law are in one direction—in favor of the buying company where gas is measured under high-pressure conditions.

That the different gases have marked peculiarities and marked differences of deviation.

That there is no direct relationship between the deviation and ethane content.

That the direct application of Boyle's law to high-pressure natural gas-measuring problems gives only an exceedingly rough approximation.

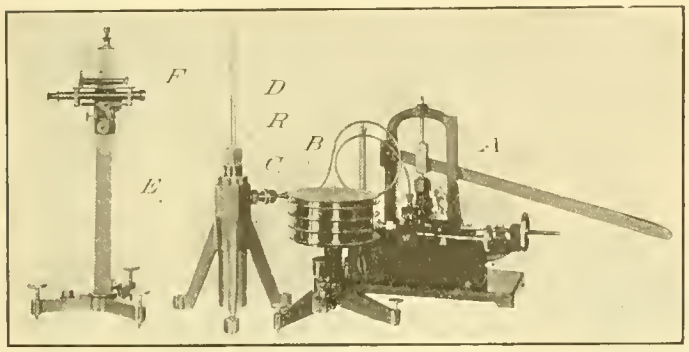

Fig. 1. Assembly of Apparatus

In the discussion, C. N. Cross states that plottings of the authors' observations on logarithmic cross-section paper give values of n (in the equation $PV^n = C$) between 0.92 and unity. Obtaining new initial PV products from the plottings and recomputing, the percentage deviations resulting are in all cases larger than those given by the authors.

E. O. Hickstein suggests a method of testing PV percentage deviation that relies for its accuracy on the correctness of a stop watch, pressure gage and thermometer, and is entirely independent of reservoir volume, prover calibration or the specific gravity of the gas tested.

G. A. Burrell and I. W. Robertson give a formula developed by the U. S. Bureau of Mines, by means of which the deviation from Boyle's law of any natural gas, at any pressure, can be determined from a simple analysis of the gas.

T. R. Weymouth presents a simple empirical equation, by the use of which he states that it is quite possible and practical to obtain measurements of natural gases under high-pressure conditions well within the commercial requirements of accuracy, despite the wide deviation of such gases from Boyle's law.

F. P. Fisher examines in detail some factors of the methods used by different investigators, in order to determine the reasons for disagreement in numerical results obtained in cases where methods differed but slightly.

W. C. Baxter states that in practically all field measurements of gas, large quantities of water vapor and oil vapor are condensed after having passed the meter, causing a shrinkage or loss to the buying company.

P. F. Walker and others who preceede him draw attention to the apparent inconsistency of certain results obtained by the authors in the range between 1 and 2 atmos., concerning which the latter state that there was no perceptible deviation from Boyle's law.

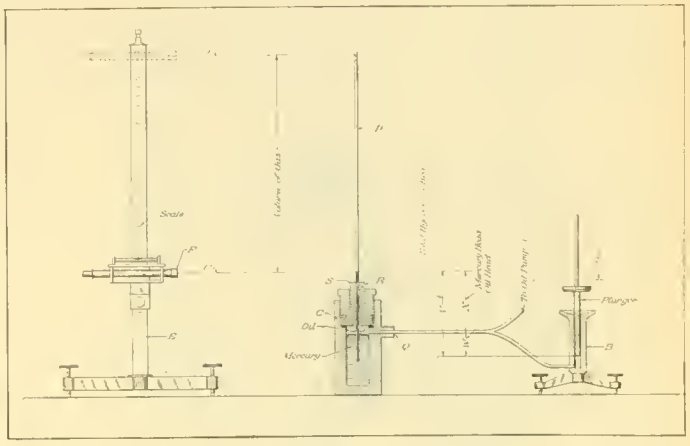

Fig. 2 Diagram of Apparatus

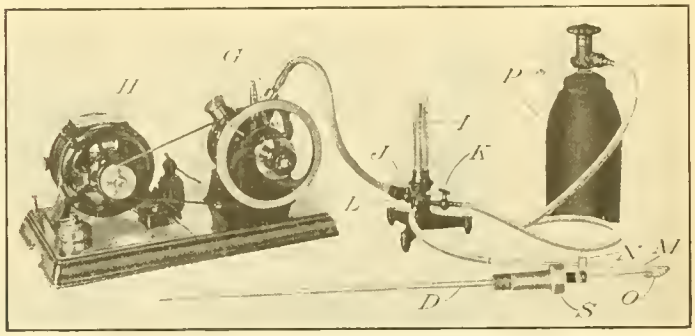

Fig. 3 Method of Filling Capillary Tube

THE law that "the volume of a gas at constant temperature varies inversely as its absolute pressure, or that the product of the volume and absolute pressure of a gas is constant," discovered by Boyle in 1660, is the starting point of natural gas compressor and high pressure natural gas measuring calculations. The extent of the commercial application of the law becomes evident when we consider that in the United States over 600,000,000 cu. ft. of gas per annum are now measured under high pressure conditions, and that there are in this country over 200 natural gas compressing stations, aggregating more than 315,000 h.p. of compressor capacity and compressing more than 85 per cent of all the gas used.

[1] Professor of Physics, Ohio State University.

Presented at the Spring Meeting of The American Society of Mechanical Engineers, New Orleans, La., April 1916. Pamphlet copies of complete paper without discussion may be obtained; price 10 cents to members, 20 cents to non-members.

The universal custom in the natural gas business has been to assume that the gas obeys Boyle's law. That the law is not followed rigorously by natural gas, or by any other commercial gas, is evident, however, from the following: Boyle, in his original memoirs in 1661, called attention to the fact that undoubtedly there would be deviations from the law. In the nineteenth century, experiments by Regnault, Amagat and Cailletet showed marked deviations.[1] Professor Walker, in 1912, was probably the first to call attention to the deviation of natural gas from Boyle's law on account of the then known deviations of methane gas, the principal constituent of natural gas,[2] and again in 1914, in his paper on the Physical Laws of Methane Gas.[3]

Fig. 4 Method of Inserting Capillary Tube Seal in Mercury

All the data published heretofore referred to the so-called permanent gases. The data given in the present paper were obtained by making actual volume measurements of representative natural gases, from atmospheric pressure up to 48 atmos. The tests were made in the Physics Laboratory of the Ohio State University, with the apparatus shown in Figs. 1 and 3. *A*, *B*, *C*, *E* and *I* were made by the Geneva Society.

Referring to Figs. 1 and 2, *A* is an oil pump, *B* a gage tester connected to the oil pump so as to indicate the pressure developed by *A*. *C* is a Cailletet piece (named for the French scientist who designed it) with calibrated capillary glass tube *D*. The inside construction of *C* is shown in Fig. 2. *E* is a cathetometer with moving telescope *F* used for reading the height of the mercury column in *D*.

In Fig. 3, *G* is a Gaede box vacuum pump, driven by the electric motor *H*. *I* is a manometer with cocks *J*, *K*, and *L*, and a small mercury gage underneath the glass, which indicates the degree of vacuum obtained. *M* is a bent glass tube with glass cock *N* and short rubber hose *O*. The hose *O* is tightly wired to *M* to prevent it slipping off. *P* is a standard gas tank used for shipping the gas to the laboratory.

The capillary glass tube *D* had an inside diameter of 3 mm. and was sealed off squarely at the top and held in a vertical position in collar *S* by means of a stuffing box and gland on the inner side of the collar, as shown in Fig. 2. The tube was selected from a large number, and was calibrated in a vertical position by forcing the column of mercury up into the tube and then separating a slug of mercury about 1 in. long from the main column by an air cushion, raising this short slug of mercury through the entire working length of the tube and noting its variations in length by means of the telescope *F* on the cathetometer *E*. The variation in diameter of the tube was so small that volume could safely be considered to be directly proportional to length. The tube *D* was originally surrounded by a water bath, but on account of the practically constant temperature conditions prevailing in the room this was abandoned. The readings for volume contractions were always made with a rising meniscus in *D*.

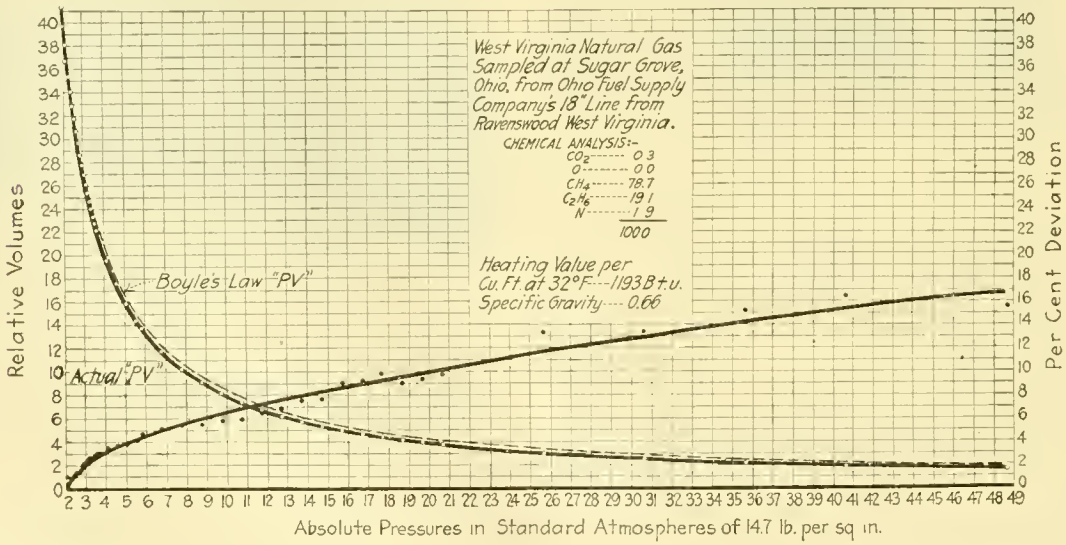

Fig. 5 Typical Plot Showing Deviation of Natural Gas (Sample of West Virginia) From Boyle's Law

The order of conducting the tests was as follows: The capillary tube *D* was connected as shown in Fig. 3, with cocks *J*, *L* and *N* open, and *K* closed. By means of *G* the capillary tube *D* was then evacuated and the degree of vacuum noted by the small mercury column in *I*. In operating, the vacuum was

[1] Meyer's Kinetic Theory of Gases, 1877; Preston's Theory of Heat, 1894; Vol. 1, Wüllner's Lehrbuch der Experimental Physik, 1895; Harper's Scientific Memoirs, Laws of Gases, Edited by Carl Barus, 1899.

[2] Proc. Natural Gas Assoc. of America, vol. 4, p. 172.

[3] Trans. Am.Soc.M.E., vol. 36, p. 781.

pulled down to 1 mm. of mercury; cock J was then closed and K opened, allowing D to be filled from the natural gas tank P. This operation was repeated at least four times, to wash out the inside of D thoroughly and leave it free from every trace of air. In the last operation, cock N was closed and M disconnected from the rubber hose leading to L. D and M were then held in a vertical position as shown in Fig. 4, and inserted in the mercury inside of C so that the mercury ran out of the opening Q. When O and the lower end of D were well under the surface of the mercury in C, D was held stationary by the one hand and M pushed down with the other hand, in that way slipping the rubber O from off D underneath the mercury surface in C, thereby entraining the gas in D. The nut R was then screwed down loosely on S, connections made to the oil pump as shown in Fig. 1, and the pump worked slowly so as to force the air out around R. After the air was all driven out, R was then screwed down tightly onto S.

The maximum pressure to be used on B was now applied so as to produce the maximum strain on D, and by means of telescope F and cathetometer E the top position of the inside of D was determined by the line T, as shown in Fig. 2. The pressure in D was now released and the smallest weight that would make the mercury visible in D was applied to B, as indicated by U in Fig. 2. Successive increments of weight on B now produced corresponding contractions in the gas volume D. The gas in D was also allowed to expand, and several readings taken with each gas checked with those taken on compression. The volume changes were accurately observed by means of telescope F and the centimeter scale on cathetometer E.

All readings were made in metric units and pressures reckoned in standard atmospheres of 76 cm. of mercury, or 14.7 lb. per sq. in.

TABLE 1 DEVIATION OF NATURAL GAS FROM BOYLE'S LAW

Pennsylvania "Dry" natural gas from Tri-County Gas Company, Roystone, Pa.

Percentage Analysis { CO_2, 0.1; O, 0.3; CH_4, 77.7; C_2H_6, 21.7; N, 0.2

Heating Value per Cu. Ft. at 32 deg. fahr. = 1231 B.t.u.
Specific Gravity = 0.66

P Abs. Press. in Standard Atmos.	V Relative Vol. Observed	Boyle's Law Vol.	PV Product of P and V as "Constant"	Per Cent Deviation
2.024	41.62	41.62	84.24	0.00
2.103	39.97	40.06	84.06	0.21
2.183	38.49	38.59	84.02	0.26
2.264	37.04	37.21	83.86	0.45
2.345	35.58	35.92	83.44	0.96
2.429	34.37	34.68	83.48	0.91
2.513	33.18	33.52	83.38	1 03
2.598	32.04	32.42	83.24	1.201
2.684	30.98	31.40	83.15	1.31
2.771	29.98	30.40	83.07	1.408
2.947	28.11	28.62	82.84	1.69
3.124	26.39	26 96	82.44	2.18
3.305	24 93	25.50	82.39	2.24
3.487	23.59	24.16	82.26	2.407
3.671	22.38	22.95	82.16	2.53
4.137	19.79	20.36	81.87	2.89
4.611	17.77	18.27	81.94	2.806
5 088	16 06	16.56	81.71	3.09
5.570	14.65	15.12	81.00	4.00
5.838	13 99	14.43	81.67	3.14
6.822	11.97	12.35	81.66	3.15
7.792	10.42	10.81	81.19	3.75
8.776	9.22	9.60	80.91	4.12
9.764	8.29	8.63	80.94	4.08
10.753	7.48	7.83	80.43	4.73
11.744	6.82	7.17	80.09	5.18
12.737	6 27	6.61	79.86	5.48
13.731	5.80	6.13	79.64	5.78
14.726	5.40	5.72	79.52	5 93
15.721	5.05	5.36	79.39	6 109
20.705	3.82	4.07	79.09	6.51
25.695	3.04	3.28	78.11	7.85
30.688	2.52	2.75	77.33	8.94
35.682	2.12	2.36	75.65	11.35
40.679	1.85	2.07	75.26	11.93
48.675	1.56	1.73	75.93	10.94

Aug. 30, 1915. Barometer 29.4 in. Temperature at start, 67.2 deg. fahr.; at close, 65.0 deg. fahr

TABLE 2 DEVIATION OF NATURAL GAS FROM BOYLE'S LAW

Pennsylvania "Wet" natural gas from the Pennsylvania Gas Company's "East Branch" intake

Percentage Analysis { CO_2, 0.0; O, 0.0; CH_4, 61.3; C_2H_6, 37.7; N, 1.0

Heating Value per Cu. Ft. at 32 deg. fahr. = 1354 B.t.u.
Specific Gravity = 0.75

P Abs. Press. in Standard Atmos.	V Relative Vol. Observed	Boyle's Law Vol.	PV Product of P and V as "Constant"	Per Cent Deviation
1.936	42.03	42.03	81.37	0.00
2.013	40.31	40.42	81.14	0.28
2.092	38.72	38.89	81.00	0.45
2.172	37.21	37.46	80.82	0.68
2.254	35.80	36.10	80.69	0.84
2.336	34.48	34 83	80.55	1.02
2.420	33.26	33.62	80.49	1.09
2.505	32.08	32.48	80.36	1.25
2.590	30 96	31.42	80.19	1.47
2.676	29.92	30.41	80.07	1.62
2.763	28.92	29.45	79.91	1.83
2.940	27.12	27.68	79.73	2.06
3.119	25.52	26.09	79 60	2.22
3.300	24.07	24.66	79.43	2.44
3.482	22.78	23.37	79.32	2.58
3.667	21.60	22.19	79.21	2.73
4.134	19.09	19.68	78.92	3.23
4.607	17.07	17.66	78.64	3.47
5.086	15.42	15.99	78.43	3.75
5.837	13.41	13.94	78.27	3.96
6.811	11.42	11.95	77.78	4.61
7.791	9.91	10.44	77.21	5.39
8.776	8.74	9.27	76.70	6.09
9.764	7.84	8.33	76.55	6.30
10.754	7.06	7.57	75.92	7.18
11.745	6.42	6.81	75.40	7.92
13.732	5.45	5.93	74.83	8.74
15.723	4.72	5.18	74.21	9.65
18.214	4.02	4.47	73.22	11.13
20.706	3.47	3.93	71.85	13.24
25.696	2.70	3.17	69.38	17.28
30.689	2.19	2.65	67.21	21.07
35.685	1.86	2.28	66.37	22.60
40.681	1.57	2.00	63.87	27.40
48.677	1.27	1.67	61.82	31.62

Sept. 2, 1915. Barometer 29.6 in. Temperature at start, 68.0 deg. fahr.; at close, 68.7 deg. fahr.

The plunger on the gage tester was of such diameter that one kilogram of weight was equal to one standard atmosphere of pressure. The plunger itself weighed 0.354 kg. and therefore represented 0.354 atmos. In addition to the disks that belonged to the gage tester B, standard laboratory weights were used for getting the smaller increments of pressure.

The total hydrostatic head indicated by V in Fig. 2 is the sum of a variable represented by mercury column X and a constant represented by the oil column W. The length of this oil column W was kept at 20 cm. in all the tests. The specific gravity of the oil, as determined by a Mohr balance, was found to be 0.866 and therefore equal to 17.32 cm. of water, which in turn was equal to $17.32 \div 76 \times 13.6 = 0.016$ standard atmos.

The readings were classified as follows:

	Typical Values
Barometric pressure in standard atmospheres	0.981
a = Weight on plunger + 0.354	1.176
b = Reading of upper end of gas column in D as T	42.31
c = Reading of lower end of gas column in D as U	1.00
d = Length of gas column = relative volume = $b - c$	41.31
e = Height of mercury in C	—8.00
f = Hydrostatic head of mercury = $X = c + e$	9.00
g = f in standard atmospheres = $f \div 76$	0.12
W = Hydrostatic head of oil in atmospheres	0.016
V = Total hydrostatic head of oil and mercury = $g + W$	0.136
h = Total net absolute pressure on gas = barometric pressure + $a - V$	2.021
PV = Product of volume and pressure = $d \times h$	83.50

Deviation in per cent corresponding to various pressures = 100 × "PV" value of lowest pressure divided by "PV" value corresponding to any other pressure, minus 100 = $(100\, P_0V_0/P_xV_x) - 100$.

TABLE 3 DEVIATION OF NATURAL GAS FROM BOYLE'S LAW

PENNSYLVANIA NATURAL GAS FROM EQUITABLE GAS COMPANY AT TRAFFORD CITY, PRACTICALLY A PURE METHANE GAS

Percentage Analysis: CO_2, 0.0; O, 0.0; CH_4, 98.6; N, 1.4
Heating Value per Cu. Ft. at 32 deg. fahr. = 1050 B.t.u.
Specific Gravity = 0.56

P Abs. Press. in Standard Atmos.	V Relative Vol. Observed	Boyle's Law Vol.	PV Product of P and V as "Constant"	Per Cent Deviation
1.936	42.10	42.10	81.51	0.00
2.013	40.41	40.49	81.35	0.19
2.092	38.79	38.96	81.15	0.44
2.173	37.32	37.51	81.10	0.63
2.253	35.82	36.18	80.70	1.04
2.337	34.57	34.81	80.79	0.89
2.421	33.40	33.66	80.86	0.804
2.505	32.17	32.54	80.59	1.02
2.591	31.06	31.46	80.48	1.28
2.676	30.00	30.46	80.28	1.53
2.764	29.05	29.49	80.29	1.52
2.940	27.20	27.72	79.97	1.92
3.119	25.60	26.13	79.84	2.09
3.300	24.18	24.70	79.79	2.15
3.483	22.87	23.40	79.66	2.32
3.667	21.70	22.23	79.57	2.44
4.134	19.20	19.72	79.37	2.69
4.621	17.20	17.64	79.48	2.56
5.086	15.55	16.02	79.09	3.06
5.838	13.53	13.96	78.99	3.19
6.812	11.57	11.96	78.81	3.42
7.792	10.09	10.46	78.62	3.67
8.777	8.94	9.29	78.47	3.87
9.765	7.99	8.35	78.03	4.46
10.755	7.23	7.58	77.76	4.84
13.236	5.83	6.16	77.17	5.62
15.724	4.88	5.18	76.73	6.23
18.215	4.20	4.47	76.50	6.55
20.708	3.67	3.93	76.00	7.25
25.698	2.90	3.17	74.52	9.38
30.691	2.41	2.66	73.97	10.19
35.687	2.10	2.28	74.94	8.77
40.684	1.82	2.00	74.04	10.09
48.679	1.52	1.67	73.99	10.16

Sept. 2, 1915. Barometer, 29.6 in. Temperature at start, 67.6 deg. fahr.; at close, 67.6 deg. fahr.

TABLE 4 DEVIATION OF NATURAL GAS FROM BOYLE'S LAW

OHIO NATURAL GAS TAKEN FROM THE OHIO FUEL SUPPLY COMPANY'S INTAKE LINES AT SUGAR GROVE, OHIO

Percentage Analysis { CO_2, 0.0; O, 0.0; CH_4, 76.0; C_2H_6, 16.3; N, 7.7

Heating Value per Cu. Ft. at 32 deg. fahr. = 1114 B.t.u.
Specific Gravity = 0.67

P Abs. Press. in Standard Atmos.	V Relative Vol. Observed	Boyle's Law Vol.	PV Product of P and V as "Constant"	Per Cent Deviation
2.022	41.07	41.07	83.04	0.00
2.101	39.42	39.53	82.82	0.27
2.180	37.90	38.09	82.62	0.52
2.261	36.45	36.72	82.41	0.76
2.344	35.10	35.42	82.27	0.93
2.427	33.83	34.21	82.11	1.13
2.511	32.65	33.07	81.98	1.29
2.596	31.52	31.98	81.83	1.49
2.683	30.48	30.95	81.78	1.54
2.769	29.45	29.99	81.55	1.82
2.945	27.60	28.19	81.28	2.16
3.123	25.96	26.59	81.07	2.43
3.304	24.52	25.13	81.01	2.51
3.487	23.20	23.81	80.90	2.64
3.671	22.00	22.62	80.76	2.82
4.138	19.47	20.07	80.57	3.06
4.611	17.43	18.01	80.37	3.32
5.089	15.78	16.32	80.30	3.41
5.840	13.69	14.22	79.95	3.86
6.814	11.70	12.19	79.72	4.16
7.794	10.19	10.65	79.42	4.56
8.779	9.05	9.46	79.45	4.53
9.766	8.07	8.50	78.81	5.36
10.756	7.29	7.72	78.41	5.90
13.237	5.90	6.27	78.10	6.32
15.724	4.90	5.28	77.05	7.77
18.215	4.20	4.56	76.50	8.55
20.708	3.70	4.01	76.62	8.38
25.699	2.96	3.23	76.07	9.16
30.692	2.45	2.71	75.20	10.42
35.687	2.08	2.33	74.23	11.87
40.684	1.84	2.04	74.86	10.93
48.679	1.52	1.71	73.99	12.23

Sept. 3, 1915. Barometer, 29.6 io. Temperature at start, 67.3 deg. fahr.; at close, 66.9 deg. fahr.

The results obtained are shown in part in Tables 1 to 5 and Fig. 5.[1] The paper as presented includes tables dealing with three other gases, one of them being that of Fig. 5. The specific gravities are given with reference to air as unity. The gross heating values given are computed on a basis of 32 deg. fahr. and 76 cm. pressure.

It may be noted that the gases which contain a large percentage of C_2H_6 (wet gases) show larger deviations than the dry gases. The explanation lies in the fact that we are dealing with a physical mixture of gases having two principal constituents, CH_4, methane and C_2H_6, ethane. These have different critical temperatures, one of which lies below, and the other above, the temperature at which our experiments were made.

[1]On account of lack of space, only five tables and one typical plot are here given. The paper as presented contains eight tables and eight charts, the charts being plotted from the tables.

TABLE 5 DEVIATION OF NATURAL GAS FROM BOYLE'S LAW

Mixture of Ohio and West Virginia natural gas taken from the St. Mary's Measuring Station of The Ohio Fuel Supply Company at Columbus, Ohio

Percentage Analysis $\begin{cases} CO_2, 0.1;\ O, 0.0;\ CH_4, 78.1; \\ C_2H_6, 16.8;\ N, 5.0 \end{cases}$

Heating Value per Cu. Ft. at 32 deg. fahr. = 1144 B.t.u.
Specific Gravity = 0.66

P Abs. Press. in Standard Atmos.	*V* Relative Vol. Observed	Boyle's Law Vol.	*PV* Product of *P* and *V* as "Constant"	Per Cent Deviation
1.884	38.12	38.12	71.82	0.00
1.963	36.47	36.59	71.59	0.32
2.043	34.95	35.15	71.40	0.59
2.124	33.56	33.81	71.28	0.76
2.207	32.22	32.54	71.11	0.99
2.291	31.01	31.34	71.04	1.07
2.375	29.82	30.24	70.82	1.41
2.461	28.74	29.18	70.73	1.55
2.547	27.72	28.19	70.60	1.58
2.635	26.77	27.25	70.54	1.81
2.723	25.85	26.37	70.39	2.03
2.901	24.21	24.75	70.23	2.105
3.082	22.74	23.30	69.97	2.64
3.265	21.42	21.99	69.96	2.69
3.449	20.24	20.82	69.81	2.88
3.635	19.19	19.75	69.76	2.95
4.106	16.94	17.49	69.56	3.25
4.582	15.11	15.67	69.23	3.74
5.062	13.64	14.18	69.05	4.02
5.546	12.44	12.94	68.99	4.10
5.816	11.85	12.34	68.92	4.21
6.793	10.09	10.57	68.54	4.78
7.776	8.77	9.23	68.30	5.15
8.763	7.77	8.19	68.09	5.48
9.752	6.92	7.36	67.48	6.43
10.743	6.26	6.69	67.25	6.79
12.729	5.22	5.64	66.45	8.08
14.719	4.47	4.88	65.79	9.16
16.712	3.90	4.29	65.18	10.18
18.706	3.45	3.83	64.54	11.28
20.701	3.10	3.47	64.17	12.39
25.693	2.43	2.80	62.43	15.04
30.687	2.02	2.34	61.99	15.86
35.683	1.72	2.01	61.37	17.03
40.680	1.48	1.77	60.21	19.28
48.677	1.22	1.48	59.39	20.93

Aug. 31, 1915. Barometer, 29.6 in. Temperature at start, 66.2 deg. fahr.; at close, 66.9 deg. fahr.

CH_4 has a critical temperature of —140 deg. fahr.; consequently no pressure, however great, could produce liquefaction at the operating temperature, approximately 68 deg. fahr., which prevailed during our experiments. On the other hand, C_2H_6 has a critical temperature of 93 deg. fahr. It follows, therefore, that as the volume of the mixture of gases is diminished, the C_2H_6 constituent approaches the condition of a saturated vapor. When saturation is reached further diminution in volume will produce no change in the pressure exerted by this constituent, but a liquefaction. In case a mixture contains initially a large amount of C_2H_6, this saturated condition will be reached at a lower stage of compression. The fact that further diminution of volume will not thereafter alter the pressure produced by this constituent indicates why a wet gas at high pressures shows such a marked deviation when compared with the pressure-volume product computed for the lower pressures.

Our observations tend to confirm this explanation. There was at no time any visible collection of liquid within the tube, nor could this be expected under the conditions of the experiment. The initial volume of the gas was so small and the surface of the capillary so large, relatively, that we could not expect visible droplets to form.

We noted in the case of wet gases that when a particular stage in compression was reached (peculiar to the gas operated upon) there was a curious unsteadiness and agitation of the mercury meniscus. We observed this carefully in several cases, and found that the range in pressure and volume through which this occurred was very limited. It was probably due to a deposit of liquid taking place on the mercury meniscus, resulting in a change in surface tension. We could confine this region where agitation occurred to variations of pressure of about one-fifth of an atmosphere. Below and above this pressure the meniscus was steady.

We call attention to the bearing of the four preceding paragraphs to gas-handling problems. A gas containing a high percentage of C_2H_6, *i.e.*, a wet gas, will show a very different correction curve than the same gas after having been run through two or three compressors and cooling tanks where presumably the condensate would be removed. On the other hand, dry gases would show small differences before and after compression.

In conclusion, attention is directed to the following facts:

These tests were all made at room temperatures. We believe it would be desirable to have further tests made at higher and lower temperatures.

With the two gases given in Tables 1 and 3, and with another piece of apparatus, we made tests between absolute pressures of 0.978 atmos. and 2.337 atmos. and found no perceptible deviation from the law.

It is important to note that all of the deviations are in one direction, and in favor of the buying company where gas is measured under high-pressure conditions.

The data given herein indicate that the direct application of Boyle's law to high-pressure natural gas measuring problems gives only an exceedingly rough approximation.

The different gases have marked peculiarities and marked differences of deviation. Furthermore, there is no direct relationship between the deviation and the ethane content.

In practice natural gas is handled at high pressures and at a temperature below the critical point of some of its constituents. The failure to recognize this is responsible for many of the serious troubles experienced.

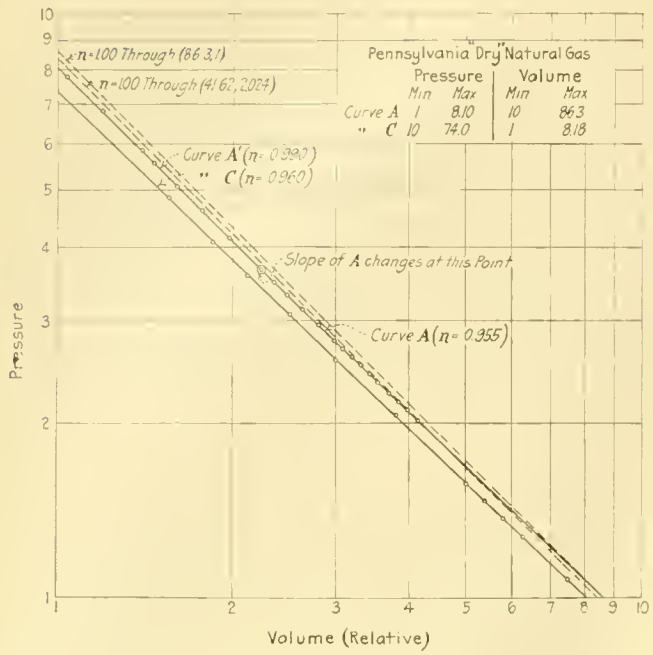

FIG. 6 LOGARITHMIC PLOT OF RESULTS IN TABLE 1

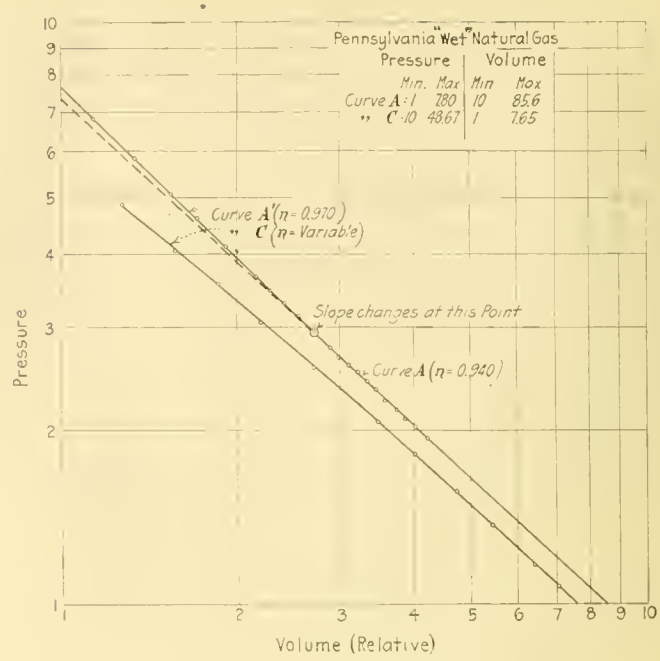

FIG. 7 LOGARITHMIC PLOT OF RESULTS IN TABLE 2

DISCUSSION

MR. CROSS FINDS DEVIATIONS LARGER THAN THOSE GIVEN BY THE AUTHORS

C. N. CROSS (written). In order to study better the relationship between pressure and volume, I have plotted the authors' observations upon logarithmic cross-section paper (Figs. 6-10), where all straight lines can, of course, be expressed by the equation

$$P\,V^n = c$$

where P = pressures, plotted as ordinates

V = volumes (relative, in this case), plotted as abscissas

c = a constant = the intercept on the P-axis when $V = 1$

n = some number = the tangent of the angle between the curve and the V-axis.

For Boyle's law, n is equal to 1, or the angle of the line and the V-axis is 45 deg.

Limitations of the logarithmic paper used in plotting necessitated three separate lines to include the values covered by the experiments. Each line varies between the following approximate limits. Curve B is omitted because of its short length.

Curve	A	B	C
P (atmospheres)	1 to about 7	About 7 to 10	10 to about 70
V (relative)	About 80 to 10	10 to about 8	About 8 to 1

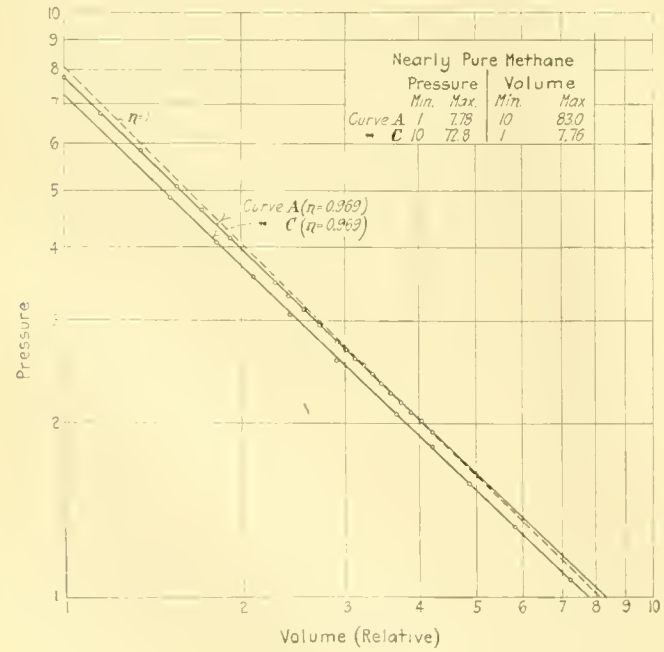

FIG. 8 LOGARITHMIC PLOT OF RESULTS IN TABLE 3

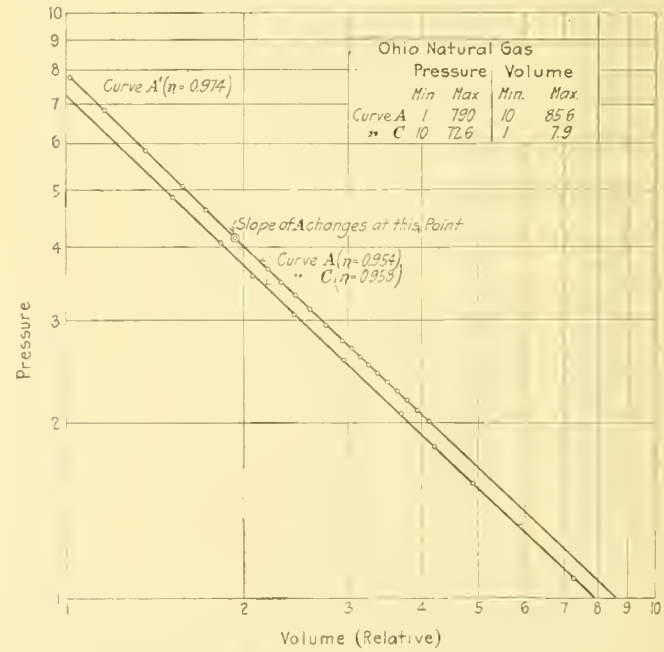

FIG. 9 LOGARITHMIC PLOT OF RESULTS IN TABLE 4

In Table 6 are given the values of n, together with the percentages of ethane and nitrogen in the gases. As was expected, n for each of the eight gases is a number less than unity.

TABLE 6 VALUES OF n

Gas of	Value of n		Per cent of C_2H_6	Per cent of N
	Curve A	Curve C		
Fig. 5.....	0.969	0.942	19.1	1.9
.....	0.975	0.949	18.8	1.2
Table 1...	0.955 and 0.990	0.960	21.7	0.2
Table 2...	0.940 and 0.970	variable	37.7	1.0
Table 3...	0.969	0.969	0.0	1.4
.....	0.980	0.987	9.3	37.7
Table 4...	0.958 and 0.974	0.958	16.3	7.7
Table 5...	0.968	0.923	16.8	5.0

As shown in Table 6, the values of n for curves A differ materially from the values for the corresponding C curves, excepting for gas of Table 3, the practically pure methane

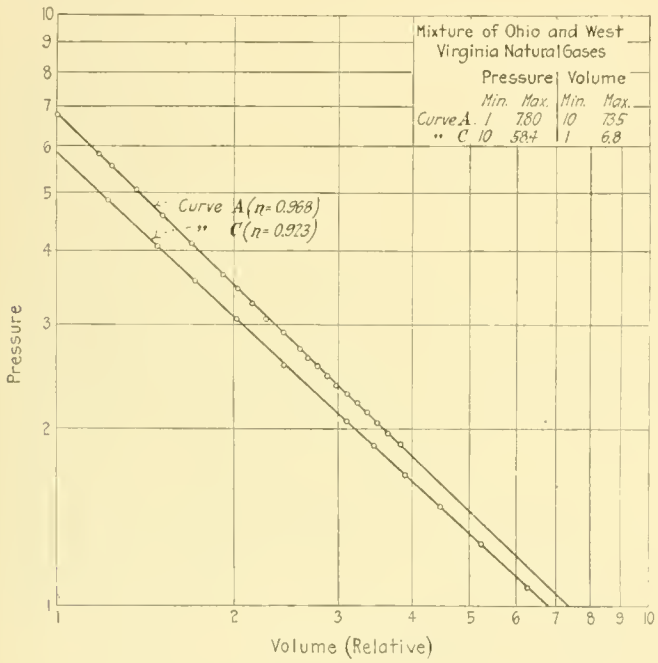

FIG. 10 LOGARITHMIC PLOT OF RESULTS IN TABLE 5

gas. The curves A for gases of Tables 1, 2 and 4, when drawn as two straight lines of different slopes, pass through nearly every point. A slightly curved line drawn through the points, possibly, might represent the facts more correctly. There are not sufficient data to settle this point definitely.

In their conclusion the authors state that no deviation was found for gases of Tables 1 and 3 between pressures of 1 and 2 atmospheres. It is to be regretted that these data were not given, as it would be interesting to plot them upon the logarithmic paper with the others.

If the contract price for gas per cubic foot is based upon a pressure of about 2 atmos., then the percentage deviations as given in the paper are correct. But, as is probably more usual, this pressure is very close to one atmosphere, then the deviation from Boyle's law should be zero at that pressure. Also, in the absence of positive evidence to the contrary and from our general knowledge of the laws of gases, it is hardly to be expected that n would change abruptly at about 2 atmos. to a new value larger than a value between 2 and 8 atmospheres.

I have searched diligently through the literature for experiments upon gases at low pressures, say from 1 to 2 atmos., and have been unable to find any results upon so-called per-

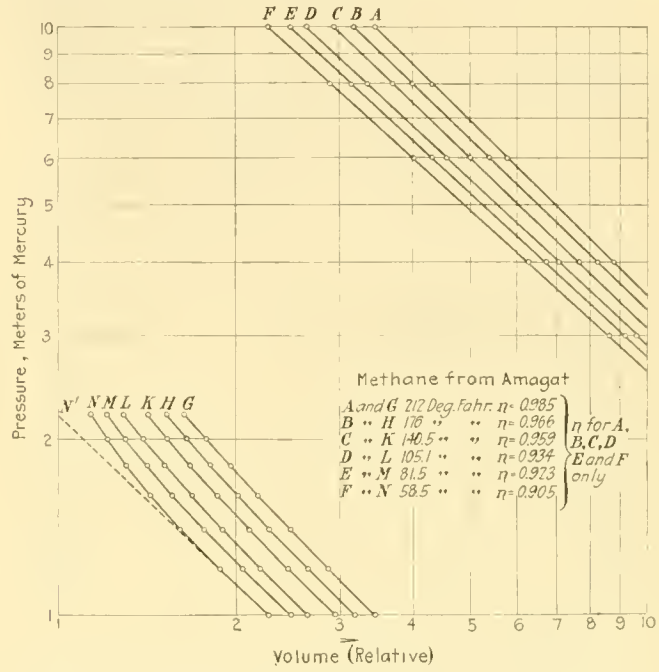

FIG. 11 LOGARITHMIC PLOT OF AMAGAT'S OBSERVATIONS

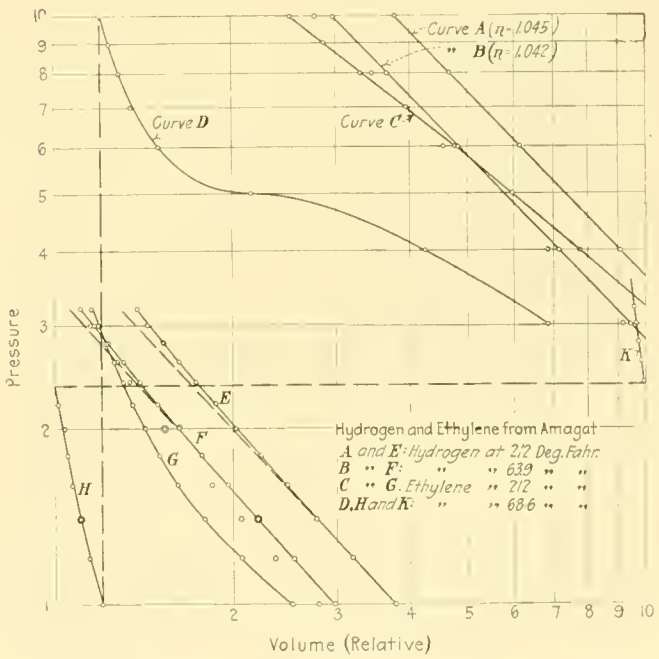

FIG. 12 LOGARITHMIC PLOT OF AMAGAT'S OBSERVATIONS

manent gases giving evidence that n should differ from its value from 2 to 10 atmospheres. Amagat spent considerable time and thought upon gases at very low pressures and was unable to arrive at any conclusion in this matter because of the magnitude of experimental errors, particularly in the measurement of pressures. See *Annales de Chimie et de Physique*, 1883, Série 55, vol. 28, pp. 480-499.

By extending the straight lines on the logarithmic paper back to a pressure of one atmosphere and reading off the volume, a new PV product for the initial, slightly different in every case from that found by the authors at about 2 atmos., was determined, and using this as a starting point, Tables 2, 3 and 5 were abridged and recomputed. The percentage deviation is in every case appreciably larger, *e.g.*, as shown in Table 7, a revision of Table 2. The deviation at 5 to 10 atmos. is increased 40 to 100 per cent. Hence the importance of locating correctly the point of zero deviation is clearly shown.

TABLE 7 (TABLE 2 REVISED)

PENNSYLVANIA "WET" NATURAL GAS

P Absolute Pressure in Standard Atmospheres	V_o Relative Volume Observed	V_b Boyle's Law Volume	Per cent deviation between V_o and V_b	
			New	Earhart & Wyer
1.00	85.6[1]	85.6[1]	0.00[1]	....
1.936	42.03	44.25	5.27	0.00[1]
2.254	35.80	38.01	6.18	0.84
2.676	29.92	32.02	7.02	1.62
3.482	22.78	24.55	7.78	2.58
5.837	13.41	14.70	9.62	3.96
10.754	7.06	7.96	12.72	7.18
20.706	3.47	4.14	19.30	13.24
25.696	2.70	3.33	23.30	17.28
48.677	1.27	1.76	38.60	31.62

[1] From logarithmic curve.

Across Fig. 6 are drawn 45-deg. reference lines through the initial observed point and through the point where the extrapolated curve A cuts the V-axis at a pressure of 1 atmosphere. Hence, at any pressure along curve A, the deviations can be seen at a glance.

Figs. 11 and 12 have been plotted from the observations of E. H. Amagat upon methane, hydrogen and ethylene at high pressures (30 to 420 atmos.), taken from "The Laws of Gases," edited by Carl Barus, 1899. These curves may aid in understanding some of the deviations shown by the natural gas curves. They illustrate briefly the facts as shown by Van der Waals' equation that $(P + a/v^2)(V - b) = C$ for constant temperature, where a/v^2 = the cohesion pressure between the molecules of the gas, and b = the volume of the gas when it is compressed to the utmost.

As a further aid, the following critical temperatures and pressures from the Smithsonian Physical Tables are inserted here.

	H	N	CH_4	C_2H_4	C_2H_6
Critical temperature, deg. fahr.	— 390.5	—220	— 115	48.5	95.0
Critical pressure, atmospheres.....	20	35	54.9	58	45.2

It is of interest to compare the values of n from Amagat's data for methane with that for the practically pure methane gas in Table 3 of the authors' paper. See Figs. 8 and 11.

	Temperature, Deg. Fahr.	n (from straight portion of curve)
Methane (Amagat)	58.5	0.905
Methane (Amagat).....	176.0	0.966
Methane gas (Earhart and Wyer)...	67.6	0.968

So great a difference for the value of n would hardly be expected. It has been alleged that the hydrogen used by Amagat was not pure, but contained as much as 20 per cent carbon monoxide. (See "Study of Gases," by M. W. Travers, 1901 ed., p. 165.) Since much more is known about the analysis of gases now than in 1875 to 1885, it is barely possible that the methane experimented upon by Amagat was not pure.

It is shown in Figs. 11 and 12 that gases at temperatures far above the critical temperature plot as straight lines until the pressure becomes very high, when the lines become convex to the V-axis, showing that the value of n increases. For gases below the critical temperature, the curves may be straight for a short distance, but soon become concave to the V-axis. Then, with an increase of pressure, the curvature is reversed and the lines become convex, as is characteristic of the curves of the so-called permanent gases. This explains why the "wet" gas of Table 2 and Fig. 7, containing 37 per cent ethane, is first straight and then concave to the V-axis.

The writer is unable to explain why the slope of the A curves should increase with the pressure in the case of natural gas.

METHOD OF TESTING PV PERCENTAGE DEVIATION IS SUGGESTED BY MR. HICKSTEIN

E. O. HICKSTEIN (written). It would be interesting to know if any precautions were taken in this work to eliminate water vapor present in the gas. If not, is there any probability of the presence of such vapor having an appreciable effect?

Some tests made by the writer about a year ago suggest a method of test which perhaps has not previously been used in this connection. The possible sources of error in this method are so few that the results may be interesting.

In tests made at Wann, Oklahoma, on orifice meter disks, a known volume of pipe line (one mile of 12-in.) was filled with high-pressure gas and closed off from the source of supply. It was then passed through different types of meters at a constant rate of discharge into the atmosphere. The length of time during which gas escaped from the reservoir was taken by stop watch, and from this reading, together with initial and final pressures in the reservoir, and its volume, the rate of discharge could be calculated, assuming that the gas acted in accordance with Boyle's law. The figures presented here were obtained from these tests.

On January 24, 1915, four tests were made without refilling the pipe-line reservoir. The rate of discharge was kept constant, the flow being regulated by an operator who slowly opened a gate through which the gas was expanded to a low pressure and then discharged to the atmosphere through a meter prover. The readings taken during the four runs are reported in Table 8, which is self-explanatory.

From these data was calculated the number of cubic feet of gas at atmospheric pressure passing per minute through a square inch of orifice area, reduced to standard conditions of 60 deg. fahr. flow temperature, 0.675 gravity and 2.70 in. of water pressure in prover. The results appear in column 2 of Table 9.

As the prover was working at all times under identical conditions, it is clear that the discrepancy between these four values must be due to the fact that the calculation of the rate of flow, based on Boyle's law, was incorrect. If, now, it is assumed that Boyle's law is true between 50 and 0 lb. per sq. in. pressure, that is, that the fourth test is correct as fig-

ured, 32.43 is the correct constant for the prover orifice; and the ratio of this figure to the other values in column 2 of Table 9 gives the correction factor for the other tests as recorded in column 3 of the same table.

The excess of gas, over Boyle's law, passing out during each of the first three tests, is expressed in atmospheres and in

TABLE 8 DATA TAKEN DURING WANN TESTS, JANUARY 24, 1915, TO INVESTIGATE *PV* DEVIATION

(Barometer reading, 29.4 in. Gravity of gas, 0.672).

Run No.	Initial and Final Pressures of Reservoir, Lb. per Sq. In., Gage	Duration of of Tests, Seconds	U-tube Reading of Prover, In. of H^2O	Temperature of Gas at Prover Outlet, Deg. Fahr.	Temperature of Storage Line, Deg. Fahr.
1	200.5 147.0 53.5	1310	2.81	32	35
2	146.5 96.0 50.5	1274	2.81	33	35
3	96.0 47.0 49.0	1239	2.84	33	35
4	47.0 6.75 40.25	1237	2.82	39	35

cubic feet of the gas in columns 4 and 5 of Table 9. The accumulative excess over Boyle's law is shown in columns 6 and 7 of the same table. Fig. 13 indicates how it is possible to correct for the assumption made that the fourth test and Boyle's law give identical discharges from the reservoir, by showing that, in reality, the excess at 50 lb. per sq. in. is

TABLE 9 PRELIMINARY FIGURES, BASED ON ASSUMPTION THAT BOYLE'S LAW IS TRUE UP TO 50 LB. PER SQ. IN.

Run No.	Calculated Constant for Prover Orifice, Based on Boyle's Law Calculation of Gas Quantity	Ratio of 32.43 (the constant assumed as correct) to Value in Previous Column	Excess Over Boyle's Law for Each Run		Accumulative Excess Over Boyle's Law (Initial Pressure to Zero Pounds)	
			Atmospheres	Cu. Ft.	Atmospheres	Cu. Ft.
1	30.39	1.0672	0.249	68.3	0.412	113.0
2	31.33	1.0352	0.123	33.7	0.163	44.7
3	32.05	1.0119	0.040	11.0	0.040	11.0
4	32.43	1.0000	0.000	0.0	0.000	0.0

0.010 atmos. (2.74 cu. ft.) over Boyle's law. Correcting for this 0.23 per cent of the theoretical quantity between 47 and 0 lb. per sq. in., the true constant for the prover orifice is 32.50 (= 1.0023 × 32.43). These corrected figures are given in Table 10.

The *PV* deviation expressed in per cent is as follows:

At 200.5 lb. per sq. in. (14.9 atmospheres), 2.96 per cent
146.5 lb. per sq. in. (11.2 atmospheres), 1.66 per cent
96.0 lb. per sq. in. (7.7 atmospheres), 0.70 per cent
47.0 lb. per sq. in. (4.2 atmospheres), 0.14 per cent

These percentages will be found plotted in Fig. 14.

While these figures are given more for their interest as a mathematical analysis, the method used appears to possess advantages. It relies for its accuracy on the correctness of a stop watch, pressure gage and thermometer, and is absolutely independent of the reservoir volume, prover calibration, or gravity of the gas.

The gas tested was taken out of a line supplying Oklahoma gas, which was a mixture from the Cushing and Pawhuska fields and had a gravity of 0.672.

It will be noted that the magnitude of the deviation as found in these tests is considerably smaller than any found by the

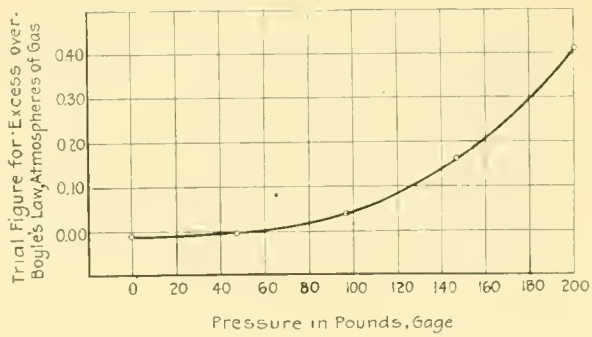

Fig. 13 Method of Correcting for Assumption that Boyle's Law is Correct Between 0 and 50 Lb. Per Sq. In.

Ordinate Value at Zero Abscissa = minus 0.010

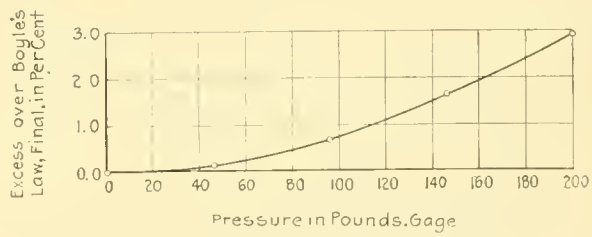

Fig. 14 Final *PV* Discrepancy Curve

TABLE 10 FINAL FIGURES, CORRECTED FOR ORIGINAL ASSUMPTION THAT BOYLE'S LAW IS TRUE UP TO 50 LB. PER SQ. IN.

Run No.	Calculated Constant for Prover Orifice, Based on Boyle's Law Calculation of Gas Quantity	Ratio of 32.50 (the Correct Constant, Calculated from No. 1 Curve, Fig. 13) to Value in Previous Column	Excess Over Boyle's Law for Each Run		Accumulative Excess Over Boyle's Law (Initial Pressure to Zero Pounds)	
			Atmospheres	Cu. Ft.	Atmospheres	Cu. Ft.
1	30.39	1.0695	0.258	70.8	0.443	121.4
2	31.33	1.0375	0.131	35.9	0.185	50.6
3	32.05	1.0142	0.048	13.1	0.054	14.7
4	32.43	1.0023	0.006	1.6	0.006	1.6

authors and that the shape of the curve is quite different, but as the samples tested by the authors did not come from Oklahoma, this may not be significant.

MESSRS. BURRELL AND ROBERTSON GIVE U. S. BUREAU OF MINES FORMULA

G. A. BURRELL[1] AND I. W. ROBERTSON[2] (written). The Bureau of Mines have been developing a formula by means of which the deviation of any natural gas, at any pressure, can be determined from a simple analysis of the gas. The advantage lies in the ease with which analyses may be made. See Bulletins 15, 42 and 88 and Technical Paper 109, Bureau of Mines, covering analysis of natural gas and other characteristics.

In order to develop a formula by means of which the compressibility of natural gas (deviation from Boyle's law) could be determined from the analysis, the compressibility of the gases found in natural gas, principally methane, ethane, propane and carbon dioxide, were first determined. The compressibility of nitrogen has been determined by others. This preliminary information is given in the form of curves in Fig. 15. In Fig. 16 is shown the compressibility of the natural gas used in two cities. In Table 11 are the analyses of these two samples, together with seven others.

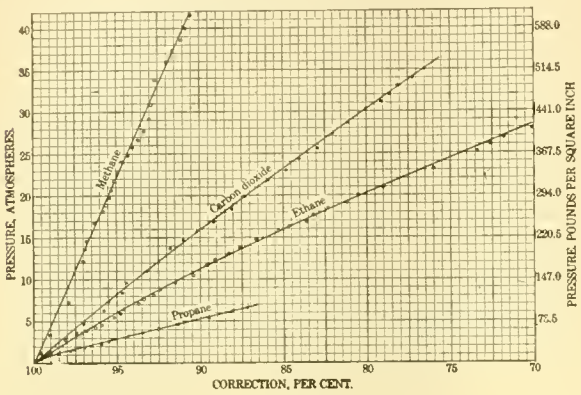

FIG. 15 COMPRESSIBILITY OF GASES FOUND IN NATURAL GAS

TABLE 11 PERCENTAGE ANALYSES OF SAMPLES OF NATURAL GAS FOUND IN NINE CITIES IN THE UNITED STATES

City	CO_2	CH_4	C_2H_6	N_2	Total
Little Rock, Ark.	1.0	96.7	0.0	2.3	100
Bartlesville, Okla.	2.8	89.1	4.2	3.9	100
Cleveland, Ohio	0.0	83.6	15.7	0.7	100
Los Angeles, Cal.	25.1	59.1	14.5	1.3	100
Palestine, Ill.	0.5	95.6	0.0	3.9	100
Buffalo, N. Y.	0.0	88.1	11.5	0.4	100
Kansas City, Mo.	0.8	84.1	6.7	8.4	100
Charlestown, W. Va.	0.0	76.8	22.5	0.7	100
Olney, Ill. (H_2S = 1.2 %)	0.0	37.5	59.6	1.7	100

The formula was developed as follows: Suppose it is desired to determine the compressibility of the natural gas used in Buffalo at 40 atmos. pressure. Buffalo gas has the following percentage composition: CH_4, 88.1; C_2H_6, 11.5; N_2, 0.4. At 40 atmos. the partial pressure of the

$$CH_4 = 0.881 \times 40 = 35.2 = P_1$$
$$C_2H_6 = 0.115 \times 40 = 4.6 = P_2$$
$$N_2 = 0.004 \times 40 = 0.2 = P_3$$

According to the compressibility curves shown in Fig. 15, the deviations per atmosphere are as follows:

for CH_4, 0.228, $= a$ for C_3H_8, 1.90, $= c$
for C_2H_6, 0.900, $= b$ for CO_2, 0.67, $= d$
for N_2 (not shown), 0.01 $= e$

The total deviation D then becomes

$$D = aP_1 + bP_2 + \text{etc.}$$

The deviation of Buffalo gas at 40 atmos. is then

$$D = (0.228 \times 35.2) + (0.90 \times 4.6)$$
$$= 8.03 + 4.14 = 12.17 \text{ per cent.}$$

The calculated and determined deviations at a pressure of 20 atmos. for different natural gases experimented with by the writers are recorded in Table 12; and the results there given show that it is possible to calculate the compressibility of different natural gases, having given the analysis of the gas.

TABLE 12 CALCULATED AND DETERMINED DEVIATION FROM BOYLE'S LAW OF DIFFERENT NATURAL GASES AT A PRESSURE OF 20 ATMOSPHERES.

	Per Cent Deviation Observed	Per Cent Deviation Calculated		Per Cent Deviation Observed	Per Cent Deviation Calculated
Little Rock	5.8	4.4	Buffalo	6.0	6.1
Bartlesville	4.8	4.8	Kansas City	4.0	4.4
Cleveland	4.3	4.5	Charleston	6.4	7.5
Los Angeles	7.8	7.6	Olney	12.3	12.4
Palestine	4.2	4.4			

MR. WEYMOUTH GIVES SIMPLE AND PRACTICAL METHOD OF MEASURING GAS UNDER HIGH PRESSURE CONDITIONS DESPITE VARIATION

THOMAS R. WEYMOUTH (written). At the suggestion of Mr. Wyer, I made a test of a gas from Roystone Station, where the samples indicated in Tables 1 and 2 were obtained, by a method originally proposed by Mr. E. B. Rosa of the Bureau of Standards. This consisted in filling a small tank of known capacity with the gas at high pressure, which, after its temperature and pressure had been observed, was expanded into a 10-cu.-ft. meter prover. The increase in volume, as indicated by the lift of the prover drum, added to the volume of the

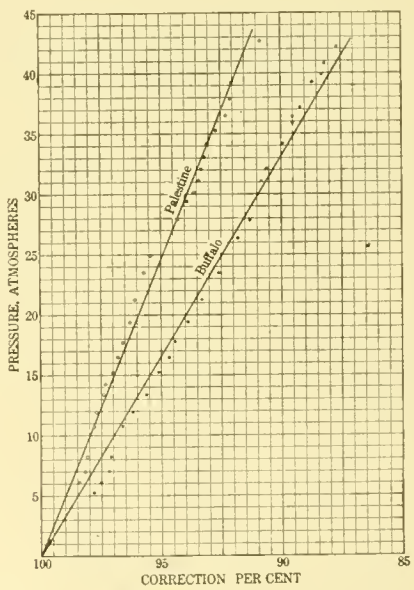

FIG. 16 COMPRESSIBILITY OF NATURAL GAS

[1] In charge, Laboratory of Gas Investigations, Bureau of Mines.
[2] Junior chemist, Bureau of Mines.

original container, gave the total volume of the gas at the pressure and temperature in the prover. In order to maintain the temperature of the gas as nearly constant as possible, it was expanded very slowly, at a rate of about one-half a cubic foot per minute. After the expansion was complete and observations of the lift and pressure of the prover had been made, the connection to the container was broken and the gas was allowed to flow from the prover through the connecting hose with a thermometer in its path, which immediately settled to the value given in the data and remained there. This temperature was the same as that obtained on similar observations of air, made just previous to the run on gas. This, therefore, is considered as giving the true temperature of the expanded gas.

The high pressure of the gas in the tank was measured by means of a sensitive bourdon spring test gage, calibrated against a dead-weight tester at the time of the test. The temperature of the gas in the tank was observed by means of a thermometer placed in contact with the exterior of the tank and heavily lagged. Three observations of pressure and temperature were made after having allowed the container to remain in rooms of different temperatures long enough to become constant in each instance, and from these observations the pressure existing in the tank at the temperature of the expanded gas was computed. The average of the three results was then used in the final computations. The data obtained were as follows:

V = volume of container at 60 deg. fahr. = 0.3938 cu. ft.

B = barometer at time of test = 29.08 in. = 14.249 lb. per sq. in.

Pressure in gas container =

p' = 277.15 lb. per sq. in. gage at 72.5 deg. fahr.

p'' = 270.50 lb. per sq. in. gage at 61.4 deg. fahr.

p''' = 271.00 lb. per sq. in. gage at 62.0 deg. fahr.

or P' = 283.85 lb. per sq. in. absolute at 58.7 deg. fahr.

P'' = 283.85 lb. per sq. in. absolute at 58.7 deg. fahr.

P''' = 283.45 lb. per sq. in. absolute at 58.7 deg. fahr.

Avg. P = 283.53 lb. per sq. in. absolute at 58.7 deg. fahr.

h = pressure in prover through test = 2.07 in. water

P_0 = absolute pressure of expanded gas = $B + 0.036h$ = 14.324 lb. per sq. in.

L = increase in volume = lift of prover = 8.07 cu. ft.

N = actual ratio of total expanded gas volume to the volume of high pressure gas = $(L + V)/V$ = 21.492

N_0 = ratio of volumes according to Boyle's law = P/P_0 = 19.794.

Deviation factor = N/N_0 = 1.0858.

In other words, the percentage error of this gas is 8.58 at a pressure of 283.53 lb. per sq. in. absolute, or 19.29 standard atmospheres. The analysis of the gas showed it to contain 56.0 per cent methane, 36.2 per cent ethane and 7.8 per cent nitrogen.

This method of testing gases to determine their deviation from Boyle's law is extremely simple and rapid, and, I believe, will furnish a ready means for the determination of correction factors to be applied in the commercial measurement of high-pressure gas.

The error introduced by the assumption of the validity of Boyle's law in cases where actual volumes at high pressure are measured by a volumetric meter and reduced to standard conditions by applying direct pressure ratios, is double the error in the measurement by rate-flow meters, such as the pitot tube and orifice, wherein the pressure factor enters under the radical sign.

In order to apply the information given in the paper to actual measurement problems, I have assumed an empirical equation of the form $P^nV = KT$, wherein the characters have the usual significance. Applying in this formula the original observations at about 2 and 20 atmos., the results are shown in Table 13, from which it is seen that the exponent of P is fairly constant, considering the wide variation in the constitution of the gases tested. From this fact I believe that much closer approximations to the true measurement of natural gas can be obtained by the use of the formula given than is now the case with the assumption of Boyle's law.

TABLE 13 COMPUTED VALUES OF n FROM $P^nV=KT$

Gas of	P_1 Obs.	V_1 Obs.	T Obs.	P_2 Obs.	V_2 Obs.	n Computed	Gravity
Fig. 5...	2.029	41.31	534.8	20.706	3.69	1.040	0.66
.....	2.020	41.35	526.2	20.709	3.73	1.033	0.65
Table 1..	2.024	41.62	526.1	20.705	3.82	1.027	0.66
Table 2..	1.936	42.03	528.4	18.214	4.02	1.047	0.75
Table 3..	1.936	42.10	527.6	20.708	3.67	1.030	0.56
.....	2.018	40.98	533.9	20.700	3.75	1.027	0.76
Table 4..	2.022	41.07	527.1	20.708	3.70	1.033	0.67
Table 5..	1.884	38.12	526.6	20.701	3.10	1.047	0.66
T.R.W.	14.320	8.464	518.7	283.530	0.3938	1.028	....
Average.....						1.035	....

In order to determine how closely the empirical formula adheres to the actual expansion curve given by the authors, I have computed from the test of Table 1 the volume corresponding to the observed pressures, using the formula $P^{1.027}V = 85.86$. The deviation of the computed from the actual is less than 1 per cent up to 30 atmos., and by slightly changing the exponent of P and the value of K this deviation can be made much smaller.

It seems, therefore, that in spite of the wide deviation of natural gases from Boyle's law, it is quite possible and practical to obtain correct measurements under high-pressure conditions well within the commercial requirements of accuracy, by means of this comparatively simple empirical relationship, readily determined for any gas by the method described.

In order to employ the equation in the transformation to standard conditions of measurement made by volumetric apparatus, it is merely necessary to multiply the measured volume by the nth power of the absolute pressure ratios.

In the case of measurements with rate-flow meters, such as the orifice or pitot tube, the pressure factor under the radical in the usual formula of such instruments (see Journal Am. Soc.M.E., Dec., 1912, p. 1645) is used with the exponent n, and the numerical coefficient is changed to correspond with the proper value of K in the empirical formula.

In connection with the observed vibration of the mercury column at certain pressures, which the authors explain as due to the liquefaction of the heavy hydrocarbons in the gas, it would be interesting to know if any attempt was made to compute the partial pressures of these heavy gases from the observed pressures and the gas analyses, and note whether or not they were the same for the different samples experimented upon. This should be approximately true in cases where the relative proportions of the various heavy hydrocarbons, reported as ethane, are nearly alike.

MR. FISHER EXAMINES FACTORS OF METHODS USED BY DIFFERENT INVESTIGATORS

F. P. FISHER (written). Because of the disagreement in numerical results obtained from experiments on the deviation of natural gas from Boyle's law when slightly different methods have been used upon similar gases, the writer is led to examine in detail some factors of the methods used which might have led to erroneous conclusions in any or all of the experiments to be quoted.

In the work done in our laboratories, the method used by Mr. Baxter was that of expanding the gas from a metal container of known volume into a second similar container, similar in principle to the cubic-foot bottle, and observing the volume of the expanded gas delivered in order to effect a given reduction in pressure in the original container. This roughly reproduced the conditions under which the gas is expanded in actual industrial application. The experiments were originally attempted by measuring the expanded gas in a precision gasometer of small bore and long travel, but the results were unsatisfactory because of the very difficult element of vapor tension in measuring over water, which showed the necessity of dry measurement.

In the work done at the laboratory of Kansas University at Lawrence, by Prof. Walker and Prof. Garver, a mercury column was used as a source of pressure, and the method of compression was very similar to that in the experiments of Earhart and Wyer, with the exception that the precaution was taken to guard against the presence of water vapor in the gas sample by passing the gas carefully through chloride drying tubes before entering the apparatus. The importance of this was pointed out by our own experience in measuring over water. I do not find reference to any such precaution in the paper under discussion. The pressure in the Kansas University experiments was limited by the available height of the mercury column to slightly over 200 lb., but the apparatus admitted of very accurate work in the very important range between 1 and 2 atmospheres.

Taking specific examples of the results of these three series of experiments at a pressure of about 200 lb. and on similar gases, I find that the relative numerical value of the deviation was approximately 2, 4 and 6 per cent, maintained consistently through a considerable number of samples in each case, and considering the experiments in the order of Baxter, Walker and Wyer. This difference makes necessary first, a careful analysis of the methods to arrive at the possible cause of the difference, and second, corroborative experiments verifying any theories deduced as to the cause of the difference.

I would confine the present discussion to pointing out some possible causes for this difference, which should be validated by various experiments. Our own work has pointed out the great importance of freeing the gas from water vapor in order to get significant results. From this I would assume that the difference between the two compression methods, where similar samples were compressed in carefully calibrated tubes, would lie largely in the fact that the gas was carefully freed from water vapor in one of the tests.

The difference between the expansion and compression methods is more difficult, but a reasonable and possible explanation appears to be pointed out near the close of the authors' paper, where they refer to the probable condensation of a minute volume of invisible fluid under certain specific degrees of compression as practically demonstrated by their observations.

Our knowledge of oils, gasolines and fluids of the paraffin series would tend to show that such liquids will wet glass surfaces freely, whereas glass strongly repels mercury, giving a high and inverted meniscus as compared with gasoline. Any fluid formed would therefore have a strong tendency to wet the glass surface and remain below the upper surface of the mercury as compression was carried to the higher point, giving a false observation as to the true reduced volume by not including all of the substance of the original gas above the mercury. Any fluid thus trapped would represent a relatively large volume of the original gas, so that the slightest tendency in this direction would materially affect the value of the final observations.

It is necessary in filling a good barometer tube to boil the mercury for some time in all parts of the tube to remove the air from the surface of the glass. I would therefore infer that there is considerable probability that in these experiments of compression over mercury, irrespective of the condensation of small quantities of fluid, that a volume of the gas itself is attached to the surface of the glass as the mercury column ascends, giving an unobserved deduction from the true quantity of substance and consequently a false reading of the volume.

In the concluding paragraph Mr. Wyer refers to experiments with a different apparatus in the range between 1 and 2 atmos., in which there was no perceptible change from Boyle's law within those limits. This result seems to be contradictory and irreconcilable with the shape of the curve of per cent deviation in the charts given, which show a maximum divergence of the curve from a horizontal line in the range immediately beyond 2 atmospheres. It would not seem reasonable or consistent with other experiments along the same line that gas should be compressed from absolute pressure of 1 atmos. to 2 1/3 atmos. "with no perceptible deviation from the law" and begin sharply at 2 atmos. to attain the maximum rate of deviation from this same law, for a given increase in pressure, falling off to a minimum deviation at a pressure higher than 4 or 5 atmospheres.

Before accepting as final any of the numerical values so far proposed, more work of a very careful nature should be done upon this subject of divergence from Boyle's law.

COMMERCIAL FACTOR OF DEVIATION POINTED OUT BY MR. BAXTER

W. C. BAXTER[1] (written). The 1912 U. S. report shows 600,000,000,000 cu. ft. of natural gas used in the United States per annum (not 600,000,000).

The authors' statement about the deviation from Boyle's law being in favor of the purchasing company when measured at high pressures is based upon only seven samples of gas tested, and does not necessarily apply to the United States as a whole.

The tests show the expected deviation from Boyle's law without proving it to be a commercial factor and without suggesting a means for correcting for this deviation. The authors point out the impracticability of attempts to correct for the deviation by saying that different gases have marked differences of deviation, and that no relationship can be established, since the exact ethane content cannot be determined, any higher hydrocarbon present being shown as ethane in the usual analysis. Furthermore, any appreciable amount of the higher hydrocarbons would probably have a greater influence than a high percentage of ethane.

Refinements in the measurements of natural gas are to be welcomed by purchaser and selling company, but the statement

[1] Wichita Natural Gas Co., Bartlesville, Okla.

that "the direct application of Boyle's law to high-pressure gas measurements gives an exceedingly rough approximation" is very alarming, if not altogether misleading, since it is made without regard to other considerations that enter into the measurement. The authors, evidently, are not familiar with actual field conditions and the many measurements that are made at high pressure and found to be consistent.

Any sand, oil or water passing through a meter would not be affected by deviations from Boyle's law, but their presence in any considerable quantity results in an overmeasurement. In practically all field measurements, large quantities of water vapor and oil vapor are condensed after having passed the meter, causing a shrinkage or loss to the purchasing company. The difficulty of removing such vapors at or near the fields can be appreciated only by those having actual field experience.

From a commercial standpoint, actual measuring conditions should be considered rather than a single isolated factor.

The remarkable feature of the test results is that the percentage deviation curve has a point of inflection at 2 atmos. pressure, when the tests at lower pressure, not published, show no deviation. This would indicate that the roughest approximation would be made by applying Boyle's law at or near 2 atmos., introducing an uncertainty as to which party is favored. The upper parts of the curves indicate that the percentage factor might become constant or decrease with a sufficiently high pressure. However, very little natural gas is measured above 400 lb. per sq. in. gage, and an extension of the curve would be of no practical value.

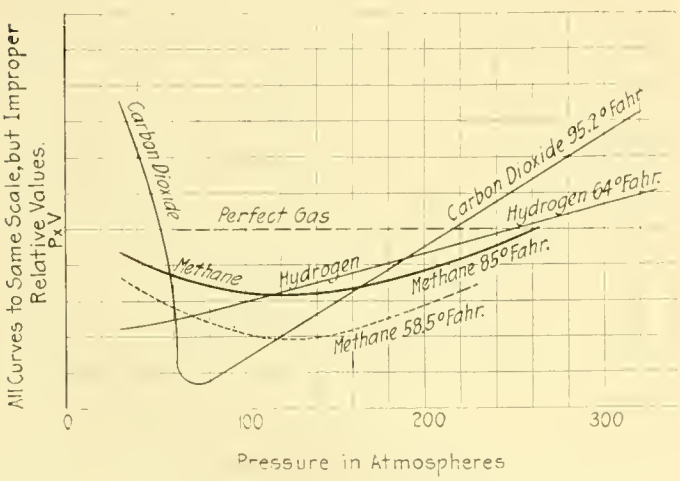

Fig. 17 Characteristic Variations of Gases from Boyle's Law

PROFESSOR WALKER CALLS ATTENTION TO APPARENT INCONSISTENCIES IN THE RESULTS

P. F. Walker (written). I have taken great interest in the matter treated in this paper, which bears upon the work of several scientists of note, particularly upon that of Amagat.

Amagat set up a mercury column with which to measure pressures in a mine shaft where he could secure high pressures, and for a gas-measuring tube employed a closed tube similar to that employed by the authors. After developing the characteristic curve for hydrogen shown in Fig. 17, he proceeded to investigate several gases not far removed from their critical states at ordinary temperatures, such as carbon dioxide, ethylene, and methane. The form of characteristic curve for the first two is that shown in Fig. 17 and marked carbon dioxide. The critical point, where the gas changes from diminishing to increasing values of the product, PV, is sharply marked. For higher temperatures this is less sharply defined, as represented for methane. At the higher temperatures and pressures the curves all appear to approach the form of that for hydrogen.

On the low-pressure side the gases close to saturation pass promptly from the critical point to a form of curve convex toward the horizontal line indicating the perfect gas, which convexity continues to the lowest pressures. At the lowest pressures the rate at which the gas deviates from the perfect gas with changing pressure becomes small, the curve being asymptotic to the horizontal. As these gaseous vapors become more like true gases this convexity diminishes, it being as though the methane curves of Fig. 17 were continued to the left without reversal of curvature. Whether methane reverses or not has not been shown absolutely as yet, but there is evidence to show that at the lower temperatures the curve does reverse.

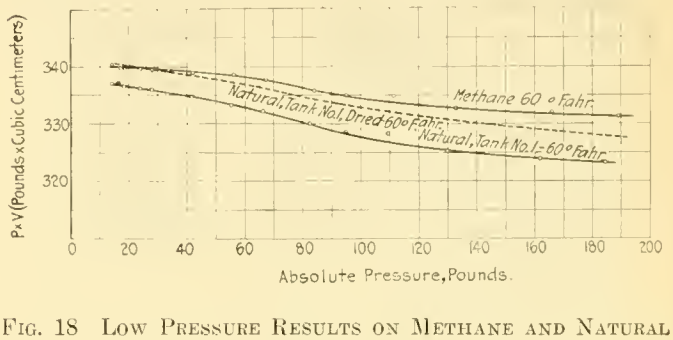

Fig. 18 Low Pressure Results on Methane and Natural Gas

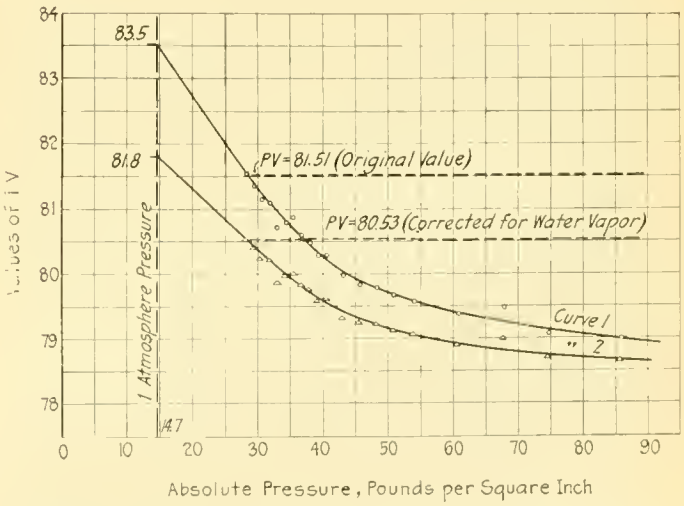

Fig. 19 Authors' Values in Table 3 Replotted and Extended

Fig. 18 shows the definite character of the curve for methane at 60 deg. fahr. for pressures down to atmospheric, as determined with the apparatus in use in the Kansas laboratory. Alongside the methane curve is shown, also, the curve for a sample of natural gas containing about 87 per cent methane drawn from the Kansas-Oklahoma gas field. The effect of drying this gas before its admission to the measuring tube of the apparatus is shown by the broken curve to be but slight. The undried gas indicates a greater total deviation from the

perfect gas, and both indicate greater deviation than does pure methane.

These curves are in sharp contrast to the form of curve given by the data supplied by the authors. Fig. 19 is constructed from the data taken from Table 3 by the authors, it being for the natural gas which contains 98.6 per cent methane, with the remainder nitrogen. If the sharp curvature secured by the authors for all of their gases at the low pressures were due to the presence of condensible vapors, we would expect this curve for almost pure methane to be distinctly different in form. The only difference is in magnitude, however, which really is the result to be expected. The curve on original data in Fig. 19 has been extended to meet the atmospheric pressure line, at a value of PV of about 83.5. If percentages of variation were to be calculated from this value, and in the gas business we want volume referred to atmospheric pressure, they would be considerable greater than those given by the authors.

As to the form of the curves at low pressures, it is clear that the sharp variation is such as would be produced by a constant error in the observed pressures. Such an error, the amount being added to the true pressure, would be of maximum significance at low pressure where the added quantity would be large in proportion to the true value, and would produce an effect on the form of the curve as noted. In order to determine if the presence of water vapor in the gas would account for the peculiarity, I have recalculated the values of PV after deducting from P the partial pressure which would be produced by vapor in the saturated state at the temperature of 67.6 deg. fahr. This partial pressure is 0.337 lb. per sq. in., or 0.023 atmos. The result is shown in Curve 2 of Fig. 19. Clearly this is not enough to change the form vitally, although it acts in that direction.

All of these curves in Figs. 18 and 19 should be viewed as extensions of the curves for methane by Amagat as shown in Fig. 17, the extension being to the left into the region of low pressure. The scales of these drawings differ so greatly that the imagination must assist the eye in taking this view. It would be unnatural to expect so sharp a change in characteristics of the gas at the low pressures as is indicated in the results of the authors, and then after an increase in pressure come to the critical point of change indicated in Amagat's curves by a curvature in the same direction as the first. It is not to be expected that the maximum rate of deviation would come at the lowest pressure unless it is produced by a combination of several vapors in saturated condition. As much as I admire the excellent work which has been done by the authors, I cannot agree with the results here shown as regards the deviation at low pressures. I wish to emphasize again that it is important in the natural-gas industry to obtain the variation in volume between the measurement made at some high pressure and that at a pressure close to one atmosphere. These deviation curves, if extended in accordance with the same general law of curvature, would show from atmospheric pressure conditions a deviation so great as to be out of proportion.

W. F. M. Goss remarked that the paper was an instance of the permanent value of researches going on in our great educational institutions.

Gardner T. Voorhees said that he had made an investigation with carbon dioxide and had concluded that "at the critical point, and for some distance above it, the substance might be a chemical mixture in solution in the gas and not a chemical mixture."

According to *The Engineer* (July 28, 1916), it has been found that ordinary cast iron can be readily cut by a carpenter's saw if the iron be heated.

The pitch diameter ($P.D.$) of a V-grooved pulley can be readily determined from the formula: $P.D. = D + (d/\sin \frac{1}{2}a) - (b/\tan \frac{1}{2}a)$, where D = diameter at bottom of groove, d = diameter of belt, and b = width of groove at bottom, all in inches; a = angle between sides of grooves, deg.—C. A. M. Weber, in *The Electric Journal*, August, 1916.

The initial pressures of different explosives when detonated in their own volume are as follows: Straight dynamite (nitroglycerine mixed with an inert base), 80 tons per sq. in.; blasting gelatine, 113 tons; guncotton, 71 tons; black powder, 21 tons. Blasting gelatine, the most powerful, has the highest rate of detonation: 25,262 ft. per sec. as against 22,368 for straight dynamite and 984 for black powder.—*Mining and Scientific Press.*

A machine for cutting the teeth of double helical or herringbone gears, designed and patented by W. F. Sykes, is described in *Engineering*, July 14, 1916. The machine is a development of the principle underlying the well-known Fellows gear shape (Edwin R. Mem.Am.Soc.M.E.), the teeth being formed in the blank by cutters which are themselves gear wheels. Two cutters are employed, one of which cuts the teeth belonging to the left-hand helix, and the other those corresponding to the right-hand helix. The cutters are reciprocated to and fro by cranks, and the teeth thus cut meet in a sharp angle, without the clearance which is necessary in the case of hobbed gears.

In a recent address before the Brooklyn Engineers Club, William J. Baldwin, Mem.Am.Soc.M.E., gave a description of an apparatus designed by him to be placed between the boilers of a power house and the stacks for preventing the discharge from the latter of cinders and dust. Such elimination has been successfully accomplished with the aid of water; numerous installations operating under that method being in use. However, it was stated that too much water cools the gases and impairs the draft, that the corrosive action set up by the water in the presence of flue gases eats away the smoke connections, and that even cement surfaces and chimney linings are injuriously affected.

Mr. Baldwin's method is denominated a dry one, and when operating in that way it has been shown that as high as 95 per cent of the dust has been removed, and practically all of it when water is used in addition. An advantage in designing such a method is offered by the fact that, given favorable conditions, there will be a gravity precipitation of the dust from the air.

The dust is centrifugally expelled throughout a complete circle within an annular enclosure and through a perforated flat ring therein, the particles remaining in the box and falling to its lower side for later removal.

When the annular chamber was revolved it was found that an added impulse was acquired by the particles projected against the inner surface and they were thus prevented from returning. For this reason the annular chamber was made revolvable.

Alluding generally to the necessity for eliminating dust and cinders from flue gases, Mr. Baldwin stated that with boilers so frequently being operated at 300 per cent rated capacity, the demand for such removal was more insistent than ever.

EXPERIMENTS ON WATER FLOW THROUGH PIPE ORIFICES

By HORACE JUDD, COLUMBUS, OHIO

Member of the Society

DURING the past ten years papers upon the flow of fluids have appeared from time to time in the Transactions of the Society; most of these have dealt with the flow of air and gas, although a few have treated of the flow of steam. The methods set forth in these papers have for the most part centered around the venturi meter and the pitot tube.

During this period, also, many forms of meters have been brought out for the measurement of air, gas and steam, as well as of water, all more or less successful in operation, and of these, also, a great many have made use of the principles of the venturi meter or the pitot tube.

The pipe orifice, consisting of a diaphragm in which there is an orifice inserted in a pipe, has not hitherto met with much favor for the measurement of the flow of steam or water in a pipe, although it is coming into use for air and gas measurement and has been used with certain types of steam meters of German make and also in Bailey flow meters.

The chief objections to the pipe orifice have seemed to be that a special form of orifice flange was needed and that considerable uncertainty prevailed concerning the pressure conditions adjacent to the orifice, so that the working coefficients for an orifice in a pipe were not so reliable as those of the venturi meter or the pitot tube.

About two years ago, while employing the Bailey meter to measure the steam used by an engine, the writer became interested in the orifice as a pipe-flow measuring device. It was important to know at what point near the orifice the attachment should be made in order to measure correctly the pressure drop of the steam flowing through the orifice. It was thought at the time both by Mr. Bailey and the writer that an investigation would reveal many valuable point concerning the flow conditions through the orifice in a pipe. The present line of work is the final outcome of this thought and has been carried on in connection with water flow, since water could be more easily handled than steam, the intention being to continue later with a study of the flow conditions in a steam line. The work was done in the hydraulics laboratory of the Ohio State University. The experiments on the orifice diaphragms in the pipe formed the thesis of H. J. and W. W. Watson, of the Class of 1915, in Mechanical Engineering, for whose able assistance within the past year credit is hereby duly given.

The paper is really a record of progress, for only a few points have been touched upon, such as the pressure changes in the vicinity of the diaphragm, or orifice; the probable location of the least section, or zone of greatest velocity of the water jet; and the working coefficients of the diaphragms; leaving many other points of equal interest and importance to be studied later. The experiments were confined to one size of water pipe (5-in.) and the pressure drop through the diaphragm did not run much in excess of 6 ft. of water, which was considered to be the probable maximum drop desirable to use in connection with any automatic registering device. For the largest diaphragm this range of pressure drop gave a maximum velocity of 17.5 ft. per sec.

SYNOPSIS

A series of experiments was made on 5-in. pipe orifices, both cap orifices and orifices inserted in a 5-in. pipe flange placed in a horizontal water line.

The purpose of the tests were:

a To study the pressure relations existing in the vicinity of an orifice in a pipe in order to determine the most suitable point of attachment for manometer connections.

b To note the position of greatest pressure drop due to flow through the orifices.

c To obtain reliable coefficients of discharge for the orifices.

The orifice diaphragms (of Monel metal, outer edge corrugated to form gasket) ranged from 4.5 in. diameter to 1 in. diameter in ½-in. steps, giving a series of 90 to 20 per cent pipe diameter sizes with concentric openings. Two sizes of eccentric and segmental diaphragms having offset orifice openings equal in area to the 90 and 80 per cent diameter sizes were also tested.

Pressure connections were made on each side of the pipe at six points in one pipe diameter above the diaphragm and at eleven points at varying distances in five pipe diameters below the diaphragm. A series of curves have been plotted showing the pressure variation between a fixed point above and the various points below the diaphragm.

Coefficients of discharge have been computed from volumetric measurement of the water discharged by the orifices. Discharge curves are also included for all the pipe orifices, plotted on logarithmic coördinate paper for ready reference.

The average diaphragm coefficients range from 0.602 to 0.706 and the 5-in. cap orifice coefficients range from 0.610 to 0.637 for the 40 to 90 per cent orifices.

The conclusions reached in the paper are:

1 The plate orifice in pipe is as reliable for flow measurement as the ordinary thin plate orifice.

2 The point of maximum pressure drop is at about ½ pipe diameter from the diaphragm.

3 The eccentric and segmental orifices increase the pressure drop reading, but more care is necessary in making pressure connections.

4 The best point for pressure connection is not less than ½ pipe diameter below diaphragm and not less than 1 pipe diameter distance above the diaphragm.

5 For steady flow conditions the 80 per cent size should not be exceeded.

6 The average coefficient of discharge for the 5-in. pipe diaphragm agrees very closely with that for the 5-in. pipe cap orifice.

7 The coefficients of the pipe diaphragm vary more nearly in accord with the variation in size of diaphragm orifice than those for the 5-in. pipe cap orifice.

8 The agreement is closer for all the pipe orifices at about 80 per cent diameter ratio.

9 The point of maximum velocity of flow is apparently a function of the pipe diameter and not of the diameter of the diaphragm orifice.

10 The restoration of pressure on the downstream side of the diaphragm is apparently a function of the area of the diaphragm.

Presented at the Spring Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New Orleans, La., April, 1916. Pamphlet copies without discussion may be obtained; price 15 cents to members, 30 cents to non-members.

PURPOSE OF THE TESTS

In general, the purpose of the tests was

a To discover the pressure relations existing immediately above and below an orifice diaphragm in a pipe in order to determine the most suitable points for making the pressure connections (for the manometer).

b To note the position of greatest pressure drop due to flow through the orifice, or the probable point of greatest velocity, corresponding to the point of least section of a jet of water flowing freely into the air.

c To obtain reliable coefficients of discharge for orifice diaphragms of different diameters.

THE EQUIPMENT

For these experiments a horizontal line of 5-in. standard pipe was used, approximately 42 ft. long, in which was located an extra-heavy flanged coupling for holding the orifice diaphragms. The heavy coupling was not required for strength, but was employed to allow the use of diaphragms adapted for

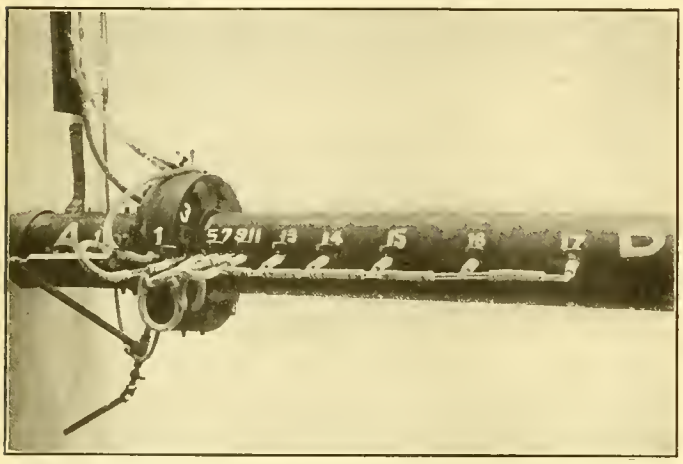

Fig. 1 Manifold and Manometer Connections at the Diaphragm Flange

high-pressure pipe and fittings. In Fig. 1 is a view of the pipe, flanges and manometer connections, and from the diagram in Fig. 4 it will be noted that the location of the diaphragm is 21 ft. 11 in. below an ell and 20 ft. 2 in. from the discharge end of the pipe, on which is screwed a cap having a discharge orifice. Water was supplied to the pipe line by a 6-in. centrifugal pump direct-connected to a steam turbine. The water was measured by means of several large measuring bays.

The diaphragms were all formed from plates of Monel metal $^1/_{32}$ in. thick, with the outer rings of their surfaces, above 5.1 in. diameter, corrugated to form a tight joint between the flanges, without the use of gaskets. The orifices were bored out accurately to size and were of three types: (1) Concentric with the rim of the diaphragm; (2) eccentric with the rim; and (3) segmental.

There were eight concentric diaphragms and two each of the eccentric and segmental diaphragms. The concentric diaphragms had orifices ranging from 4.5 in. diameter to 1 in. diameter, by steps of 0.5 in., making a series in terms of pipe diameter of 90, 80, 70, 60, 50, 40, 30 and 20 per cent diameter sizes. The eccentric and segmental diaphragms were in two sizes, having orifices equal in area to the 90 per cent and 80 per cent concentric sizes mentioned above.

The eccentric diaphragms were made with the edge of the orifice just flush on one side with the inner surface of the pipe. The orifices of the segmental diaphragms were of the same diameter as the inside of the pipe, but had strips inserted which were so located as to produce segmental openings equal in area to the 90 per cent and 80 per cent sizes of the concentric diaphragms. The three types of diaphragms are shown in Fig. 2. These diaphragms were furnished by E. G. Bailey

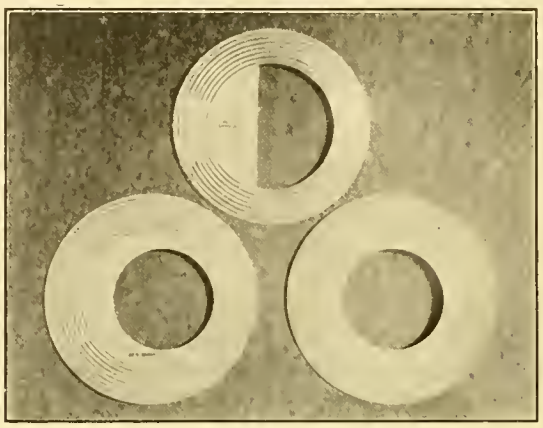

Fig. 2 Types of Diaphragms Used

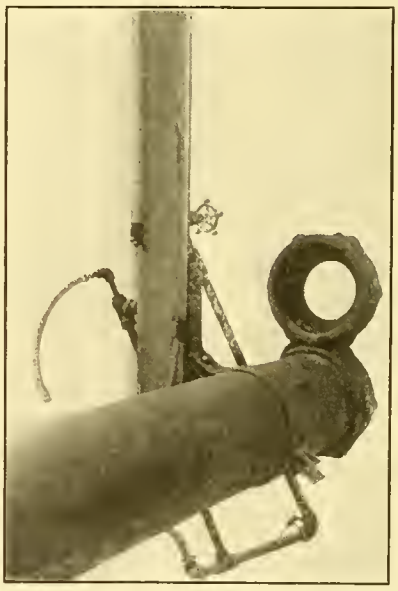

Fig. 3 Orifice at End of 5-In. Pipe with Manometer or Gage Glass Connection

and are the standard form of orifice plate used in the Bailey fluid meters.

PIPE-CAP ORIFICES

Pipe-cap orifices were placed on the end of the 5-in. pipe (Fig. 3), to provide a means for regulating the water contents of the pipe below the diaphragm and so control more easily the pressure drop through the diaphragm. These orifices also gave an opportunity to secure data for computing the coefficients of discharge for this form of orifice. The pipe-

cap orifices varied in size, ranging from 4-in. diameter to 1-in. diameter by ½-in. intervals. No special refinements were practiced in finishing the caps except to bore and ream the orifices accurately to size and to smooth up the inside surfaces of the caps.

TABLE 1 OBSERVED DATA

4-in. Concentric Diaphragm with 4-in. Pipe Orifice. Run No. 18

Drop in Pressure, Feet Water, at Position Shown									
At A	At B	Manometer			At A	At B	Manometer		
		left	right	total ft.			left	right	total ft.
[1]A5	B1	−2.23	+1.32	3.55	A5	B2	−2 33	+1 36	3.69
	3	2.30	1 33	3.63		4	2.33	1.36	3.69
	5	2.24	1.31	3.55		6	2.22	1.28	3.50
	7	2.10	1.20	3.30		8	1.94	1.07	3.01
	9	1.79	1.00	2.79		10	1.71	0.90	2.61
	11	1.58	0.82	2.40		12	1.55	0.77	2.32
	13	1.28	0.58	1.86		13	1.30	0.58	1.88
	14	1.15	0.46	1.61		14	1.15	0.45	1.60
	15	1.06	0.40	1.46		15	1 07	0.38	1.45
	16	1.05	0.38	1.43		16	1.01	0.34	1.35
[1]	17	−1.04	+0.40	1.44		17	−1.03	+0.35	1.38
[1]A1	B14	−1.27	+0.57	1.84	A2	B14	−1.22	+0.52	1.74
3		1.18	0.47	1.65	4		1.17	0.46	1.63
5		1.16	0.43	1.59	6		1.15	0.44	1.59
7		1.15	0 42	1.57	8		1.15	0.45	1 60
9		1.12	0.39	1.51	10		1.16	0.46	1 62
[1]11		−1.14	+0.42	1.56	12		−1.13	+0.45	1.58
4-in. Eccentric Diaphragm with 4-in. Pipe Orifice. Run No. 22									
[1]A5	B1	−1.98	+1.96	3.94	A5	2	−1.33	+1.43	2.76
	3	2.04	2.01	4.05		4	1.58	1.65	3.23
	5	2.12	2.06	4.18		6	1.60	1.65	3.25
	7	2.06	2.01	4.07		8	1.72	1.78	3.50
	9	1.96	1.93	3.89		10	1.80	1.67	3.47
	11	1.82	1.86	3.68		12	1.58	1.68	3.26
	13	1.51	1.54	3.05		13	1.50	1.56	3.06
	14	1.20	1.32	2.52		14	1.18	1.32	2.48
	15	1.01	1.16	2.17		15	1.02	1.08	2.10
	16	0.86	1.05	1.91		16	1.88	1.07	1.95
[1]	17	−0.83	+1.03	1.86		17	−0.83	+1.06	1.83
[1]A1	B14	−1.21	+1.35	2.56	A2	B14	−0 80	+0.81	1.61
3		1.20	1.35	2.55	4		0.92	1.01	1.93
5		1.11	1.23	2.34	6		0.92	1.01	1.93
7		1.10	1.16	2.26	8		1.07	1.17	2.24
9		1.04	1.12	2.16	10		1.07	1.16	2.23
[1]11		−1.05	+1.16	2.21	12		−1.13	+1.21	2.34
4-in. Segmental Diaphragm with 4-in. Pipe Orifice. Run No. 26									
A5	B1	−2.40	+1.97	4.37	A5	B2	−1.53	+1.35	2.88
	3	2.44	2.00	4.44		4	1.92	1.63	3.55
	5	2.49	2.05	4.54		6	2 01	1.67	3.68
	7	2.47	2.05	4.54		8	2 14	1.81	3.95
	9	2.50	2.07	4.57		10	2.12	1.79	3.91
	11	2.45	2.00	4.45		12	2.16	1 80	3.96
	13	2.13	1.80	3.93		13	2.05	1.70	3.75
	14	1.69	1.42	3.11		14	1.66	1.43	3.09
	15	1.36	1.22	2.38		15	1.40	1 25	2.65
	16	1.21	1.09	2.30		16	1.20	1.05	2.25
	17	−1.15	+1.03	2.28		17	−1.17	+1.02	2.19
A1	B14	−1.56	+1.35	2.91	A2	B14	−1 02	+0 60	1.62
3		1.63	1.44	3.07	4		1.26	0.95	2.21
5		1.64	1.40	3 04	6		1.30	1.02	2.32
7		1.60	0.32	1.92	8		1.38	1.12	2.50
9		1.55	1.23	2.78	10		1.41	1.18	2.59
11		−1.55	+1.25	2.80	12		−1.41	+1.18	2.59

[1] Static gage at A = 6.0

PRESSURE CONNECTIONS

Fig. 4 shows the locations of the pressure connections for the manometer, which are spaced along lines on diametrically opposite sides of the pipe in a horizontal plane with its axis.

Above the diaphragm, on the upstream side, there are six connections on each side of the pipe, and below the diaphragm there are 11 connections. It will be seen that on the right side of the pipe, looking downstream, the pressure connections begin at a point located ½ in. from the plane of the diaphragm and that the first six connections are spaced 1 in. apart; while the remaining five points on the downstream side are spaced respectively 2½, 3, 4, 5 and 5.3 in. apart, making the last one, No. 17, five pipe diameters from the diaphragm plane.

The connections on the left side are similarly placed, except that those nearest the diaphragm are located 1 in. from it, instead of ½ in., and that the five connections farthest away from the diaphragm are placed opposite those on the right side. These connections are designated by odd numbers on the right side and even numbers on the left side, except that the five points farthest away from the diaphragm on both sides of the pipe are given numbers in order from 13 to 17 inclusive.

On the downstream side the connections were made by drilling and tapping holes for ⅛-in. brass air cocks which were screwed into the pipe until their ends were flush with the inside. These air cocks have openings $^3/_{16}$ in. in diameter. A

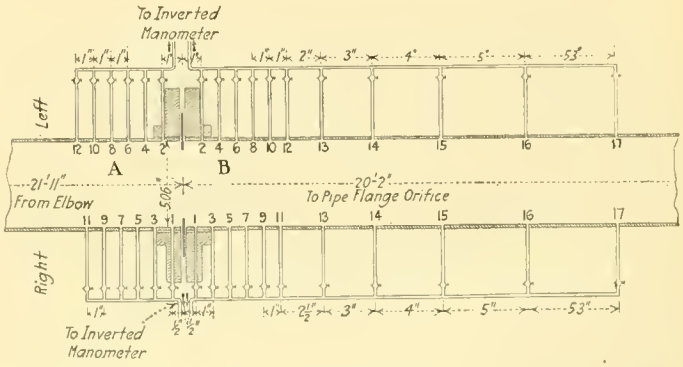

Fig. 4 Position of Diaphragm Flange and Points of Pressure Connections

manifold formed with glass tees and heavy rubber tubing led from these pressure connections to one side of a water manometer 7 ft. in length, the bottom of which is shown in Fig. 1. The glass connections made it possible to see whether the tubes were free from air pockets.

On the upstream side air cocks of the same size were used, but the nipple connections leading to the air cocks were plugged and then drilled with holes of only ⅛ in. in diameter. The manifold for the upstream side was formed from a rigid brass bar, to which the air cocks from the pipe were connected by nipples and from which a rubber tube led to the other side of the inverted water manometer mentioned above.

A second water-gage glass (shown in Fig. 1 with a rubber tubing leading to a connection at the bottom side of the pipe) was used to indicate the head on the diaphragm and to aid in maintaining a more constant water head.

The complete manifold arrangement (see Fig. 4) made it possible to maintain a pressure difference, or drop, between any point of connection above and any point below the diaphragm without disturbing the gage glass which indicated the head on the upstream side of the pipe.

The static head at the cap orifice was read at a point 7.5 in. from the plane of the orifice on a water column whose zero scale reading was on a level with the center of the pipe.

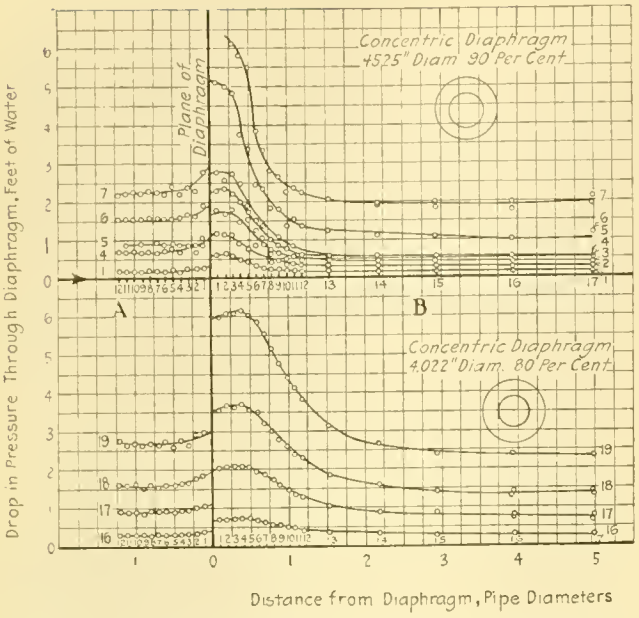

Fig. 5 80 and 90 Per Cent Concentric Diaphragms

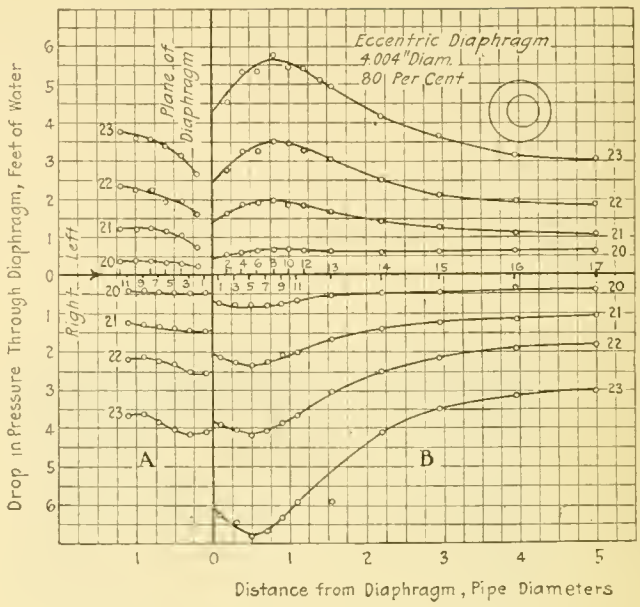

Fig. 6 80 Per Cent Eccentric Diaphragm

PRESSURE TRAVERSES

A series of explorations of pressures was made along the horizontal element of the pipe on each side of the diaphragm, going upstream one pipe diameter and downstream five pipe diameters. In making these explorations, or longitudinal traverses, those on the downstream or B side were all made with the upstream connection open at A-5, or one-half pipe diameter above the diaphragm (excepting for the 90 per cent concentric diaphragm, when A-10 was open). When traversing the upstream or A side, the downstream connection was open at B-14 (excepting for the 90 per cent concentric diaphragm, when B-10 was open). In this way the pressure changes in the vicinity of the diaphragm could be noted. Such traverses were made for four different pressure drops (approximately ½ ft., 2 ft., 4 ft. and 6 ft.) for the 90 to 50 per cent diaphragms inclusive; and for a 6-ft. pressure drop for the 40, 30 and 20 per cent diaphragms.

In general, the pressure head conditions could be maintained with little variation by means of the centrifugal pump. Such variation was watched and controlled by a man stationed at a valve in the supply pipe line some 50 ft. distant from the diaphragm.

During the calibration of the diaphragms and orifices the water was measured volumetrically in a calibrated cistern, or bay, of about 200 sq. ft. cross-section and 12,000 gal. capacity. A series of deflector pipes was used so that the water could be shifted into or from the measuring bay as desired.

PROCEDURE IN MAKING A TRAVERSE

The usual procedure was to bring the static pressure above the diaphragm to the desired height, and when conditions had reached a constant state and the manifold connections were found to be free from air a traverse was made of the pres-

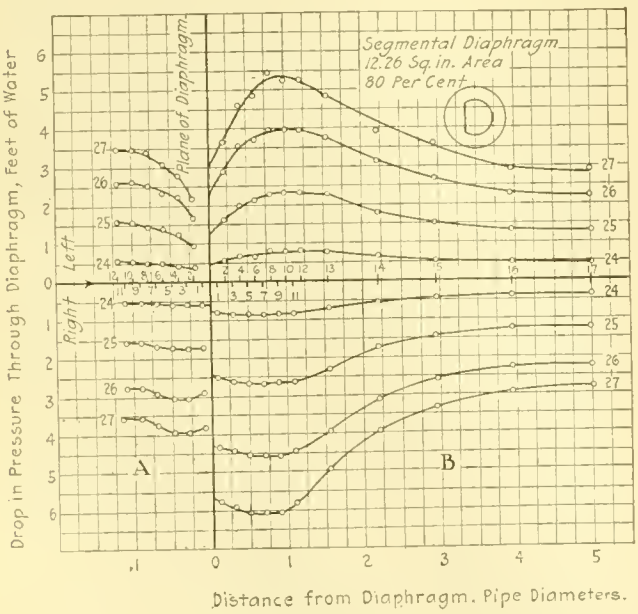

Fig. 7 80 Per Cent Segmental Diaphragm

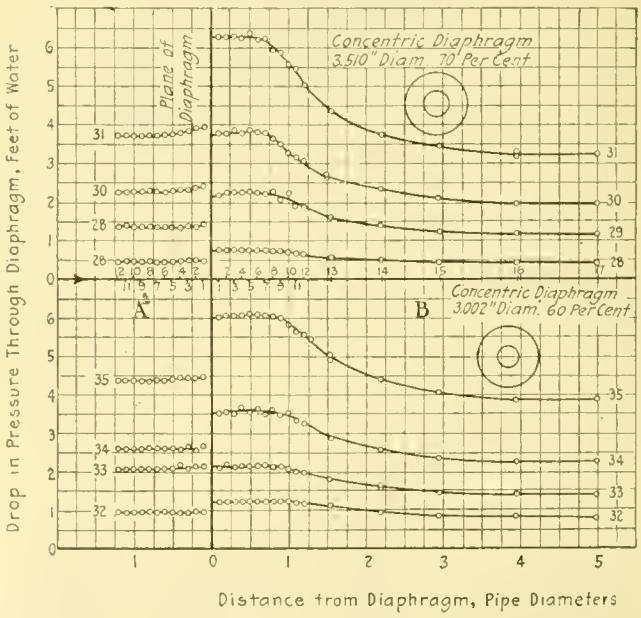

Fig. 8 60 and 70 Per Cent Concentric Diaphragms

sure drop through the diaphragm between the fixed point A-5 (½ pipe diameter upstream) and each point in succession on the downstream side, taking the odd-numbered points first and then following with the even-numbered pressure points.

A fixed reference point B-14 was then taken on the downstream side, and the upstream reading was explored, to get the pressure variation above the diaphragm. Each time a reading was taken the inverted manometer column was allowed to assume its state of equilibrium. The height of the water in the two lengths of the manometer was read simultaneously by two observers at a given signal. The whole traverse required from 10 to 15 minutes.

TABLE 2 OBSERVED DATA

Time, Min.	Head at orifice, ft.	Head at A, ft.	Manometer A5 to B5 left	Manometer A5 to B5 right	Manometer A5 to B5 total	Manometer A1 to B1 left	Manometer A1 to B1 right	Manometer A1 to B1 total	Volume Scale	Cu. Ft.
Calibration of 4-in. Concentric Diaphragm and 4-in. Pipe Orifice. Run No. 16										
0	3.77	6.15	−2.36	+1.10	3.46	−2.36	+1.10	3.46	0.8	−23
	3.78	6.15	2.40	1.12	3.52	2.38	1.08	3.46		
3	3.78	6.15	2.41	1.09	3.50	2.36	1.06	3.42	1.84	
			2.38	1.05	3.43	2.37	1.02	3.49		
6	3.71	6.10	2.43	1.07	3.50	2.39	1.01	3.40	2.90	
			2.43	1.07	3.50	2.41	1.03	3.44		
9	3.71	6.10	−2.50	+1.03	3.53	−2.41	+0.96	3.37	3.95	574
	3.77									
avg.	3.748				3.50		Cu. ft.	3.47 per	total sec. =	597 1.105
Calibration of 4-in. Eccentric Diaphragm and 4-in. Pipe Orifice. Run No. 20										
0	3.60	6.00	−2.07	+2.03	4.10	−2.00	+1.95	3.95	4.39	778
			2.02	2.00	4.02	2.00	2.00	4.00		
3			2.04	1.99	4.03	2.02	1.98	4.00	5.95	
	3.52	6.00	2.13	2.01	4.14	2.04	1.96	4.00		
6			2.02	1.92	3.94	2.01	1.94	3.95	6.98	
	3.55	5.95	2.10	1.95	4.05	2.04	1.93	3.97		
8.58	3.55	5.95	−2.15	+1.97	4.12	−2.00	+1.90	3.90	8.00	1351
avg.	3.555				4.057		Cu. ft.	3.967 per	total sec. =	573 1.065
Calibration of 4-in. Segmental Diaphragm and 4-in. Pipe Orifice. Run No. 24										
0	3.48	5.90	−2.58	+2.01	4.59	−2.40	+1.83	4.23	0.70	−42
			2.60	2.00	4.60	2.38	1.82	4.20		
3	3.44	5.90	2.55	1.95	4.50	2.36	1.83	4.19	1.70	
	3.52	6.00	2.55	1.97	4.52	2.38	1.84	4.22		
6	3.50	5.95	2.60	1.99	4.59	2.38	1.85	4.23	2.725	
	3.50	5.95	2.54	1.96	4.50	−2.41	+1.87	4.28		
9	3.52	6.00	−2.56	+2.00	4.56				3.74	535
avg.	3.49				4.55		Cu. ft.	4.22 per	total sec. =	577 1.068

CALIBRATION OF ORIFICES

The flow of water was also measured, using these same diaphragms and orifices for the same pressure conditions as were maintained during the so-called traverses. In most cases, though not always, a calibration either followed a traverse or immediately preceded it, so as to have flow conditions the same. The length of the runs for the calibrations ranged from 9 to 30 minutes, depending on the quantity of water discharged by the orifices. The readings were taken in many cases every minute of the pressure drop between A-5 and B-5, A-1 and B-1, and also of the head at the pipe orifice. These readings were taken in rotation and formed entirely independent observations. For the large-sized diaphragms more time was needed to take each individual reading, hence fewer readings in all could be taken. The time readings were all taken on a stop watch whose accuracy was checked.

DATA SECURED FROM TESTS

Only one set of data is included in this paper, since the same scheme was pursued in getting the other sets of readings. Table 1 shows the data taken for the 4-in. diaphragms, or the 80 per cent sizes. This includes, besides the data for the concentric orifice, or diaphragm, those for the eccentric and segmental diaphragms. Table 2 shows the observations during the calibrations of these same diaphragms, taken for the quantity of water discharged at the same or nearly the same rates of flow. In this table are included the pressure drops between points A-5 and B-5; between A-1 and B-1; and also the head readings at the pipe orifice; and the cubic feet of water discharged per run, together with the quantity in cubic feet per second.

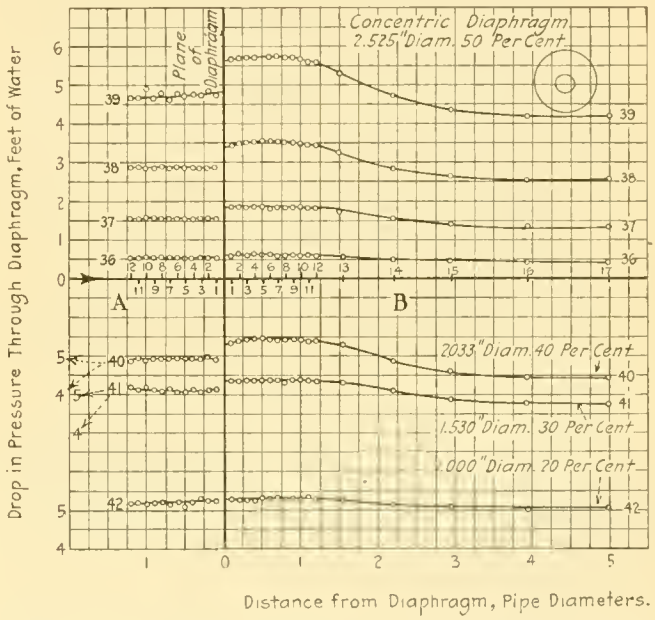

Fig. 9 50, 40, 30 and 20 Per Cent Concentric Diaphragms

The data so taken were made use of in two ways: (*a*) the observations taken during a traverse were plotted on coördinate paper to show the pressure distribution at the diaphragm, and (*b*) from the calibration data the coefficients of discharge for the diaphragms and pipe-cap orifices were computed.

PRESSURE DROP CURVES

The curves plotted in Figs. 5 to 9 inclusive show the pressure drop variation for all the diaphragms. The horizontal scale was laid off in pipe-diameter distances, and is also marked at the proper points showing the positions along the pipe where the pressure readings were taken. The vertical

scale is laid off to represent pressure drop through the diaphragm in feet.

To illustrate: Run No. 18, Table No. 1 (4.022-in. concentric diaphragm) gives the reading from which curve No. 18 (Fig. 5) was plotted. A and B indicate the location of the points above and below the plane of the diaphragm. The upstream connection was A-5 (one-half pipe diameter above diaphragm) and is considered as a zero pressure point. Starting with B-1, the pressure drop of 3.55 ft. is laid off upwards. For B-3 and B-5 the pressure drops are 3.63 and 3.55 respectively, and so on. On the A side of the diaphragm are laid off the pressure drops between B-14 (as fixed point) and each point in succession as shown in Run 18, Table 1, by A-1 = 1.84 ft., A-3 = 1.65 ft., A-5 = 1.59 ft., and so on.

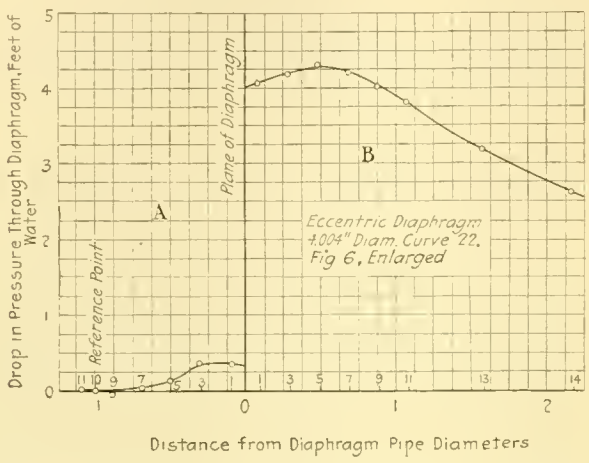

Fig. 10 Curve No. 22, Fig. 6 Enlarged. Eccentric Diaphragm

For the concentric diaphragms the pressure-drop readings for both the right and left sides of the pipe are plotted together and form a single curve, as shown by curve No. 18 (Fig. 5). The eccentric and segmental diaphragms, however, have a different pressure drop for each side of the pipe and have been plotted separately, as may be seen in curves Nos. 20 to 23 (Fig. 6) for the 80 per cent eccentric diaphragms, where the curves for the right side of the pipe have been placed below and those of the left side above the center line of the curve sheet.

The curves for the A side of the diaphragm have been plotted as read from the data, and, since A-5 was taken as a zero point for the downstream side of the diaphragm, all points on the A side should start at A-5 as zero; but if so plotted, it was feared that a confusion of curves would result, hence they are separated on the diagram and are intended to show only a relative change in pressure and not the absolute change above the diaphragm.

For the special diaphragms, viz., the eccentric and segmental, enlarged curves have been plotted from the observed data (*e.g.*, Fig. 10), on which the readings on the A side have been corrected so as to start from A-10 as the zero reference point; these curves will show the actual pressure drop between the two sides of the diaphragm.

For example: Fig. 10 (plotted from Run 22, Table 1), giving curve No. 22 (Fig. 6) for the 80 per cent eccentric diaphragm, shows the true pressure relations when A-10 is taken as the zero point. From the data for Run 22, Table 1, the pressure drop between A-5 and B-5 equals 4.18 ft.; the pressure drop between A-10 and A-5, as read from curve No. 22 enlarged (Fig. 10), equals 0.13 ft.; the plotted point for the pressure drop between A-10 and B-5 (curve No. 22, Fig. 10) will then equal 4.18 + 0.13 = 4.31 ft. The other points are found in a similar manner.

Formula for Coefficient of Discharge

In computing the coefficients of discharge, the pipe orifices were considered as frictionless or thin-plate orifices having a velocity of approach. Hence the total head acting on the diaphragm will be:

$$\text{Total head} = \text{Static head} + \text{velocity head}$$

$$h = \frac{V^2}{2g} = H + \frac{v^2}{2g} = H + \frac{V^2}{2g}\left(\frac{A_2}{A_1}\right)^2 \ldots\ldots\ldots\ldots [1]$$

Since $Q = A_1 v = A_2 V$

$$v^2 = \left(\frac{A_2}{A_1}\right)^2 V^2$$

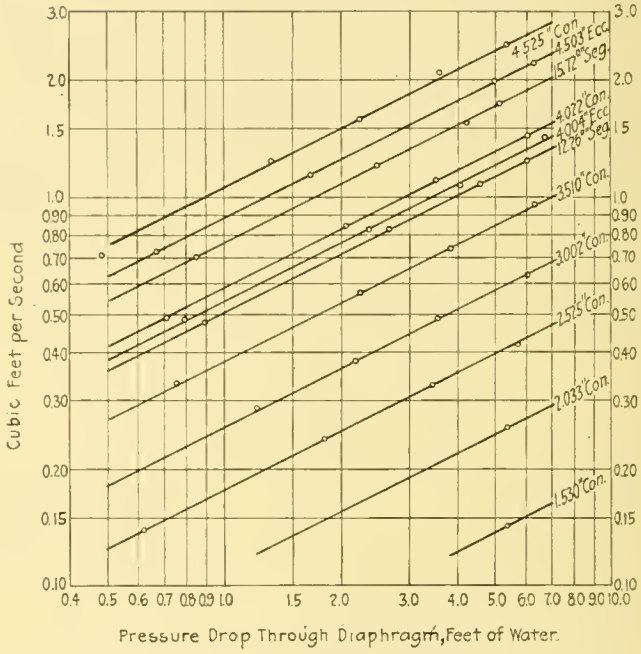

Fig. 11 Discharge Curves in Cu. Ft. per Sec. for Diaphragm in 5-In. Water Pipe

Then from [1]

$$\left[1 - \left(\frac{A_2}{A_1}\right)^2\right] V^2 = 2gH$$

$$V = \sqrt{2gH} \div \sqrt{1 - \left(\frac{A_2}{A_1}\right)^2} \ldots\ldots [2]$$

Introducing coefficient of discharge K

$$q = \frac{KA_2\sqrt{2gH}}{\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}}$$

$$K = \frac{q\sqrt{1 - \left(\frac{A_2}{A_1}\right)^2}}{A_2\sqrt{2gH}} = \frac{q}{A_2\sqrt{2gH}} F \ldots [3]$$

In the above formulæ:

h = total acting head on the diaphragm
V = velocity through diaphragm
v = velocity through pipe
A_2 = area of diaphragm
A_1 = area of pipe
q = actual discharge through diaphragm
Q = theoretical discharge through diaphragm
K = coefficient of discharge through diaphragm
F = factor of correction for velocity of approach

$$= \sqrt{1-\left(\frac{A_2}{A_1}\right)^2}$$

H = drop through diaphragm or orifice

In the formula no attempt has been made to correct for the contraction of the stream as has been done by some experimenters[1] in hydraulics, since it is believed that the simpler formula will best serve the purpose in finding the coefficients and in their application.

The factor of correction (F) in the formula may be read directly from the curve for velocity of approach in Fig. 15.

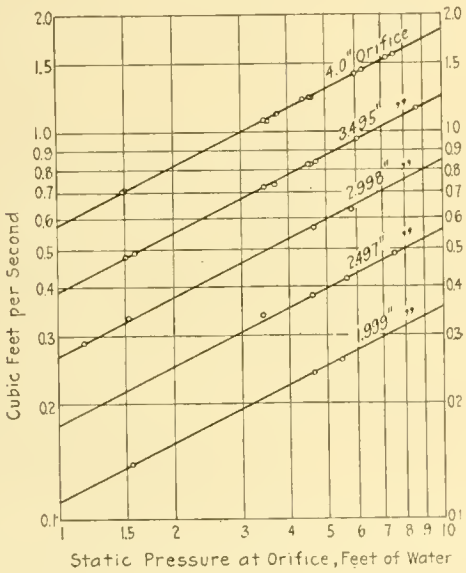

Fig. 12 Discharge Curves in Cu. Ft. per Sec. for Orifices Attached to 5-In. Water Pipe

For the diaphragm the drop in pressure was taken at two points, the first at A-5, B-5; the second at A-1, B-1. This was done so as to compare coefficients of discharge for a point close to the diaphragm with a point some distance away from the diaphragm and which is a better point at which to make an attachment.

Curves have also been plotted on logarithmic coördinate paper between the cubic-feet-second discharge and the pressure drop through the diaphragms (see Fig. 11). Similar curves are also given for the 5-in. pipe cap orifices (see Fig. 12).

The coefficients of discharge for the diaphragms and the 5-in pipe-cap orifices are to be found in Tables 3 and 4. Other coefficients of discharge for pipe-cap orifices are given in Table 5. These coefficients are computed from results obtained from experiments made by Prof. R. S. King, Mem.Am. Soc.M.E., University of Arizona, and the writer some years ago. They are given for the purpose of comparison with the results obtained from the 5-in. pipe orifices.

These results, which were obtained from the calibrations of orifices attached to 3-in. and 4-in. water pipes, have been used repeatedly since then, and together with the discharge curve sheets have been found of great value in measuring quantities of water up to 1000 gal. per min. The curve sheets are given in Figs. 16 and 17 with the thought that other members of the Society may also find them useful.

A comparison of the coefficients of discharge for the series of pipe orifices, including the diaphragms and the pipe-cap orifices, can be noted in Fig. 13, and also in Table 6. The

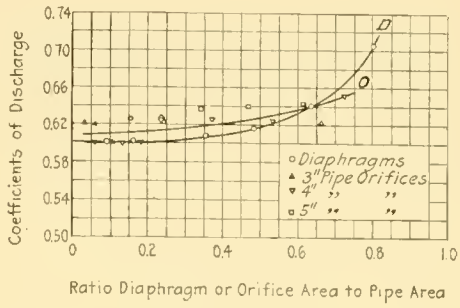

Fig. 13 Coefficients of Discharge for Pipe Orifices

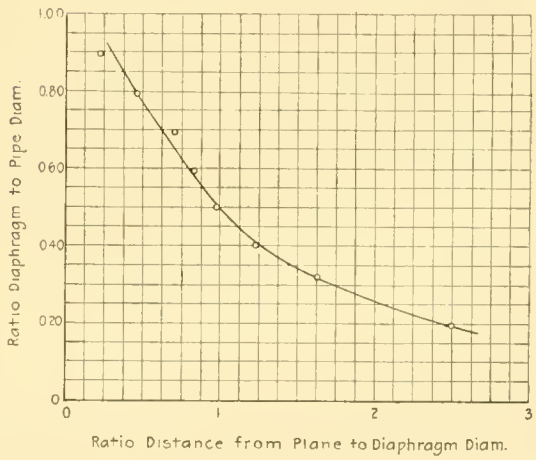

Fig. 14 Probable Position of Least Section as Shown by Location of Greatest Pressure Drop Through Concentric Diaphragms

coefficients for the 5-in. pipe orifices, including both the diaphragm orifices and the pipe orifice, show a more uniform variation through the range of head maintained than is found for the coefficients as computed for the 3-in. and 4-in. pipe-cap orifices. This uniform variation is partly accounted for by the fact that more runs were made for the low range of head with the 5-in. pipe orifices than for the 3-in. and 4-in. cap orifices.

The average diaphragm coefficients range from 0.602 to 0.706, while the average coefficients for the 5-in. cap orifices range from 0.610 to 0.637 for the 40 to 90 per cent orifices respectively. For the 80 per cent 5-in. pipe-cap orifice the coefficients agree very closely (Table 4) with an average value of 0.646, as compared with a probable average value of 0.629 for the 3-in. and 4-in. cap orifices for 80 per cent orifices. For the 5-in. pipe orifices the coefficients for the orifices below the 80 per cent size average 0.608 for the diaphragms and 0.622 for all the cap orifices, or a difference of about 2.3 per

[1] Proc. Inst. Civil Engineers, vol. 197, p. 243, "The Diaphragm Method of Measuring the Velocity of Fluid-Flow in Pipes," by Holbrook Gaskell, Jr.

cent, which is relatively a small variation and would seem to indicate that the behavior of water in passing through the diaphragm is very similar to that of a jet of water issuing from a thin-plate, or frictionless, orifice, into the air.

The variation of the coefficients of discharge may also be seen from Fig. 13, where O is the average curve for the cap orifices and D the average curve for the diaphragms. It will be seen that the average curve for the cap orifices coincides with the curve for the diaphragms at about 0.640, which is equivalent to 80 per cent pipe diameter.

COEFFICIENTS FOR SPECIAL ORIFICES

For the special orifices (80 and 90 per cent eccentric and segmental diaphragms) the coefficients, of course, run lower than for the concentric diaphragms, since the pressure drop through the diaphragm is magnified by the offset at one side. For the 90 per cent size the variation is about 14 per cent for the eccentric and 24 per cent for the segmental diaphragm.

For the 80 per cent size, as might be expected, the variation

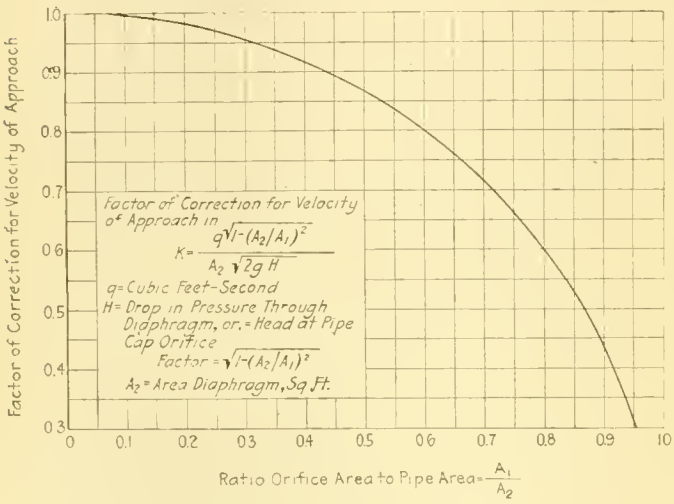

Fig. 15 Factor of Correction for Velocity of Approach

is not so large, being 7 per cent for the eccentric and about 9 per cent for the segmental diaphragm (Table 7). Figuring the coefficient for the 80 per cent eccentric and segmental diaphragms on the basis of the average of the two pressure drops for both sides of the pipe at points ½ pipe diameter downstream, and comparing with the coefficient for the 80 per cent concentric diaphragm, the results would be as shown in Table 7.

When figured on average head, the eccentric diaphragm gives a coefficient only 1.8 per cent less than the concentric diaphragm, and the segmental diaphragm gives on the average head a coefficient 3.9 per cent less than the concentric diaphragm. This indicates that the eccentric diaphragm, especially, has very little distorting effect on the stream flow. The curves also show that for the 80 per cent eccentric diaphragm, for a point ½ pipe diameter downstream, the pressure drop is 18.8 per cent greater on one side than on the other, or a probable average magnification over the concentric diaphragm of 9.4 per cent; and for the segmental diaphragm there is a 24 per cent magnification, with a probable average of 12 per cent over the concentric diaphragm.

The coefficients of discharge for points A-1, B-1 ($\frac{1}{10}$ pipe diameter from diaphragm) for all sizes of diaphragms except the 90 per cent size, agree fairly well with those computed from points A-5, B-5 (see Table 3), running above in some cases and below in others. The coefficients run practically constant for each size of orifice for the full range of 6 ft. pressure drop.

TABLE 3 COEFFICIENTS OF DISCHARGE FOR DIAPHRAGMS

Run			Diaphragm			Pressure Drop at			Coefficient		
No.	Lgth. Min.	Readings	Kind	Diam. In.	A_2, Area, Sq. Ft.	H_5 Pressure Drop A-5, B-5 Ft.	H_1 Pressure Drop A-1, B-1 Ft.	Cu. Ft. Sec. q	K_5	K_1	K Computed from Curves
1	15	8	con-	4.525	0.1117	0.48	0.69	0.708	0.683	0.578	
2	9	4	cen-	4.525	0.1117	1.32	2.00	1.226	0.714	0.580	
3	12	6	tric	4.525	0.1117	2.24	3.40	1.573	0.704	0.571	
4	11	5		4.525	0.1117	3.62	5.46	2.085	0.733	0.597	
5	9	7		4.525	0.1117	5.34		2.446	0.718		
				(F =	0.600)						
								av.	0.710	0.582	0.706
6	15	9	eccen-	4.503	0.1106	0.67	0.73	0.725	0.615	0.584	
7	20	10	tric	4.503	0.1106	1.66	1.87	1.136	0.608	0.572	
8	9	7		4.503	0.1106	4.98	5.64	1.970	0.607	0.571	
9	10	5		4.503	0.1106	6.26	6.89	2.195	0.603	0.575	
				(F =	0.611)						
								av.	0.608	0.576	0.609
10	12	5	seg-		0.1092	0.85	0.78	0.701	0.540	0.562	
11	12	5	men-		0.1092	2.48	2.306	1.208	0.544	0.564	
12	15	8	tal		0.1092	4.21	3.73	1.554	0.537	0.570	
13	12	5			0.1092	5.11	4.72	1.728	0.541	0 564	
				(F =	0.622)						
								av.	0.541	0.565	0.542
14	15	10	con-	4.022	0.0882	0.707	0.744	0.489	0.637	0.622	
15	12	10	cen-	4.022	0.0882	2.055	2.177	0.837	0.639	0.622	
16	9	8	tric	4.022	0.0882	3.500	3.466	1.104	0.647	0.651	
17	9	7		4.022	0.0882	6.074	6.380	1.440	0.640	0.626	
				(F =	0.775)						
								av.	0.641	0.631	0.640
18	12	10	eccen-	4.004	0.0875	0.790	0.760	0.484	0.604	0.615	
19	12	9	tric	4.004	0.0875	2.361	2.279	0.824	0.594	0.605	
20	9	7		4.004	0.0875	4.057	3.967	1.065	0.586	0.593	
21	9	7		4 004	0.0875	6.720	6.570	1.410	0.601	0.609	
				(F =	0.779)						
								av.	0.596	0.606	0.598
22	12	10	seg-		0.0851	0.880	0.838	0.476	0.588	0.603	
23	12	10	men-		0.0851	2.646	2.474	0.823	0.587	0.606	
24	9	7	tal		0.0851	4.545	4.224	1.068	0.585	0.603	
25	9	8			0.0851	6.061	5.693	1.233	0.581	0.600	
				(F =	0.752)						
								av.	0.585	0.603	0.585
26	15	21	con-	3.510	0.0672	0.752	0.752	0.332	0.622	0.622	
27	15	16	cen-	3.510	0.0672	2.248	2.258	0.566	0.614	0.612	
28	12	16	tric	3.510	0.0672	3.824	3.852	0.737	0.613	0.612	
29	15	19		3.510	0.0672	6.335	6.413	0.955	0.614	0.607	
				(F =	0.877)						
								av.	0.616	0.613	0.611
30	15	18	con-	3.002	0.0492	1.217	1.210	0.288	0.618	0.619	
31	15	18	cen-	3.002	0.0492	2.166	2.166	0.379	0.610	0.610	
32	15	13	tric	3.002	0.0492	3.525	3.533	0.484	0.612	0.609	
33	18	13		3.002	0.0492	6.052	6.081	0.629	0.607	0.605	
				(F =	0.936)						
								av.	0.612	0.611	0.609
34	24	21	con-	2.525	0.0348	0.619	0.620	0.138	0.608	0.607	
35	21	21	cen-	2.525	0.0348	1.818	1.819	0.239	0.615	0.615	
36	21	21	tric	2.525	0.0348	3.459	3.462	0.327	0.610	0.610	
37	21	21		2.525	0.0348	5.727	5.721	0.419	0.606	0.607	
				(F =	0.969)						
								av.	0.610	0.610	0.611
38	27	25		2.033	0.0225	5.378	5.371	0.257	0.606	0.606	0.602
pipe at diaphragm					A_1						
				5.059	0.1396						

COEFFICIENT OF DISCHARGE FOR POINT A-10, B-5

The points at which the pressure drop was taken for computing the coefficients of discharge referred to in Table 3 were

A-1, B-1 ($\frac{1}{10}$ pipe diameter) and A-5, B-5 (½ pipe diameter) from the diaphragm. In many cases A-10 would have been a more desirable point of attachment. For the concentric diaphragms a change from that point A-5 to A-10 on the upstream side would make no appreciable change in the coefficient of discharge. For the special diaphragms there is more variation in pressure adjacent to the diaphragms on the upstream side, so that a change of from two to five per cent is shown in the coefficient of discharge in changing from A-5 to A-10 on the upstream side. Table 8 gives a comparison of coefficients of discharge for points A-5, B-5 and A-10, B-5.

TABLE 4 COEFFICIENTS OF DISCHARGE FOR ORIFICES ON 5-IN. PIPE

(Values of K are averages of from 60 to 100 readings—take over periods of 60 to 140 minutes).

Diameter of Orifice, In.	Static Head at Orifice, H Ft.	Cu. Ft. per Sec., q	K (Average)	K computed from log. curves
4.000	1.48 to 7.54	0.701 to 1.573	0.646	0.646
3.495	1.51 to 8.63	0.476 to 1.136	0.639	0.639
2.998	1.17 to 5.85	0.288 to 0.629	0.635	0.636
2.497	3.47 to 7.57	0.327 to 0.484	0.627	0.624
1.999	1.55 to 5.49	0.138 to 0.257	0.623	0.626
(of pipe, 5.113)				

TABLE 5 COEFFICIENTS OF DISCHARGE FOR ORIFICES ON 3-IN. AND 4-IN. PIPE

(Averages for Static Heads (H) of 4 ft. and 9 ft.).

	3-In. Pipe (Judd and King, 1907)					
Orifice diam., in.	0.500	0.750	1.000	1.500	2.000	2.500
K, average	0.621	0.619	0.608	0.628	0.619	0.627

	4-In. Pipe (H. Judd, 1913)						
Orifice diam., in.	0.998	1.495	1.750	2.000	2.495	2.993	3.497
K, average	0.608	0.595	0.601	0.602	0.625	0.625	0.637

Diam. of 3-in. pipe at orifice = 3.072 in.; of 4-in. pipe, 4.10 in.

TABLE 6 VARIATION OF COEFFICIENTS OF DISCHARGE FOR PIPE ORIFICES, TAKEN FROM TESTS

Kind of Orifice	Orifice Diameter Expressed in Per Cent Pipe Diameter						
	40%	50%	60%	70%	80%	90%	Av.
3-in. cap	0.608	0.628	.....	0.622	0.627	.....	0.621
4-in. cap	0.595	0.602	0.625	0.625	0.631	0.637	0.619
5-in. cap	0.626	0.624	0.636	0.639	0.646	. . .	0.634
Average	0.610	0.618	0.631	0.629	0.635	0.637	0.627
Concentric diaphragm	0.602	0.611	0.609	0.611	0.640	0.706	0.630

Since from formula 3 given above the coefficient of discharge varies inversely as the square root of the head,

$$K_{10} = K_5 \sqrt{\frac{H_5}{H_{10}}} = K_5 \sqrt{\frac{H_5}{H_5 + d}} = \frac{K_5}{\sqrt{1 + \frac{d}{H_5}}}$$

K_{10} = coefficient of discharge for points A-10, B-5

K_5 = coefficient of discharge for points A-5, B-5

H_5 = pressure drop between A-5, B-5 taken as average from pressure-drop curves

d = pressure drop between A-10 and A-5 as read from enlarged pressure drop curves, or read from the observed data

Example: Referring to curve No. 22 (Fig. 10)

$H_5 = 4.28 - 0.13 = 4.15$

$= 4.15$ (as also read direct from curve No. 22, Fig. 6)

$d_5 = 0.13$ from Fig. 10

$K_5 = 0.598$ (Table 3, 80 per cent eccentric diaphragm)

$$K_{10} = \frac{0.598}{\sqrt{1 + \frac{0.13}{4.15}}} = 0.589.$$

For the concentric diaphragms, one run for each size diaphragm was selected, having a head ranging from 3.0 to 5.0 ft. and K_{10} was computed, noting the values of the pressure drop for A-5, B-5, either from the observed data or from the curves as plotted direct from the data taken. The values thus computed vary for K_{10} (Table 8) from the average values for K_5 by about 0.5 per cent. For the 90 and 80 per cent eccentric and segmental diaphragms the coefficients referred to points A-10, B-5 run from 1.6 per cent to 5.2 per cent lower than the coefficients when referred to points A-5, B-5.

TABLE 7 COMPARISON OF COEFFICIENTS, 80 PER CENT DIAPHRAGMS, 4-FT PRESSURE DROP

Kind of Diaphragm	Coefficients	Comparison of Coefficients with that for Concentric Diaphragm
Concentric	0.641 From Table 3	
Eccentric	0.596 From Table 3	7 per cent less
Segmental	0.585 From Table 3	8.7 per cent less
Eccentric	0.629 From average head for both sides of pipe	1.8 per cent less
Segmental	0.616 From average head for both sides of pipe	3.9 per cent less

TABLE 8 COEFFICIENTS OF DISCHARGE FOR CONCENTRIC DIAPHRAGMS REFERRED TO A-10

Curve No.	Diameter of Diaphragm In.	Drop in Pressure, Ft.			Coefficient		Per Cent Difference
		From Curve A-5, B-5	From Data A-10, A-5	A-10, B-5	A-5, B-5	A-10, B-5	
1	2	3	4	5	6	7	8
Concentric Diaphragms							
6	4.525	3.1	0.01	3.11	0.706	0.705	−0.2
18	4.022	3.55	0.03	3.58	0.640	0.637	−0.5
30	3.510	3.82	0.02	3.82	0.617	0.614	−0.4
34	3.002	3.59	0.03	3.62	0.609	0.606	−0.5
38	2.525	3.53	0.0	3.53	0.611	0.611	0.0
40	2.033	5.44	0.02	5.42	0.602	0.604	+0.2
41	1.530	5.35	0.06	5.29	0.603	0.607	+0.6
Eccentric Diaphragms							
10	4.503	5.15	0.35	5.50	0.608	0.588	−3.2
22	4.004	4.15	0.13	4.28	0.598	0.589	−1.5
Segmental Diaphragms							
14	area 15.72	4.13	0.48	4.69	0.542	0.514	−5.2
26	12.26	4.53	0.25	4.78	0.585	0.570	−2.6

BEST POINT FOR PRESSURE CONNECTION

An inspection of Figs. 5, 8 and 9 shows that the point of greatest drop in pressure on the downstream side of the diaphragm lies at a distance from the place of the diaphragm varying from 1 in. for the 90 per cent diaphragm to 2.5 in. for the diaphragms below the 70 per cent size. The curves for the smallest sizes and those for all the lowest heads on all the diaphragms below the 70 per cent size do not give this point of greatest pressure drop so clearly defined on the curves, although the observed data in nearly every case show a low point at 2.5 in. out from the plane of the diaphragm.

These results are shown graphically in Fig 14, in which the distance from the diaphragm is given in terms of the orifice diameter. The vertical scale gives the orifice diameters in per cent of the pipe diameter.

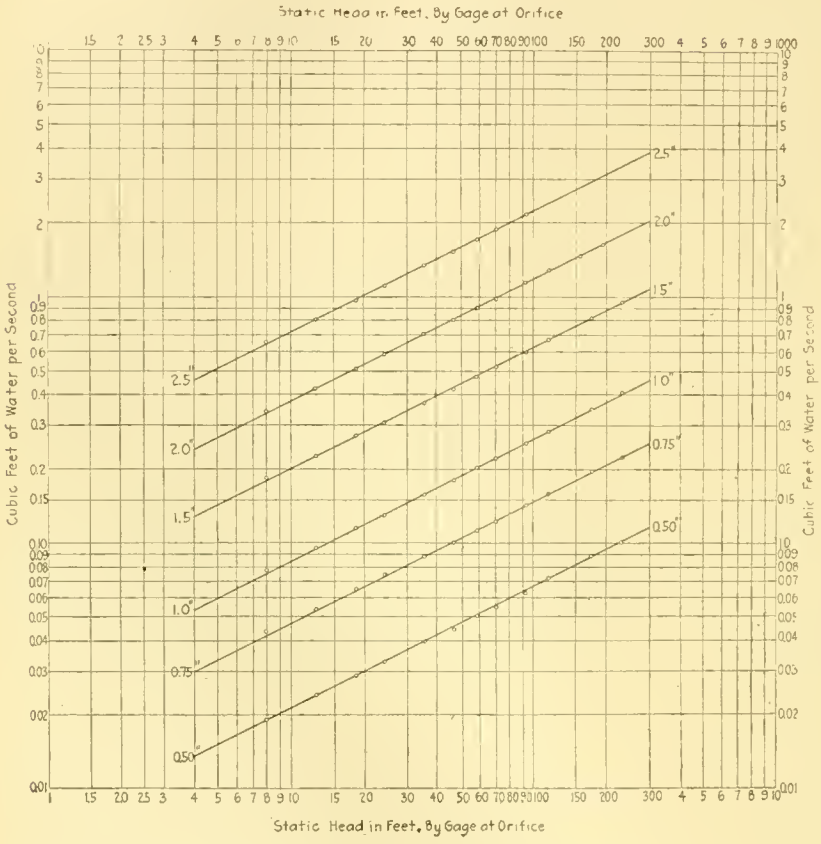

Fig. 16 Discharge Curves in Cu. Ft. per Sec. for Frictionless Orifices Attached to a 3-In. Water Pipe

For nearly all of the diaphragms except the 90 per cent size a point of connection for pressure readings (2.5 in. from plane) on the downstream side would give pressure drop readings varying but little from the maximum pressure drop. For the diaphragms below the 70 per cent size the range of point of connection could easily be extended to one pipe diameter distance from the place without appreciable change for pressure drops for the concentric diaphragms. On the upstream side for the concentric diaphragms the point of pressure connection could be made at any point from ½ pipe diameter to 1 pipe diameter from the plane of the diaphragm.

For the special orifices with one exception the point of greatest pressure drop lies surprisingly close to the ½ pipe diameter distance from the plane of diaphragm on the right side of the pipe, which is the side of greatest offset. For the 80 per cent segmental diaphragm the point of greatest pressure drop occurs at 3.5 in. from the plane.

On the left side of the pipe, where the edge of the diaphragm is nearly in line with the inside of the pipe, there is found, of course, a less total pressure drop than on the other side. In all cases except for the 90 per cent eccentric the point of greatest pressure drop is moved downstream to about $\frac{8}{10}$ pipe diameter, or 60 per cent more than the corresponding point on the right side. For the 90 per cent eccentric diaphragm the point of greatest pressure drop seems to lie slightly within the ½ pipe diameter distance from the plane.

On the upstream side, as might be expected with these special orifices, there is found to be a greatest pressure variation in the vicinity of the diaphragm. This difference seems to be more pronounced with the segmental orifice, due probably to the increase of swirling and eddying as the water suddenly changes its direction sidewise on approaching these offset diaphragms, in addition to the sudden contraction it undergoes in passing through the orifice. In view of these disturbances the curves show that the upstream pressure connection should not approach the diaphragm nearer than 1 pipe diameter, to secure steadiness of pressure-drop readings.

It is also plain to be seen that for the diaphragms above the 70 per cent size there is more need of care in making a pressure connection to keep close to the ½ pipe diameter distance from the plane in order to avoid sudden pressure changes. It is also quite evident that for pressure drops through the diaphragm above 3 ft. the 90 per cent diaphragm would likely give unsteady readings, owing to rapid pressure changes, unless the downstream connection could be made as close as 1 in. from the plane of the diaphragm.

Some experiments along this same line have recently been made in England by Holbrook Gaskell, Jr. (*op. cit.*) on water flow in 6-in. and 8-in. cast-iron water pipes. Mr. Gaskell states that the point of connection may be made at any point within 1½ in. from the plane of the diaphragm. It is not usually convenient to make a pressure connection even at 1½ in. distance from the diaphragm, hence it would seem advisable to use a diaphragm of not over 80 per cent size so as to allow the pressure connections to be made not nearer than ½ pipe diameter from the diaphragm. This would also insure more steady flow conditions.

ZONE OF MAXIMUM VELOCITY

Since the pressure drop must be largely due to increase of velocity, because of contraction of the jet of water on leaving the orifice, the point of least pressure would be at the zone of greatest contraction; that is, the zone where the water is moving most rapidly. The contour of the pressure-drop curves would seem to indicate a jet of moving water whose shape must somewhat resemble the jet of water issuing into the air from an orifice. The curve in Fig. 14 is plotted to indicate the position of this so-called least action.

Its distance from the diaphragm, expressed in orifice diam-

eter distances, is seen to increase as the diaphragm diameter decreases, although the actual distance does not vary much from ½ pipe diameter from the diaphragm plane. It is difficult to say whether or not the point of maximum pressure drop would be found at ½ pipe diameter distance for all diameters of pipes. The pressure-drop curves show that the pressure has reached in nearly every case its maximum amount of restoration at about 4 pipe diameters from the diaphragm for all concentric diaphragms below the 70 per cent size. For these sizes the maximum pressure drop occurs at ½ pipe diameter from the diaphragm, which would seem to indicate that for area ratios of 50 per cent and under the pipe itself has more influence on the point of greatest pressure drop than the size of the diaphragm opening.

TABLE 9 PER CENT PRESSURE RESTORATION

Size of diaphragm	Per cent restoration of initial pressure	Size of diaphragm	Per cent restoration of initial pressure
90 per cent concentric.....	77.0	30 per cent concentric.....	11.0
80 per cent concentric.....	62.0	20 per cent concentric.....	4.0
70 per cent concentric.	48.0	90 per cent eccentric.....	65.0
60 per cent concentric.....	35.0	80 per cent eccentric.....	57.0
50 per cent concentric.....	30.0	90 per cent segmental.....	65.0
40 per cent concentric.....	20.0	80 per cent segmental.....	54.0

AMOUNT OF PRESSURE RESTORATION

The amount of pressure restoration after passing through the diaphragm will average as given in Table 9.

An example will serve to show how the per cent of pressure restoration was found. From Curve No. 18, Fig. 5, 80 per cent concentric diaphragm, the maximum drop in pressure through the diaphragm = 3.7 ft.

The drop in pressure at B-16, point of greatest restoration = 1.36 ft.

$$\text{Per cent of restoration} = \frac{3.7 - 1.36}{3.7} = 63.3.$$

Average per cent for four heads = 62.0 (from Table 9).

After the water has passed the contracted section of the jet its velocity is somewhat gradually reduced, which causes a restoration of pressure similar to the action in a venturi tube. For all the concentric diaphragms the pressure is entirely restored at a distance of 4 pipe diameters, and for the special diaphragms the restoration of pressure is nearly if not quite completed at 5 pipe diameters distance from the plane of the diaphragm. The restoration of pressure appears to be nearly proportional to the area of the diaphragm.

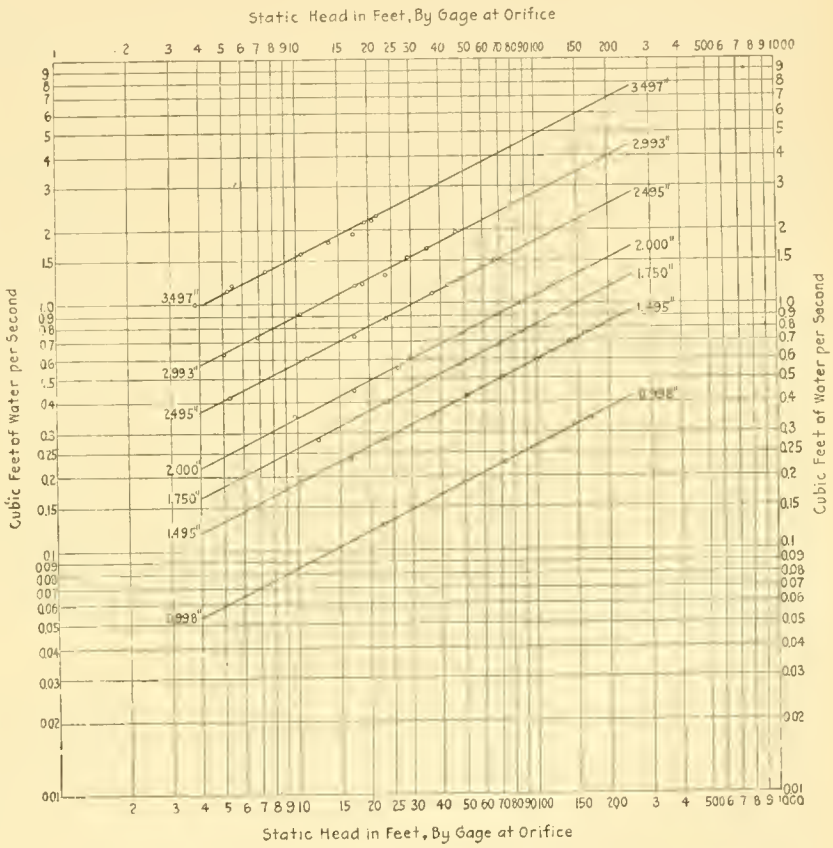

Fig. 17 Discharge Curves in Cu. Ft. per Sec. for Frictionless Orifices Attached to a 4-In. Water Pipe

CONCLUSIONS

In conclusion the results of these experiments would seem to bring out the following points:

1 A thin plate orifice inserted in a pipe is as reliable for flow measurement as the thin plate, or frictionless orifice, as used ordinarily.

2 The shape of the pressure-drop curves indicates a maximum point at about ½ pipe diameter from the diaphragm, which would seem to indicate a zone of maximum velocity of flow.

3 The eccentric and segmental diaphragms are advantageous in that they increase the drop reading, but more care is necessary in making the pressure connections, especially on the upstream side of the diaphragm.

4 The best point for the pressure connection is not less than ½ pipe diameter from the diaphragm on the downstream side, and not less than 1 pipe diameter from the diaphragm on the upstream side of the pipe.

5 The 80 per cent diameter size of diaphragm should not be exceeded to secure uniform flow conditions and to insure steady pressure-drop readings.

6 The average coefficient of discharge for a 5-in. pipe diaphragm agrees very closely with the average coefficient of discharge for the 5-in. pipe cap orifice.

7 The coefficients for the pipe diaphragms vary more nearly in accord with the variation in size of diaphragm orifice than those for the pipe-cap orifices.

8 The agreement is closer for the coefficients for all the pipe orifices at about 80 per cent diameter ratio.

9 The point of maximum velocity of flow is apparently a function of the pipe diameter and not of the diameter of the diaphragm orifice.

10 The restoration of pressure on the downstream side of the diaphragm is apparently a function of the area of the diaphragm.

DISCUSSION

SANFORD A. MOSS (written). There is no doubt that orifices in thin plates or pipe diaphragms are accurate and valuable instruments in many cases. It must be borne in mind, however, that in some cases the venturi meter and orifice with gradual approach offer superior advantages. The most important one is the matter of calibration. A properly shaped convergent orifice or venturi meter with a smooth and gradual entrance and a proper parallel portion for sizing the jet has a velocity coefficient of about 0.99 for all cases whatever, whether for liquids, steam, air or gas, and whether for relatively small differentials where the incompressible fluid formula $V = \sqrt{(2gh)}$ can be used, or for relatively large differentials where the accurate thermodynamic formula has to be used. On the contrary, for thin-plate orifices, calibration has to be made for all of the different cases.

In the case of the measurement of flow of air and gas in pipes, there is often the problem of securing a differential of sufficient magnitude to give satisfactory readings. If a venturi meter is used the differential can be made properly large without causing any serious net pressure drop. The net pressure loss due to a good venturi meter with large differential and 3 to 1 ratio is in the neighborhood of 1/5 of the differential. That is, 80 per cent of the differential is restored. This is to be compared with the figure of about 11 per cent given by Mr. Judd. For cases where the pipe pressure is high, so that a satisfactory differential can be secured with a total pressure drop which is a small percentage, the thin-plate orifice is satisfactory. With lower pressures, however, where pressure drop is more important, it is necessary to use a venturi meter because it gives very much less drop.

The formation of scale in a boiler may be prevented, it is stated, by applying a coat of aluminum paint to its inside surface.

Spent hemlock tan bark as it is discharged from the leach has a fuel value of 60 cents per ton when compared with 13,000-B.t.u. coal at $3.00 per ton.

The Baltimore & Ohio Railroad has donated to the Industrial Commission of Ohio a steel car to be used in demonstrating modern safety devices. The car will be equipped early in September by various manufacturing companies, as well as by the Commission, with models of safety devices and exhibits illustrating proper sanitation and ventilation. It will be sent into the yards of industrial plants throughout the state, so that employers and workmen may inspect the exhibits. The Commission is also preparing a motion picture film showing the working of the compensation law in Ohio, and particularly the causes of accidents as reported by the Commission.

The power required in rolling rectangular steel sections (*i.e.*, that expended in deforming the heated metal) may be approximately calculated from Victor E. Edwards' formula: Horsepower $= [C\,W \log(A_1/A_2)\sqrt{(D/T)}]/t$, in which W = weight of ingot, lb.; $A_1(A_2)$ = sectional area of ingot before (after) the pass, sq. in.; D = diameter of rolls at the pass in question, in.; T = thickness of ingot when leaving rolls, in.; t = duration of pass, sec. For preliminary calculations, assuming an initial rolling temperature around 2200 deg. fahr., the coefficient C may be taken as 12, a mean value determined by the author from the data of an elaborate series carried out in Germany some years ago by Dr. Ing. J. Puppe.—C. M. Sames, in *The Iron Age*, June 1, 1916.

The advantages of pulverized coal in locomotive practice are summarized by the committee of the International Railway Fuel Association in charge of the subject as follows: (1) Smokeless, sparkless, and cinderless operation; (2) maintenance of maximum boiler pressure within a uniform average variation of 3 lb. without popping; (3) an increase of from 7.5 to 15 per cent in boiler efficiency as compared with burning lump coal on grates; (4) saving of from 15 to 30 per cent in fuel of equivalent heat value fired; (5) enlarged exhaust-nozzle area, resulting in greater drawbar pull and smoother working of locomotive; (6) elimination of ashpit delays, facilities and expense, and reduction of time required for, and ease in, firing up; (7) maintenance of a relatively high degree of superheated steam; (8) no accumulation of cinders, soot or ashes in boiler flues, smoke box or on superheater elements; (9) no punishment or overheating of fire box, sheets, etc.; (10) elimination of arduous manual labor for building, cleaning and dumping fires; (11) avoidance of expense and annoyance of providing various sizes and kinds of fuel; (12) elimination of necessity of front-end and ash-pan inspection, and for special fuels, firing tools and appliances for building, stoking and cleaning fires; (13) equal provision with engineer for fireman to observe signals and track, thus reducing the liability of accident.

The economical production of power from coke-oven gas is discussed by G. Dearle in a recent paper before The Institution of Electrical Engineers. In collieries where a proportion of the output of coal is converted into coke in either waste-heat or regenerative ovens, there is always a certain surplus volume of gas of high calorific value which is available for the production of power. In the case of the regenerative type of coke oven, the volume of gas thus available is much greater than in the older pattern of waste-heat oven, and it is partly for this reason that the majority of new coke-oven installations during the past few years have been of the regenerative type.

The advantage of regenerative ovens is that the whole of the surplus heat in the coal is produced in the form of a combustible gas instead of merely as a waste-heat product. This combustible gas can be used to much greater advantage than the waste-heat product, for by utilizing it in gas engines it is possible to develop 3 to 4 times the power that can be obtained from the use of waste heat under boilers. There is also an advantage in being able to convey the gas any distance without deterioration, which is not possible in the case of the waste heat where the boilers must be installed quite close to the coke ovens.

The particular installation under review forms the power plant for a colliery, and consists of three 500 b.h.p. vertical tandem single acting gas engines operating on the Otto or 4-cycle principle. Further engine details are given and reference is made to ignition, lubrication, cooling and ventilation.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

PREPAREDNESS AND DOMESTIC NITRATE

To the Editor:

In the recent discussion[1] of the methods of organizing our industries in preparation for a possible war, a short reference was made to the necessity for a domestic supply of nitrogen in a form available both for plant life and convertible to war munition purposes in case of a conflict.

There has been recently considerable publicity given to the fixation of atmospheric nitrogen. The proposals along this line have been somewhat spectacular, and it is perhaps well to sound a note of warning in this matter lest there be a tendency to exaggerate the necessity of developing huge supplies of water power purely for the production of nitric acid. A very timely word is given in an article appearing in the July issue of the *Journal of Industrial and Engineering Chemistry,* by J. W. Turrentine, of the United States Bureau of Soils. In this article the writer calls attention to the possibilities of obtaining an independent nitrate supply from the bituminous fuel resources of this country.

The process of producing coke with the recovery of by-products in the form of tar and ammonia, as well as a certain quantity of gas, is well known and widely practised in this country, and the ammonia supply from this source represents a very considerable factor in the present fertilizer situation. The great bulk of ammonia thus produced is in the form of ammonium sulphate, which is directly available as a fertilizer. It is not so well recognized that all the ammonia thus produced is directly available as a raw material for nitric acid production.

The catalytic oxidation of coal gas ammonia to nitric acid is being commercially operated in Germany, and had been commercially operated there for a period of at least five years preceding the start of the war. There is no problem in connection with the oxidation of this coal ammonia which has not been solved on a commercial scale in at least one large plant in Germany.

It may be taken for granted, therefore, that the ammonia generated from our bituminous coals is directly available in time of war for the production of huge quantities of nitric acid. The only thing lacking is that this process should be introduced on a commercial scale in this country so that it may be thoroughly understood in its practical full-scale application. By this means we would put ourselves in position to take immediate advantage of our domestic ammonia supply as a source of nitric acid in case the Chile nitrates should be cut off.

The second problem in connection with such means of nitric acid production lies in providing a more flexible source of ammonia from the coal. The great point raised against the by-product coke ammonia has been its almost complete dependence on the major product, coke. The heavy first cost of a by-product coke plant, the amount of time needed to build and put these plants in operation, and the necessity of providing some immediate use and market for the main coke product have all been urged against this source of nitrate supply.

The writer also calls attention to a further objection to this method of ammonia production, which is that the amount of available nitrogen recovered from the fuel is little more than 15 per cent. This means that 85 per cent of the theoretical possible ammonia in the fuel is being lost in the coking process. There is, however, a process of treating bituminous fuel known as the by-product producer gas system, by which not 15 but 70 per cent of the available nitrogen in the fuels is converted into ammonia in such way that the products of the plant consist of a useful fuel gas, ammonia and tar only. The first cost of a plant capable of producing fuel gas and ammonia in this manner is very much less than the first cost of an equal coal capacity by-product coke oven, and the fuel gas which is the main product of the producer plant is entirely suitable for almost all industrial operations requiring heat application, as well as in gas engines or as fuel for a modern steam turbine plant in the production of power. These plants, therefore, may be expanded rapidly in time of trouble and without limit, being independent of the narrow field of coke requirements. They would produce not less than four times the amount of valuable ammonia per ton of fuel that is recovered from a corresponding by-product coke plant.

The by-product producer gas industry is well known in Europe and has been thoroughly developed. Its introduction in this country is lagging behind European practice mainly for the very reasons which caused the early neglect of the by-product coke oven system, that is, a lack of intelligent adaption of the process to our local fuels and conditions. It is of interest, however, to note that in the last two years some very successful development work has been undertaken in this country looking toward the economic adaption of the by-product producer system to American conditions. It would seem, therefore, that full consideration should be given to this process as a means of providing a domestic nitrate supply.

Lewis A. Riley, 2d.

New York, N. Y.

[1] Industrial Preparedness, The Journal, June, 1916, p. 435.

DISCUSSION OF TURBINE TESTS

To the Editor:

Although not a member of The Am. Soc. M. E., I submit the following as a discussion of the paper by H. G. Stott and W. S. Finlay, Jr., on Report upon Efficiency Tests of a 30,000-kw. Cross-Compound Steam Turbine which appeared in the June issue of The Journal.

A notable and admirable feature of the paper is the summary of the turbine test results uncorrected to standard conditions, Table 2. The correction curves for pressure variation, superheat-variation and vacuum variation, Figs. 12, 13 and 14, which are used to calculate the last three columns of Table 2, the figures of which are in turn plotted as Figs. 7, 8 and 9, raise the question as to the foundation upon which the correction curves rest. If the writer is not much mistaken they do not rest upon experimentation with the turbine to the test

results of which they have been applied, nor upon any similar turbine. This point is not brought up in the paper, but the writer believes it to be of considerable importance. The turbine characteristics after correction by these curves displayed features unexpected either by the manufacturer or the purchaser; and therefore probably, had it been possible to determine the real correction curves from the turbine itself or from a turbine of similar size and design, the final turbine characteristics referred to standard conditions would have displayed features not exactly like those shown in Figs. 7, 8 and 9.

That apparently no attempt was made to establish the precise characteristics of the turbine from the actual tests data appears to the writer somewhat unfortunate, because by the conditions of the tests the variation of pressure, superheat, and vacuum from the contract conditions were very considerable, and it is such considerable variation from constant conditions of pressure, superheat, and vacuum which it is essential that actual test results should show if the inherent performance of the turbine with varying initial and final steam conditions is to be determined by the turbine itself; thereby determining of course the performance of the machine under the definite contract conditions.

That is, every turbine obeys an individual law, all quantities establishing its performance being bound together in a definite relationship. Of these quantities there are five, namely, the power generated (measured electrically, thus including the generator efficiency); the rate of steam flow; the initial pressure; the initial superheat; and the terminal pressure, that is, the vacuum. It is these five quantities which are ordinarily made use of, more or less arbitrary relationships between the ratio of the rate of steam flow and the power generated (that is, the economy) and the initial and final conditions being applied, and then the resulting figures of weight of steam flow and power generated being plotted and recorded as the performance of the machine under rated conditions.

It need hardly be said that this procedure is inaccurate and unnecessary, if only, by analysis of actual results under varying conditions (such as are tabulated in all but the last three columns of Table 2), the relationship which binds together the five quantities named above may be discovered. I would commend to those interested the paper of Edgar Buckingham on the forms of empirical equations read before the Society in 1915.[1] In his paper problems of just this sort and apparently not more difficult than the one here discussed are handled by a method of great power.

With reference to the important matter of the queer results and effects produced by the separator between the high- and low-pressure cylinders, both before and after removal of the internal baffles, mentioned in the paper and elaborated in the oral discussion, it is the writer's opinion that a good deal is to be explained by the probable simultaneous action of the separator as a separator and as a superheater. The basis for this opinion is the writer's experience in testing steam turbines of various detailed designs and rated capacity ranges from 7,500 kw. to 20,000 kw., in which it has invariably been proven that superheating of the exhaust steam occurs when sudden transformation of energy from kinetic form is occasioned by the blast of exhaust steam striking on the top row of condenser tubes. This superheating, under the ordinary range of high vacuum and load variation, has had the magnitude of anywhere between one and four deg. fahr. superheat. It seems obvious that with steam of very much higher initial pressure, and therefore higher density, entering the separator and caused to pursue a tortuous course by the baffles, ample opportunity exists for similar superheating. Such superheating would naturally vary decidedly with the rate of steam flow and the entrance pressure. Simultaneous separation of moisture and superheating of steam would occur.

It is not improbable that this unlooked-for phenomenon was at least a partial cause of the unexpected hump in the economy curve between 22,000 kw. and 27,000 kw.

The writer regards as still more remarkable, as did some of those taking part in the oral discussion, the dip in the economy curve between 30,000 and the maximum load which the machine could carry, approximately 33,000 kw. He confesses to having remained unenlightened by the oral discussion given this point. It is of course possible that here again the variation of the relative moisture separation and superheating in the separator with varying rate of steam flow and entrance pressure may have played a part.

H. L. H. Smith.

Brooklyn, N. Y.

[1] The Journal, September, 1915, p. 531.

To the Editor:

I note in connection with Table 2, sixth column from the right-hand end of the paper by H. G. Stott and W. S. Finlay, Jr., on Report upon Efficiency Tests of a 30,000-kw. Cross-Compound Steam Turbine which appeared in the June issue of The Journal, that the temperature is given for the 30-in. barometer (presumably that of the mercury) as 58.1 deg. fahr.

Some years ago, in preparing a book of Steam Tables for Condenser Work I had occasion to calculate the temperature of the mercury for 30-in. mean atmospheric pressure barometer and found that this was 58.4.

As it had usually been assumed that the temperature for a 30-in. barometer was 62 deg., this being also the temperature at which the standard English yard is maintained, the figures leading to the temperature of 58.4 were carefully checked and are given below.

On the basis of experiments by Scheel, a deg. fahr. change in the temperature of a column of mercury confined in a tube changes its height 0.000101 times. If the height is increased from 29.92 to 30 in. the mean height is 29.96 and the mean change for each degree rise in temperature is $29.96 \times 0.000101 = 0.003026$ in. The increase from 29.92 to 30 in. is 0.08 in., which, divided by 0.003026, equals 26.4 deg. fahr. Adding this to the 32 deg., the temperature for the 29.92-in. barometer, we have $32 + 26.4 = 58.4$ deg. fahr. as the temperature for a 30-in. barometer.

I would be interested to know what figures were used in arriving at the temperature of 58.1 deg.

Paul A. Bancel.

New York, N. Y.

HAND-FIRED BOILER SETTINGS

To the Editor:

So far as hand-firing is concerned, Mr. Monnett's paper published in the August issue of The Journal illustrates in an interesting way the development of settings to reduce smoke. The principles involved may be shown to underlie the construction of practically all stoker settings as well. The author of the paper mentions these principles in a somewhat parenthetical way, as (1) high temperature; (2) auxiliary air supply; (3) mixture of gases. Many engineers would eliminate the second of these principles. Air jets introduced back of the main grate, more especially if steam is used to supply the air, are apt to have a chilling effect, and in the hands of a

careless operator may lead to serious impairment of boiler efficiency. Steam jets have frequently been regarded with suspicion, the smoke abatement which they are pretty certain to produce being mainly the result of smoke dilution. I think Mr. Monnett's supplementary air jets are profitable because he runs with a heavy fuel bed, and that with a fire of normal thickness the proper place to introduce all of the air is under the grates, so that it will get the maximum amount of warning before it begins to combine with gases from the fuel. Supplementary air, heated in passages through the walls of the setting, is a delusion, because the heating is inadequate and the passages cannot be kept clear.

As a substitute for the second principle offered in the paper, some operators would suggest *room for the flame*. A suitable distance must be traversed before the flame is allowed to strike a relatively cold surface (such as the shell of the boiler). Anyone can verify the necessity for this by the old experiment with a candle flame and a saucer. In Figs. 1 to 3 of the paper this distance is provided. In Figs. 4 and 5 it is not, and the supplementary air supply is introduced as a device for transferring combustion from the grate, where it belongs, to the region behind the bridge wall. Just how much room should be provided for the flame is not known. Twelve feet is sometimes suggested, but few stokers even attempt this. Undoubtedly the desirable amount of space depends upon the nature of the coal, the thickness of fuel bed, the rate of combustion and temperature relations. This is the most important factor in smokelessness, next to thorough mixture of air and gases, because it implies the third principle, of a maintained high temperature.

W. D. Ennis.

Brooklyn, N. Y.

DYNAMIC BALANCE

To the Editor:

In the discussion of Mr. Akimoff's paper on Dynamic Balance, published in the August issue of The Journal, I note that Mr. Hodgkinson speaks of the difficulty of balancing heavy bodies by rolling the axles on level hardened surfaces because the journals sink into the ways to a slight degree so that "extreme sensitiveness cannot be obtained because of the field having to run uphill." It is true, of course, that this deformation of the axle or shaft, and of the hardened straight edges, adds to the resistance of rotation, but it does not seem to me to be true that the field runs uphill. If the deformation of the shaft and of the straight edges is uniform, the path of the axis of the rotating body will be parallel to the straight edges, and if they are level this path will also be level, and there will be no running uphill.

Assuming that the deformation of the shaft and of the straight edge gives a bearing surface of considerable magnitude, say for instance ¼ in. in width, then the metal for ⅛ in. in advance of a vertical line drawn from the center of the axis is being compressed by the rolling axle. But so long as this compression is within the elastic limit of the materials, the energy consumed in this deformation ahead of the vertical line referred to is restored to the rolling axle by the recovery of form in that part of the depressed surface which is behind the vertical line drawn from the center of the axis; and the only loss of energy is in the internal resistance of the materials themselves, which, in the case of hardened steel deformed well within its elastic limit, is very small.

Probably the main cause of the impression that heavy bodies have considerable frictional resistance to rotation under such conditions is that relatively large forces are required to set them in motion, or to accelerate them, independently of friction.

Mr. Hodgkinson speaks also of the fact that the film of oil in the bearing of a heavy armature will be squeezed out within a short time, so that there will be metallic contact and a considerable increase of friction. In 1897 I first saw in a municipal electric light station in Manchester, England, bearings of direct-connected generators which were fitted with oil channels and force pumps so that oil was driven under the journals at the center of the bearings, flowing out around the journal at the ends in a thin stream and literally supporting the journals upon this maintained film.

I do not know to what extent this plan has been adopted elsewhere, but whether there are sufficient reasons for its general adoption or not, it would remove the difficulty referred to by Mr. Hodgkinson.

Fred J. Miller.

New York, N. Y.

REPLY TO COMMENTS ON RECLAMATION PLANT

To the Editor:

Answering Mr. W. B. Gregory's comments, appearing on page 561 of the July issue, on my paper entitled Design and Test of a Large Reclamation Plant, published in the May issue, I would state that in the particular plant under consideration, the average pumping head has been estimated to be approximately 16 ft.; and that during the normal operation of the plant, only three units would be running, one on each discharge pipe. Conditions of rainfall and run-off would be such that the occasion for operating more than three units would be comparatively rare. Therefore the design of discharge pipes has been governed to some extent by the normal operation—in other words, the conditions of operation which call for the greatest expenditure of power for pumping purposes. Further, the diameter of the discharge pipes is governed by the relation between the power cost and construction cost. The writer's calculations in this particular case showed that the most economical annual cost, including operating and depreciation interest charges, was obtained with pipes approximately 78 in. in diameter.

During the winter months, when this plant will be in operation, the suction pipes will be under water. In Fig. 8 of the paper, the water outside of the levee is at the end of a very dry season, and at a normal low period. It might be said that at no time during the ordinary course of operation of the plant will the suction pipes be exposed, as shown by this illustration, therefore the discharge pipes may be said to have a complete water seal.

In reference to advantages and disadvantages of carrying pipes through or over the levees, this question was gone into rather carefully, and it was decided to carry the pipes through the levee, primarily on account of construction difficulties. At the time the plant was installed, the levees at this point were not completed, therefore pipes were very easily carried through levees and supported on firm ground. To carry pipes over levees would have meant considerable trestle work and would interfere seriously with the building of levees, particularly with additions to levees, which are necessary as time goes on, on account of wasting away due to action of the elements and other causes.

The installation of gate valves on the discharge pipes was not governed by whether pipes went through or over levees. The valves were installed for two reasons: *First,* to reduce priming

difficulties on account of the extremely large volume of discharge pipes, and *second*, as a safety factor in case of breakage of pumps, etc., which might cause serious flooding before sluice gates and check valves could operate on the extreme end of discharge pipes.

G. C. Noble.

San Francisco, Cal.

THE INDUSTRIAL SERVICE MOVEMENT

To the Editor:

The paper entitled Industrial Service Work in Engineering Schools, read by Prof. J. W. Roe, of Yale University, at the June, 1914, meeting of the Society, created a great deal of interest. Among other things Professor Roe said:

"While thousands have been invested in welfare enterprises, we know that the purpose behind them is being accomplished in scores of industrial organizations, without any special equipment, by the personal influence of some man or men in charge. These men seem to have a genius for understanding and developing the best in the men under them. They have no fixed rule or system. It is a question of attitude and personality. They create an atmosphere of confidence instead of suspicion and distrust. Their influence permeates a whole factory, kindling ambition and developing better workmen and better industrial conditions. Such men can accomplish wonders without welfare equipment. Given a welfare they make it successful and beneficial to all. Their value to the employer, to the workman, and to the community can hardly be overestimated; the new art of management under the direction of such men as these will prove a permanent success. The development of just such men as these is the aim of the Industrial Service Movement."

Members of the Society will be interested in some of the most recent developments in this Industrial Service Movement, and in some of the latest statistics of its growth. At present over 4000 students from upwards of 250 colleges and technical schools are engaged in many forms of volunteer service for 100,000 working men and boys. Their service is surprisingly conscientious and efficient. Nevertheless the college students probably get more than they give, which is part of the game.

The Industrial Department of the International Committee of Young Men's Christian Associations now has on its mailing list several thousand engineering graduates, who became interested in their undergraduate days. These men are followed up and kept in touch with as far as possible. Remarkable letters are frequently received from many parts of the continent. The quotations below are characteristic:

"I had already read of this Movement in the technical journals, and it seems to me to be one of the most admirable and needed advances made in the industrial field for years. I want to be of every possible service to you."

"I have always intended to take an active part in this work as soon as I should settle down, for the little I did in college in that line has left me with a sense of personal responsibility to continue work. I am writing to you now to let you know that you can count on me to do my utmost to help the good cause along."

"I am glad to state that I think the industrial work is of very great permanent benefit to those who take active part in it. I am sure that by giving English lessons to Italian laborers I learned more of them than I could have learned in any other way."

"I have come to realize to much greater extent than ever before the importance and even necessity of this work in the routine of the undergraduate, especially the one who intends going into such lines as I have taken up."

"Although I never did any of this work in college. I heard various men speak of it and resolved to undertake it after graduation. I have now charge of all the foreign employees in this plant and have always tried to treat them on the square. Before I came, a cursing, brutal foreman made all sorts of labor difficulties. Since I took hold there has been no trouble whatever and the men have remained absolutely loyal. Am now starting special classes for our men in rooms provided by our company. I am teaching one of the classes myself and enjoy it hugely."

"I now have charge of all the accident prevention work in our factory and feel sure that I would not be holding this position today were it not for the sympathetic touch with the work which I got in my undergraduate days. I consider the Industrial Service Movement one of the greatest influences for industrial righteousness in the country today."

One of the most interesting illustrations of how much can be accomplished by the young engineer is afforded by a Michigan man who graduated in 1913. Because of his touch with the Movement in his senior year, he showed a remarkable interest in the foreign men in his company. Officials noted his ability, placed him in partial charge of all their educational work for foreigners, with the result that over a thousand employees in that company study English and American citizenship. They are taught by sixty volunteer leaders in sixteen different class rooms provided by the company.

Why confine the advantages of this Movement to these engineering students who can find time to teach a class of foreigners, lead a club of apprentices, talk in labor unions or engage in some other form of definite service? It is manifestly impossible to get every student to do such work. But *it is possible to help every engineering student in a college to realize his opportunities and social responsibilities, and to get some conception at least of the human side of his job.* To this end it is encouraging to note the increasing tendency to include such instruction in the engineering curriculum. Probably the most recent suggestion in this regard is a proposed required course for seniors, a rough outline of which is given below.

This outline has been prepared by request with the help of some leading engineering professors and business men. It is arranged to cover 32 or 64 class periods—four months' or eight months' work at the rate of two periods a week. This is merely a rough preliminary outline. The course should be supplemented by engineering trips to study certain industrial conditions and the betterment work of selected companies and social agencies.

1 *Introductory—The Human Factor in Industry*
Two periods. Showing in an interesting way that men comprise the most important element in any industrial operation. Do we realize that one of the greatest elements of success is the ability to deal intelligently with men?

2 *Historical—The Evolution of the Individual Worker in Industry*
From two to four periods—Industrial Evolution.

3 *Industrial Organization—The Influence of the Modern Factory System on the Worker*
Three to five periods. General and departmental organization. Management. The relation of wages, hours, etc. The interdependence of men.

4 *Human Factors in Production*
From six to sixteen periods. Problems to be solved.
a General—Capital and Labor, immigration, unionism, etc. What shall our attitude be toward these great questions?
b Working Conditions. Do right conditions pay?
c Living Conditions. What relation has health to efficiency?

d Leisure Conditions. Why is "big business" interested in these things?

5 *Vocational Guidance and the Education of Employees*
Two to four periods. To what extent does improving a man's education increase his efficiency?

6 *Coöperative Organizations*
Two to four periods. National Civic Federation, National Council for Safety, Russell Sage Foundation, the Y. M. C. A., etc.

7 *Legislation and Public Opinion on Industrial Questions*
Two to four periods. To what extent have welfare requirements been incorporated in Federal and State Laws? To what extent is public opinion a determining factor?

8 *The Programs of Typical Companies. Industrial Betterment*
What has been and can be done along such lines as indicated above?

9 *Scientific Management*
Principles, importance of motion study, time study, division of labor, etc. Human aspects of the system.

10 *How to Handle Men*
Examples of industrial leaders who have been successful in handling men. The Industrial Service idea.

11 *Conclusion—The Engineer's Responsibility for Service*
In the light of the above what will be your attitude as you graduate? Will your life purpose be wealth regardless of others, or service for others?

This is merely a suggested outline and is being constantly improved. Most of the sub-topics and comments have been omitted through lack of space. Where it is not thought possible to give such a course, special lectures on kindred subjects help greatly. Weekly discussion groups on industrial problems are often planned. A special reference library on industrial service, frequent articles in college periodicals, *discussions of the work at meetings of the student engineering societies,* all help maintain interest.

After spending six years promoting this Movement in scores of colleges, the writer is convinced that it is destined to a great future. The response grows every week. In a recent trip of six weeks through the Universities of the Middle West over 1500 students indicated their interest, and over 600 volunteered for definite service. Men are not pushed into this work. It is placed squarely before them and they can do as they please. Yet the universal experience is that the best and "biggest" men in college find time to help.

The interest and coöperation of the National Engineering Societies is of tremendous value, and I bespeak the continued and increasing support of The American Society of Mechanical Engineers.

Fred H. Kinge, Jr.

New York, N. Y.

HIGH-TEMPERATURE INSULATION

To the Editor:

While inaccuracies in the introductory generalizations of the paper by Mr. Boeck in the August issue of The Journal do not lessen the importance and accuracy of the main body of his article, it is none the less unfortunate that this introduction contains such statements.

It is true that "heat is a form of energy consisting of molecular vibrations," but it is not true that it is "subject to the general laws of wave motion." It can not "be reflected, refracted and dispersed by creating the proper conditions." While the introduction of layers of material of low heat-transmitting value decreases heat flow, the use of alternating layers is not necessary, because the resistance to flow of heat in such cases is not due to "breaking up or changing the wave length."

It is inaccurate to speak of heat as being radiated. Heat cannot be radiated. Hot bodies do emit radiant energy, which is, however, not heat, but vibrational energy of the luminiferous ether. This energy can be transmitted not only, as Mr. Boeck states, through the gaseous state of matter, but also through liquids and many solids, such as glass, silica and the like. In the opinion of the writer, some of the phraseology in the introduction of this paper produces loose and inaccurate thinking, and renders infinitely more difficult the application of scientific knowledge to the solution of industrial problems.

On the other hand, the value of Mr. Boeck's contribution in calling the attention of the engineering profession to a material of high resistance to heat flow, yet possessing at the same time satisfactory mechanical qualities, especially reasonable mechanical strength and resistance to vibration and to the contraction and expansion caused by temperature change, must not be underestimated. Furthermore, the emphasis laid upon the fact that air spaces at high temperature are better conductors of heat than even relatively poor solid insulators, owing to the high radiation losses across the gaseous spaces at high temperature, is well worth while. This fact, though long known, is not even yet appreciated to the extent that it should be. Owing to the high heat conductivity of firebrick, and even of common brick, the construction of a fire wall of high heat resistivity is difficult, and indeed impossible, without the use of some such insulating material as that described by Mr. Boeck.

It would be of very real value if Mr. Boeck would state whether the heat loss diagrams of Fig. 7 are diagrammatic, or represent experimental results. In the latter case, a statement of the experimental method employed is important, because the accuracy and reliability of the methods hitherto employed are unsatisfactory; and if carefully conducted experiments of this sort were reported in detail, they would not only furnish the heat conductivity of the specific material tested, but also add to our knowledge of the best methods of testing such substances intended for technical insulation.

W. K. Lewis.

Boston, Mass.

There were nearly 33,000 students in the engineering schools of the United States in 1915, divided among the various branches as follows: Mechanical, 7751; civil, 7182; electrical, 6637; general, 6059; chemical, 2383; mining, 1922; other, 958.

The U. S. Bureau of Standards has made tests of unusually large wire ropes intended for the Panama Canal. These ropes, of plow steel, showed an ultimate strength, in lb. per sq. in. of net area, of 184,200 for the 2-in. rope and 214,900 for the 2¾ in., while the total ultimate loads ranged between 304,000 lb. for the 2-in. rope and 866,000 lb. for the 3¼ in.; a specimen of the last named diameter Monitor plow steel showed 937,000 lb.

The tests were made on the Emery machine at Washington, and special holders were designed for it by the Bureau. The capacity of this machine is 1,200,000 lb. and the special holders were provided in order that this full tension might be utilized.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

Since the publication of the April issue of The Journal, in which interpretations of Cases Nos. 45-58 inclusive were presented, three meetings of the Boiler Code Committee have been held: one in March, at which Cases Nos. 59-60 and 63-66 were taken up, Cases Nos. 61-62 being left in the hands of the Committee; one in May, when Cases No. 68, Nos. 70-73 and Nos. 75-80 were considered, Cases Nos. 67, 69 and 74 being left in the hands of the Committee; and one in June, at which interpretations were rendered in Cases Nos. 49*a*, 61, 67, 69, 74, and 84-88, Cases Nos. 81-83 having been annulled and Case No. 87 left in the hands of the Committee. Thus, a total of 26 interpretations have been rendered, three cases having been annulled, leaving two Cases and Case No. 49*b* still in the hands of the Committee.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that anyone interested may readily secure the latest information concerning the interpretations.

Below are given the interpretations of the Committee, as approved by the Council on July 27, 1916, in Cases Nos. 49*a* and 59-88 inclusive. In this report, as previously, the names of inquirers have been omitted.

Case No. 49

Inquiry: a. How far does the Boiler Code apply to the case of flash type boilers, or those having a forced circulation with no fixed steam and water line?

Reply: a. The material for boilers of this class shall conform to the requirements of the Code. All other requirements shall also be met except where they relate to special features of construction made necessary in boilers of this type, and to accessories that are manifestly not needed or used in connection with such boilers, such as water gages, water columns and gage cocks.

Inquiry and Reply: b. (In the hands of the Committee.)

Case No. 59

Inquiry: Is it within the requirements of the Boiler Code to use flange steel for parts of boilers where fire-box steel is required, provided the steel has all the physical and chemical requirements of the fire-box grade. The condition of the iron and steel market is such that the manufacturers must resort to extreme means to obtain the material.

Reply: If the plate manufacturers will guarantee the steel is up to that of the specifications for fire-box steel, it is obvious that they, the steel manufacturers, may restamp for you the plate in question. The Code requires that no plates shall be used as fire-box steel unless so stamped by the steel manufacturer.

Case No. 60

Inquiry: Is Par. 199 applicable to the stay-bolting of water legs in water tube boilers of the Heine type? We understand it is the practice of some manufacturers to calculate this construction under Par. 206. Please give an interpretation of Par. 207 also.

Reply: Your staybolt spacing would rightly come under Par. 206. The construction of handhole openings, etc., must be such that the requirements of Par. 207 are complied with.

In applying Par. 207, the plate with handhole openings must be considered as a continuous beam supported at the center lines of stays for which there are standard engineering formulae.

Case No. 61

Inquiry: Can flanges for blow-off piping be drilled for six bolts on a 6 1/16-in. bolt circle for the 2½-in. pipe size, whereas Table 16 of the Boiler Code requires four bolts on a 5⅞-in. bolt circle?

Reply: Par. 299 of the Code refers to the flanges on the discharge sides of steam nozzles, or to flanges, when used, left by the manufacturer as a part of the boiler for the connection of other piping or fittings, and to fittings shown on page 112 for pressures up to and including 250 lb., and does not apply to fittings specially designed as part of the boiler. Where threaded openings are left on the boiler, Par. 268 shall apply.

Case No. 62

(In the hands of the Committee.)

Case No. 63

Inquiry: Are we to understand that iron through-bolts not welded will be allowed 8500 lb. per sq. in. under Table 4? Par. 4 specifies that welded braces should be of iron.

Reply: Stresses given in Table 4 cover both iron and steel stays, either of which may be used. According to Par. 4, if stays or braces are welded, they must be made of iron.

Case No. 64

Inquiry: Interpretation is requested relative to the value of the constant in the formula of Par. 199 when applied to vertical tubular boilers in which the furnace sheet is thicker than the outer barrel sheet. If the furnace sheet is of such thickness as to permit of using 120 for C in the above mentioned formula, and the outer barrel sheet to which the furnace sheet is stayed is of such thickness as to permit of a value of 112 for C, which constant should be used?

Reply: When two sheets are connected by stays and but one of these sheets requires staying, the value of C, in rule 199, is governed by the thickness of the sheet requiring staying. When both sheets require staying as flat surfaces, the value of C is governed by the thickness of the thinner sheet.

Case No. 65

Inquiry: A definition is requested of the word "fitting," as to whether it refers, in connection with Par. 299, to ells, tees, crosses, and the other ordinary pipe fittings, or whether it may be extended to cover such irregular shapes as water columns, blowoff connections, valve bonnets, etc.

Reply: Par. 299 refers to the flanges on the discharge sides of steam nozzles or to flanges, when used, left by the manufacturer as a part of the boiler for the connection of other piping or fittings, and to fittings shown on page 112 for pressures up to and including 250 lb., and does not apply to fittings spe-

cially designed as part of the boiler. Where threaded openings are left on the boiler Par. 268 shall apply.

Case No. 66

Inquiry: Par. 270 is ambiguous in that one clause of the Paragraph specifies a maximum rise of pressure of 6 per cent above the highest pressure to which the valve is set, while the other specifies a maximum of 9 per cent above the allowable working pressure. An interpretation is also requested of what is intended in Par. 292, page 75, respecting water glass connections.

Reply: Par. 270, page 68 of the Code, is intended to specify a safety valve capacity such that the safety valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure in any case to rise more than 6 per cent above the maximum allowable working pressure, and there is no rule in the Code which warrants a rise in pressure of more than this for any safety valve setting. Where a safety valve or valves are set at a pressure considerably lower than the maximum allowable working pressure this rule alone would not be sufficient, as it would allow the pressure in a boiler built for 100 lb. to increase to 106 lb. with a low pressure safety valve on the boiler set at, say, 5 lb. In order to cover this feature, the further condition was imposed that the discharge capacity must be such that the pressure will not rise more than 6 per cent above the highest pressure to which any valve is set.

An interpretation of what is intended in a reply to an inquiry in regard to Par. 292, page 75, respecting water glass connections, is published in the January 1916 issue of The Journal under Case No. 35.

Case No. 67

Inquiry: Is there not a conflict between Pars. 253 and 223 of the Boiler Code as to the punching of rivet holes full size? Par. 253 makes exception as regards rivet holes for attaching stays or angles to heads, inferentially permitting such rivet holes to be punched full size.

Reply: Par. 253 excepts rivet holes for attaching stays or angle bars because such parts need not be bolted in position when drilled.

Par. 223 requires that all rivet holes in the parts to be braced, as well as in the brace itself, must be either drilled full size, or punched under size and drilled. (See Case No. 27).

Case No. 68

Inquiry: What is the application of Par. 186 to unfired vessels subjected to pressure, whether steam, water or air? Such unfired vessels with joints formed by autogeneous welding are extensively used carrying high pressures.

Reply: The Committee has not formulated rules for pressure vessels other than steam boilers, and is, therefore, not in a position to pass upon this question.

Case No. 69

Inquiry: Please explain the application of Par. 223 of the Boiler Code to the design of the ordinary form of diagonal boiler brace.

Reply: In previous cases of this kind (See Case No. 29) the Committee has said that all braces used in A.S.M.E. Code boilers should conform to the Code in every detail. Difficulty has been experienced in interpreting Par. 223, which applies to such braces, and the Committee therefore submits the following to explain how this paragraph should be applied:

> The requirements in Par. 223 are based on the "required cross sectional area of the brace." To apply Par. 223, proceed as follows:
>
> 1. Determine the "required cross sectional area of the brace" by first computing the total load to be carried by the brace, and dividing the total load by the values of stresses for unwelded stays given in Table 4.
>
> 2. Design the body of the brace so that the cross sectional area shall be at least equal to the "required cross sectional area of the brace" for unwelded braces. Where the braces are welded, the cross sectional area at the weld shall be at least as great as that computed for a stress of 6000 lb. per sq. in. (See Table 4.)
>
> 3. Make the area of pins to resist double shear at least three-quarters of the "required cross sectional area of the brace."
>
> 4. Make the combined cross section of the eye at the side of the pin (in crowfoot braces) at least 25 per cent greater than the "required cross sectional area of the brace."
>
> 5. Make the combined cross sectional area of the rivets at each end of the brace at least 1¼ times the "required cross sectional area of the brace."
>
> 6. Design each branch of a crowfoot to carry two-thirds the total load on the brace.
>
> 7. Make the net sectional areas through the sides of the crowfeet, tee irons, or similar fastenings at the rivet holes at least equal to the required rivet section, that is, at least equal to 1¼ times the "required cross sectional area of the brace."
>
> 8. The cross sectional area through the blade of a diagonal brace where attached to the shell of the boiler shall be at least equal to the required rivet section, that is, at least equal to 1¼ times the "required cross sectional area of the brace."

Case No. 70

Inquiry: Should the use of a non-return stop valve not be made compulsory on all power boiler delivery connections.

Reply: Suggestions for changes will be considered at a hearing before the Committee, where all interested parties may be heard. It is recommended in the Code that such hearings to consider revisions be held at least once in two years, and the time for the first hearing is now near at hand.

Case No. 71

Inquiry: Does Table No. 7 in the Code apply to the thickness of plate used where washout plugs are threaded through the sheet?

Reply: It is the opinion of the Committee that Par. 268, including Table No. 7, is intended to refer to any threaded opening in a boiler, which includes openings for threaded washout plugs.

Case No. 72

Inquiry: Is there not a misprint in Par. 21 in specifying standard gages for 4 in. and 5 in. tubes and one gage heavier than standard for 3 in. tubes for maximum allowing working pressures not exceeding 165 lb. per sq. in.

Reply: The table in Par. 21 should read:

Diameters less than 3¼ in.....No. 12 B. W. G.
Diameter 3¼ in. or over, but less than 4 in..No. 11 B. W. G.
Diameter 4 in. or over, but less than 5 in....No. 10 B. W. G.
Diameter 5 in.....No. 9 B. W. G.

Case No. 73

Inquiry: Is the use of extra-heavy bronze composition blow-off valves permissible under Par. 402?

Reply: The question of the use of extra-heavy brass or bronze fittings between boiler and blow-off was not considered at the time the Code was compiled, and it is the sense of the Committee that their use is permissible.

Case No. 74

Inquiry: The rules in the Boiler Code for girth seams of horizontal return tubular boilers do not appear to provide

sufficient rivet area to draw the plates firmly enough together to avoid the necessity of excessive calking. A ruling is requested on this point.

Reply: Par. 184*a* of the Boiler Code was arranged to provide for proper strength for girth joints in all types of boilers. To cover the point raised, the Committee recommends that girth joints of horizontal return tubular boilers have the shearing strength of the rivets not less than 50 per cent of the full strength of the plate at the joint.

Case No. 75

Inquiry: An interpretation is requested of Par. 194. The punctuation is such that it is indefinite as to whether the pressure requirement in the first clause refers to the joint or to the flange only.

Reply: The intent of Par. 194 is that all domes 24 in. or over in diameter shall have butt and double strap longitudinal joints, irrespective of the pressure used.

Case No. 76

Inquiry: What net area should be considered in calculating stay bolts with tell-tale holes drilled in their ends; also an opinion is requested whether in determining the load on a bolt, the full pitch dimensions of the area stayed should be used, or whether the area occupied by the bolt itself should be deducted therefrom.

Reply: The question as to the area of a drilled staybolt is answered by Par. 220, which specifies clearly the net cross-sectional area of the stay. The full pitch dimensions of the stays should be employed in determining the load on the bolt and the area occupied by the bolt itself should not be deducted therefrom. The full pitch dimensions should be measured as in Par. 199, in which p, the pitch, is specified as the maximum measured between straight lines passing through the centers of the staybolts.

Case No. 77

Inquiry: Should the tensile strength stamped on the plate, or the result of actual test be used in the determination of the percentage of elongation as specified in Par. 28.

Reply: It is the opinion of the Boiler Code Committee that the tensile strength obtained by actual test is to be used in determining the elongation.

Case No. 78

Inquiry: An interpretation is requested of the reference in Par. 268 to "methods given in Par. 261," and concerning the application of the reinforcing ring that would seem to be required thereby to the boilers of their construction.

Reply: The proportions called for in Par. 261 refer only to reinforcements as described in Par. 260.

Case No. 79

Inquiry: Can a low pressure heating boiler, under Part I, Section 11, of the Code, be marked A.S.M.E. Standard if the metallic arc welding process has been used in the construction of headers when stay bolts are placed between parallel surfaces adjacent to the welded edges.

Reply: Inasmuch as it is proposed to provide for the lateral stresses in the headers by means other than the welded edges, the Committee sees no objection to the use of the weld in the manner indicated, and if the boiler is constructed entirely in accordance with the A.S.M.E. Boiler Code, both as regards the boiler itself and the fittings, it can be marked "A.M.S.E. Standard" and as specified in Par. 377; if it does not conform to the Code in every respect, marking it in that way would be evidently a misrepresentation. The use of the symbol is specified for power-boilers only which are constructed in conformity with the Code.

Case No. 80

Inquiry: Referring to the prohibition by the Boiler Code of any method of welding of boiler shells except by the forging process, has the Committee investigated methods of welding recently? A great deal of time and effort has been put forth by manufacturers of autogenous welding apparatus and the Committee is requested to give this matter further consideration.

Reply: The Committee has since its inception had under constant observation all sorts of welding of pressure vessels, and has gone as far as to ask some of the welding experts of this country to write papers for the Society to bring out further information regarding this particular process. Suggestions for changes will be considered at a hearing before the Committee, where all interested parties may be heard. The Committee recommended in the Code that hearings to consider revisions be held at least once in two years and the time for the first hearing is now near at hand.

Cases Nos. 81, 82, 83

(Annulled)

Case No. 84

Inquiry: Can boiler tubes for use in a porcupine type of boiler, where stub tubes are screwed into furnace sheets, be made of standard wrought iron pipe if the threaded ends are properly designed?

Reply: It is the opinion of the Committee that tubes with properly designed threaded ends with sufficient strength in the thread should be permissible. This necessitates a heavier gage of tubing for a given pressure than where the tubes have expanded ends.

The tubes should in all cases meet the boiler tube specifications, pages 40-42 of the Code.

Case No. 85

Inquiry: Is it necessary under Par. 406 of the Boiler Code to place an independent check valve between an injector and the boiler when there is a check valve incorporated in the design of the injector?

Reply: To meet the requirements of Par. 406 of the Boiler Code, it is necessary to place an independent check valve, and valve or cock between the pump or injector and the boiler, and this requirement is not covered by the check valve which is located in the injector.

Case No. 86

(In the hands of the Committee.)

Case No. 87

(In the hands of the Committee.)

Case No. 88

Inquiry: What is the required strap thickness for butt strap joints where the plate thickness used does not coincide with the thicknesses specified in Table 1 of the Boiler Code?

Reply: The thickness of butt straps should be obtained by interpolation of Table 1, page 9, of the Code, using as a minimum thickness the plate which agrees with the interpolated value to the nearest thirty-secondth of an inch.

Society Affairs

Engineering Survey

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES[1]

OFFICERS AND COUNCIL, 1916

President

D. S. Jacobus

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Vice-Presidents

Terms expire December 1916

Henry Hess
George W. Dickie
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

COMMITTEES, ETC.

STANDING COMMITTEES

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library, John W. Lieb
House, William N. Dickinson
Research, R. J. S. Pigott
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee to Determine Cost of Electric Power
Conservation
Electrical Engineering Standards
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R. Hutton
Boiler Code Committee, John A. Stevens
Engineering Education
Filter Standardization, George W. Fuller
Increase of Membership, Irving E. Moultrop
Metric System
Nominating Committee, Walter B. Snow
Patent Laws
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee, R. J. S. Pigott
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Investigation of the Clinkering of Coal, Lionel S. Marks
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Machine Tools, Leon P. Alford
- Sub-Committee on Safety Valves
- Sub-Committee on Steam Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A. Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, (Secretary not appointed)
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit (not appointed)
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

As matters of moment in the affairs of the Society required immediate consideration and action, a special meeting of the Council was called for July 27. The following members responded: D. S. Jacobus, *President*, J. Sellers Bancroft, John H. Barr, R. M. Dixon, *Chairman Finance Committee*, A. M. Greene, Jr., James Hartness, C. T. Main, Spencer Miller, H. de B. Parsons, James E. Sague, John A. Stevens, E. H. Whitlock, Wm. H. Wiley, *Treasurer*, and Calvin W. Rice, *Secretary*. By invitation, Charles Whiting Baker, representative of the Society on the Joint Conference Committee of the National Engineering Societies, and Herman Aaron, Esq., general counsel of the Society, were also present.

The important transaction of the meeting, and one of paramount interest to the whole engineering profession, was the unanimous adoption of resolutions receiving the American Society of Civil Engineers into the United Engineering Society, to become one of the Founder Societies in joint ownership, occupancy and administration of the Engineering Societies Building. These resolutions follow:

"WHEREAS, A resolution was heretofore passed by the trustees of United Engineering Society on June 24th, 1915, inviting the American Society of Civil Engineers to consider entering the United Engineering Society as an additional Founder Society, and proceedings were had thereupon as are more particularly set forth in the resolution passed by the Board of Directors of the American Society of Civil Engineers on the twenty-third day of June, 1916, which said resolution is as follows, to wit:

"WHEREAS, The following resolution was passed by the Trustees of United Engineering Society on June 24th, 1915, to wit:

'RESOLVED, That out of its desire to welcome the American Society of Civil Engineers into the fraternity of the Founder Societies and with a sense of the increased dignity and usefulness to the engineering profession which this adherence to the American Society of Civil Engineers would contribute, the United Engineering Society hereby desires to express the sentiment in favor of coalition which has been growing, and to invite the American Society of Civil Engineers to consider entering the United Engineering Society as an additional Founder Society; and the President is authorized to appoint a Committee to confer with any corresponding Committee of the American Society of Civil Engineers in the formation of a tentative plan which if this invitation is accepted can be referred on the part of the United Engineering Society to the governing bodies of the Founder Societies for their action.'

and

"WHEREAS, Such resolution has been approved by the governing bodies of the American Institute of Mining Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers, and was likewise considered and approved by the Board of Direction of this Society, and

"WHEREAS, Conferences have been held between a Committee representing the United Engineering Society, and a Committee representing this Society, and offers have been made in letters dated July 6th, 1915, August 23rd, 1915, and October 28th, 1915, by the Committee of the United Engineering Society, to the Committee representing this Society, and

"WHEREAS, By special ballot, canvassed June 15th, 1916, 2500 of the Corporate Members of this Society voted in favor of the acceptance of the invitation of the United Engineering Society, and only 390 Corporate Members voted against such acceptance, and

"WHEREAS, On that ballot the sentiment of a majority of those voting on each of the plans submitted was expressed in favor of the plan which provides for the addition of three stories to the present building of the United Engineering Society, and against the plan which does not provide for such additional stories, be it

"RESOLVED, That this Board, acting in behalf of the American Society of Civil Engineers, accepts the invitation of the United Engineering Society made, in behalf of the American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, to become one of the Founder Societies, in accordance with the terms and conditions contained in the before mentioned letter, dated July 6th, 1915, as modified by the before mentioned letter, dated August 23rd, 1915, which provide for the construction of three additional stories to the present building of the United Engineering Society, at an estimated cost of $225,000. It is understood, in accordance with the terms of said letters, that the cost to this Society in any event is not to exceed $250,000.

"RESOLVED, That Clemens Herschel, Charles Warren Hunt, and J. V. Davies, be and are hereby authorized for, and in behalf of, this Society, to execute any agreements or other instruments that may be appropriate for carrying into effect, in accordance with the above, the plan whereby this Society shall enter the United Engineering Society as an additional Founder Society, this Society assuming therein an obligation to defray the expenses of such building operations, at a cost not to exceed $250,000."

"NOW BE IT RESOLVED, That the said last mentioned resolution and the plans set forth therein be, and the same are hereby approved, and that D. S. Jacobus and Calvin W. Rice be and they hereby are authorized for and in behalf of this Society to execute any agreements or other instruments that may be appropriate for carrying into effect the aforementioned plan and to cause the corporate seal of this Society to be affixed to any such agreement or instrument."

Actions by the Executive Committee, as recorded in the minutes of the meeting of July 7, 1916, of that committee, were confirmed.

E. G. Spilsbury, John R. Freeman or H. G. Stott, the Society's representatives on the Board of Trustees of the United Engineering Society, were appointed attorneys and proxies of the Society to attend a meeting of the Founder Societies of

the United Engineering Society to vote for the Society upon an increase in the number of trustees of the United Engineering Society from nine to twelve.

Interpretations of the Boiler Code Committee, Nos. 67 to 80 inclusive, and Nos. 49, 61, 67, 69, 74, and 81 to 88 inclusive, were approved with certain corrections and ordered issued. The corrected interpretations are published elsewhere in this number of The Journal under the title Work of the Boiler Code Committee.

J. Sellers Bancroft was appointed a member of the Committee on the Metric System.

Sections in Detroit and in New Orleans were authorized and the following Committee appointed in the latter place: W. B. Gregory, *Chairman;* H. L. Hutson, *Secretary and Treasurer;* R. T. Burwell, E. W. Kerr, and H. F. Rugan.

James E. Sague, Vice-President of the Society, was appointed to represent the President at a meeting of the Board of Trustees of the United Engineering Society to perfect the preliminary arrangements for the reception of the American Society of Civil Engineers into the United Engineering Society.

In connection with the preparation of the Budget for the ensuing year, the Council directed that one-half of the initiation fees should be included in the income and one-half set aside in the reserve fund; that for the up-keep of the Society's furniture and fixtures, a depreciation, repair and renewal fund should be established, and that 15 per cent of the present inventory value should be annually appropriated to this fund, and that mileage for attendance at Council meetings be at the rate of 7 cents per mile, one way.

Matters referred by a previous Council to the Joint Conference Committee of the National Engineering Societies, viz, the subjects of Ethics and of Joint Administration of Sections were referred back by the Conference Committee with the recommendation that the existing committees on these subjects in the several Societies should be brought together in a joint conference, and the Council requested the President to take the initiative to arrange such joint meetings.

The action of the Joint Conference Committee with relation to recommending to the attention of the President of the United States the desirability of legislation relating to the development of water power was approved. Here follows the resolution:

"The Joint Conference Committee of National Engineering Societies believes that the development of the country's undeveloped water power will increase national prosperity; that private enterprise should be encouraged and stimulated to expedite such development; that unnecessary legal burdens should be removed and existing doubts as to the safety of investment eliminated. It commends to the support of engineers all efforts made to secure the fullest publicity as to the underlying facts regarding this subject."

A note regarding water power legislation now pending before Congress appears elsewhere in the Society Affairs Section of this issue of The Journal.

The Council invited the House Committee, under the general direction of the Committee on Meetings, to take charge of the President's Reception at the time of the Annual Meeting, and on account of the anticipated large attendance, it was suggested that this reception be held on the Fifth Floor of the Engineering Societies Building, where better accommodations are available.

The report of the Tellers of Election of Dr. Ambrose Swasey for Honorary Member was read, together with the letter of acknowledgment from Dr. Swasey. This letter appears at the bottom of this page.

A letter was read from Frank J. Sprague, Chairman of the Memorial Committee of The American Institute of Consulting Engineers, asking this Society to join in the erection of a memorial tablet to Alfred Noble, past-officer of this Society. This communication was referred to the Trustees of the United Engineering Society, as a Committee of Trustees has already under consideration a comprehensive scheme for tablets, etc., for the Engineering Societies Building.

A communication with respect to the standardization of machine tools, which had been solicited by the Secretary, was received from L. P. Alford. The Secretary was requested to confer with the Chairman of the Research Committee, and ascertain if the work of standardization had better be undertaken in connection with the work of the Research Committee, or independently.

A request was made to the counsel of the Society, Herman Aaron, Esq., for an opinion as to the part the Society may consistently take in the Minnesota Joint Engineering Board, the proposal for which was noted in the August issue of The Journal.

The Finance Committee reported the condition of the Society up to and including July 31, of which report the following is a resumé:

Book accounts charged this date	$137,486.32
Estimated income for the year	149,570
Expenses incurred to date	124,003.11
Budget appropriation	139,975

The Certificates of Indebtedness having been entirely paid, the total indebtedness of the Society of all kinds is solely the current expenses of the past month, amounting to $14,515.84

against which the Society has in cash and other quick assets $85,798.33

which does not include the trust funds of the Society, all of which are invested.

Calvin W. Rice, *Secretary.*

LETTER FROM DR. SWASEY

The following letter was received from Dr. Swasey, expressing his appreciation of the action of the Society in electing him an honorary member:

Cleveland, Ohio,
July 11, 1916.

Prof. D. S. Jacobus, President,
The American Society of Mechanical Engineers,
New York.

Dear Professor Jacobus:

I am pleased to receive your favor of the 5th advising me of the action of the Council in electing me an honorary member of the Society. This is a great honor, and I appreciate it more than I have words to express. I regard it one of the gratifying experiences of my life to have been a member of the Society from the time of its organization, but to be placed on the honor roll is indeed a mark of great distinction.

Very truly yours,

(Signed) Ambrose Swasey.

INDUSTRIAL PREPAREDNESS

THE returns from the vast industrial inventory made by the Committee on Industrial Preparedness of the U. S. Naval Consulting Board mark a new and vital relation between the business men of America and the Federal Government. The information gathered is the fruit of the work of the army of 30,000 American engineers, members of the national engineering societies, who formed the field force of the Committee organized to find out for the Government the available industrial resources of the nation.

The five months' campaign of the Committee on Industrial Preparedness of the U. S. Naval Consulting Board to obtain an inventory of the country's manufacturing and producing resources for national defense purposes has been remarkable.

In this article are given several interesting examples of replies received from concerns suggesting novel methods of adjusting industries to the needs of conflict.

The committee's plans for educating American manufacturers in time of peace in the requirements of the army and navy in war are provided for in proposed legislation, and excerpts from the same are here given.

The campaign of the committee, with the aid of a volunteer unpaid organization of the members of the national engineering societies, has introduced a new era of the engineer in the preservation of national governments.

The manufacturers of the nation, recognizing the highly qualified and non-partisan personnel of this movement, which has the support of the President, the military heads and the Chamber of Commerce of the United States, have with few exceptions responded with patriotism and interest in this movement for a thoroughgoing industrial preparedness. They were called upon to give comprehensive information on the adaptability of their factories, mills and mines to federal uses from the hour of military mobilization, the data to be held in the strictest confidence for the sole scrutiny and benefit of the war and navy departments of the United States. The business men have met the Committee on Industrial Preparedness and the engineers at least half way in this effort to establish a backbone for the national defense.

Chairman Coffin, Mem.Am.Soc.M.E., calls attention to the reports of State Directors to the effect that all elements of business life in their respective regions unite on the wisdom and practicability of the committee's plans for establishing annual educational orders in small quantities for the manufacture of munitions of war. The idea is to teach American manufacturers now producing, say, farm machinery, how to turn out some one war commodity best suited to their output, and this in time of peace.

NOVEL WAYS OF ADAPTING MANUFACTORIES

The response to the State Director's request to concerns for information for the industrial census has shown a desire to support the work of the committee, and a summary of the letters received discloses in a most interesting and graphic way how the industries of the country could adjust themselves to the needs of conflict.

A large capacity sash-chain maker believed he could with little difficulty produce cartridge clips for rifles and machine guns, and a manufacturer of threshing machinery was sure he could make 600 six-in. shells per day.

A maker of underwear declared he could turn out bandages and other knit goods for the army and navy and Red Cross services, a button maker thought his machines could be used for small munitions work, and a company manufacturing drugs stated that it could turn a considerable portion of its product into an adjunct for making cordite for shells.

One well-known foundry said it was well equipped to turn out tools and machinery for small arms and ammunition, a maker of belting even suggested that he could produce webbing with which to fasten equipment on soldiers, and a famous producer of condensed milk thought he could be of use to his government in time of war.

On the theory that an army is as good as the feet of its men, boot and shoe makers were queried, and showed interest, even enthusiasm, and a smart clothier of the metropolis saw no reason why he, too, could not help Uncle Sam with equipment at the proper time.

A leading Buffalo manufacturer wrote: "We look upon it as a patriotic duty to fill out the blank forwarded to us;" the president of a great railroad wrote at length analyzing the situation in a most sympathetic way, and a maker of pocket knives volunteered to produce various lines of munition supplies.

Several optical makers have pointed out where they could be of practical aid to armies in the field, and a crushed stone company saw where it could play a large part in maintaining good roads against the wear and tear of modern military transportation. An extensive tailoring concern emphasized that the production of uniforms should be standardized, one of the world's leading makers of printing presses placed himself wholly at the command of the state board, and perhaps the greatest municipal transportation system in the United States appointed its chief engineer to serve the committee's purpose.

The head of a great woolen mill wrote: "The constructive policy of the committee is surely the only means by which true preparedness can be arrived at," the leading American manufacturer of farm materials promptly offered to find out what military utilization could be made of its plants in a day of need, and a maker of chocolates, which are so important to modern armies on the march, had very definite views.

A linotype company stated that it has a large quantity of lathes, drills, milling machinery and other tools adapted for the production of shells, fuses, accurate machine tools and small metal parts of any kind requiring extreme precision.

The president of one of the world's chief railroad systems gladly offered his company's shops for the inspection of the state board, an up-state concern now making starting and lighting apparatus for automobiles was quite sure it could furnish small arms, and an elevator company is devoting earnest study as to how it could help the government with its mechanical equipment.

A prominent maker of drop forgings wrote that he would waste no time finding out how his plants could be utilized for

the military forces, and finally, a fountain pen manufacturer gladly offered to analyze his mechanical equipment, and when necessary to adapt it to the benefit of the Government of the United States.

COMPULSORY PREPAREDNESS PROBABLE

The committee's carefully worked out plans to teach American manufacturers now, in time of peace, how, through annual educational orders, to turn out war munitions and all other military and naval supplies when needed, have now been incorporated into legislation which has been passed by both Houses and is, at the time of going to press, awaiting signature by the President.

This legislation is embodied in H. R. 12766, Army Reorganization Bill, and H. R. 16460, Army Appropriation bill. In the former, legal provision is made for the preparation or acquisition by the Government of special aids and appliances for the manufacture of munitions in time of war. In the latter, a Council of National Defense, for the coördination of industries and resources for the national security and welfare, is established.

Extracts from the provisions of these measures follow:

The President, in time of war or when war is imminent, is empowered through the head of any department of the Government, in addition to the present authorized methods of purchase or procurement, to place an order with any individual, firm, association, company, corporation, or organized manufacturing industry for such product or material as may be required, and which is of the nature and kind usually procured or capable of being produced by such individual, firm, company, association, corporation, or organized manufacturing industry.

Compliance with all such orders for products or material shall be obligatory on any individual, firm, association, company, corporation, or organized manufacturing industry or the responsible head or heads thereof, and shall take precedence over all other orders and contracts theretofore placed with such individual, firm, company, association, corporation, or organized manufacturing industry; and any individual, firm, association, company, corporation, or organized manufacturing industry or the responsible head or heads thereof owning or operating any plant equipped for the manufacture of arms or ammunition, or parts of ammunition, or any necessary supplies or equipment for the Army, and any individual, firm, association, company, corporation, or organized manufacturing industry or the responsible head or heads thereof owning or operating any manufacturing plant, which, in the opinion of the Secretary of War shall be capable of being readily transformed into a plant for the manufacture of arms or ammunition, or parts thereof, or other necessary supplies or equipment, who shall refuse to give to the United States such preference in the matter of the execution of orders, or who shall refuse to manufacture the kind, quantity, or quality of arms or ammunition, or the parts thereof, or any necessary supplies or equipment, as ordered by the Secretary of War, or who shall refuse to furnish such arms, aumunitions, or parts of ammunition, or other supplies or equipment, at a reasonable price as determined by the Secretary of War, then, and in either such case, the President, through the head of any department of the Government, in addition to the present authorized methods of purchase or procurement herein provided for, is hereby authorized to take immediate possession of any such plant or plants, and, through the Ordnance Department of the United States Army, to manufacture therein in time of war, or when war shall be imminent, such product or material as may be required; and any individual, firm, company, association, or corporation, or organized manufacturing industry, or the responsible head or heads thereof, failing to comply with the provisions of this section shall be deemed guilty of a felony, and upon conviction shall be punished by imprisonment for not more than three years and by a fine not exceeding $50,000.

* * * * * *

The Secretary of War shall also make, or cause to be made, a complete list of all privately owned plants in the United States equipped to manufacture arms or ammunition, or the component parts thereof. He shall obtain full and complete information regarding the kind of arms or ammunition, or the component parts thereof, manufactured or that can be manufactured by each such plant, the equipment in each plant, and the maximum capacity thereof. He shall also prepare, or cause to be prepared, a list of privately owned manufacturing plants in the United States capable of being readily transformed into ammunition factories, where the capacity of the plant is sufficient to warrant transforming such plant or plants into ammunition factories in time of war or when war shall be imminent; and as to all such plants the Secretary of War shall obtain full and complete information as to the equipment of each such plant, and he shall prepare comprehensive plans for transforming each such plant into an ammunition factory, or a factory in which to manufacture such parts of ammunition as in the opinion of the Secretary of War such plant is best adapted. (H. R. 12766, Sec. 120.)

* * * * * * *

That the Secretary of War be, and he is hereby, authorized to prepare or cause to be prepared, to purchase or otherwise procure, such gauges, dies, jigs, tools, fixtures, and other special aids and appliances, including specifications and detailed drawings, as may be necessary for the immediate manufacture, by the Government and by private manufacturers, of arms, ammunition, and special equipment necessary to arm and equip the land forces likely to be required by the United States in time of war: PROVIDED, That in the expenditure of any sums appropriated to carry out the purposes of this section the existing laws prescribing competition in the procurement of supplies by purchase shall not governn, whenever in the opinion of the Secretary of War such action will be for the best interest of the public service. (H.R. 12766, Sec. 123.)

H. R. 16460 adopts the committee's measure for an industrial reserve, so that in time of war the skilled mechanic shall be kept at home on the job, where his services are most needed to feed the firing line. Extracts from this measure are:

That a council of National Defense is hereby established, for the coördination of industries and resources for the national security and welfare, to consist of the Secretary of War, the Secretary of the Navy, the Secretary of the Interior, the Secretary of Agriculture, the Secretary of Commerce, and the Secretary of Labor.

That the Council of National Defense shall nominate to the President, and the President shall appoint, an advisory commission, consisting of not more than seven persons, each of whom shall have special knowledge of some industry, public utility, or the development of some natural resource, or be otherwise specially qualified, in the opinion of the council, for the performance of the duties hereinafter provided.

* * * * * * *

That it shall be the duty of the Council of National Defense to supervise and direct investigations and make recommendations to the President and the heads of executive departments as to the location of railroads with reference to the frontier of the United States so as to render possible expeditious concentration of troops and supplies to points of defense; the coördination of military, industrial, and commercial purposes in the location of extensive highways and branch lines of railroads; the utilization of waterways; the mobilization of military and naval resources for defense; the increase of domestic production of articles and materials essential to the support of armies and of the people during the interruption of foreign commerce; the development of seagoing transportation; data as to amounts, location, method and means of production, and availability of military supplies; the giving of information to producers and manufacturers as to the class of supplies needed by the military and other services of the Government, the re-

quirements relating thereto, and the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the Nation.

That the Council of National Defense shall adopt rules and regulations for the conduct of its work, which rules and regulations shall be subject to the approval of the President and shall provide for the work of the advisory commission to the end that the special knowledge of such commission may be developed by suitable investigation, research, and inquiry, and made available in conference and report for the use of the council; and the council may organize subordinate bodies for its assistance in special investigations, either by the employment of experts or by the creation of committees of specially qualified persons to serve without compensation, but to direct the investigations of experts so employed.

That the sum of $200,000, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to be immediately available for experimental work and investigations undertaken by the council, by the advisory commission, or subordinate bodies, for the employment of a director, expert, and clerical expenses and supplies, and for the necessary expenses of members of the advisory commission or subordinate bodies going to and attending meetings of the commission or subordinate bodies.

* * * * * * *

That $250,000 * * * may be used to procure gauges, dies, jigs, tools, fixtures, and other special aids and appliances, including specifications and detailed drawings necessary for the manufacture by the Government and by private manufacturers of ammunition necessary for the use of the land forces of the United States in time of war, and in the purchase of lots of ammunition to complete the object of this proviso the existing laws prescribing competition in the procurement of supplies by purchase shall not govern in orders not to exceed $50,000 in any one case.

That $200,000 * * * may be used to procure gauges, dies, jigs, tools, fixtures, and other special aids and appliances, including specifications and detailed drawings, necessary for the manufacture by private manufacturers, of arms necessary to arm the land forces likely to be required by the United States in time of war, and in the purchase of lots of arms to complete the object of this proviso the existing laws prescribing competition in the procurement of supplies by purchase shall not govern in orders not to exceed $50,000 in any one case. (H. R. 16460.)

In the article Tribute to Dr. E. D. Leavitt on page 653 of the August issue of The Journal, the personnel of the committee on resolutions was incorrectly given. The committee consisted of F. W. Dean, *chairman*, J. S. Coon and A. M. Mattice.

In the death of Sir William Ramsay, science loses one of its most resourceful experimenters, as well as a most daring prognosticator. His fame as a discoverer dates back to 1894, when, with Lord Rayleigh, he demonstrated that atmospheric air contains the previously unknown gaseous element *argon*. He later separated three new gaseous elements, which he named *neon*, *krypton*, and *zenon*, as well as *helium*.

At a recent meeting of the Texas Cotton Seed Crushers' Association the following resolution was adopted:

WHEREAS, The American Society of Mechanical Engineers having prepared a satisfactory code for the standardization of boiler construction to promote the safety of human life and economy in operation, it is hereby

RESOLVED, That the Texas Cotton Seed Crushers' Association, in convention assembled, approves the said boiler code and recommends its adoption by the State of Texas.

The States of Ohio, Pennsylvania and California have accepted the A. S. M. E. Boiler Code unconditionally and have embodied it as a whole in their statutes. In Wisconsin and Indiana, the Code is acceptable as an alternative to the existing requirements.

ROLL OF HONOR

THE Society is desirous of publishing lists of all members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Navy, or in any other capacity in the services of the country. Every member who is, or who knows of any other member who is engaged in the service of the country is requested to notify the Secretary.

The first Roll of Honor was published in the August issue of The Journal. The second, comprising further names received to date, appears below.

HILL, FRANCIS L., Company H, First Virginia Regiment of Volunteers, Brownsville, Texas
NEWCOMB, ROBERT S., Captain, Coast Artillery Corps, New York National Guard. Assigned to 33rd Co., 8th C. D. C.
DAVIS, JAMES H., Second Lieutenant, Coast Artillery Corps, New York National Guard. Assigned to 33rd Co., 8th C. D. C.
WHITTED, THOMAS B., Colonel and Chief of Engineers, North Carolina National Guard
PELLY, JOHN F., Battery A, First Field Artillery, Pennsylvania National Guard
TILLSON, BENJAMIN F., Aide, Naval Consulting Board, Sussex Co., N. J.
ELSEY, H. M., Private, Company L, Fifth Infantry, California National Guard
OHMER, JOHN F., JR., First Lieutenant and Battalion Adjutant, Third Ohio Infantry
MELLEN, WILLIAM H., Machinist's Mate, Second Class, Civilian Cruise
KRAUS, SIDNEY M., Lieutenant (J. G.), U. S. N.
CHURCH, ELIHU CUNNINGHAM, Seventh Infantry, New York
WHITLEY, FREDERIC N., Major, First Battalion, New York Engineers
TUTTLE, W. B., Second Lieutenant, Training Camp Regiment, Fort Sam Houston, Texas
TOLTZ, MAX, Major, Engineering Corps, Minnesota National Guard

ENGINEER SECTION OF OFFICERS' RESERVE CORPS

Since the announcement in the August issue of The Journal of the provision made in the Army Reorganization Bill, awaiting the President's signature, for an Engineer Section of the Officers' Reserve Corps, preliminary steps have been taken by the War Department towards the formation of this corps. By direction of the Chief of Engineers, Lieut. Col. E. Eveleth Winslow, of the Army Engineer Corps, sent a letter on August 8 to all the district engineer officers of the army throughout the country. This letter sets forth the plan for the formation of this corps as follows:

"The importance of engineers in time of war is now universally recognized, and during the past few months steps have been taken to arouse the interest of the engineering profession in the national defense. Congress has now provided a means by which the civil engineers can more than fully prepare themselves for that highest duty of citizens—the defense of our country. An engineer section of officers and enlisted reserve corps has been authorized, and in the opinion of the Chief of Engineers there is for the officers of the Corps of Engineers no more important duty than their active assistance in making a success of the new corps. All the engineers in the country should be informed of the existence of this new corps, and those possessing the necessary qualifications should be enrolled as its members. A close coöperation between our engineer officers and the civilian engineers is therefore necessary, and fortunately the first steps in such coöperation have been already taken by the action of some of the most important of the engineering societies in indorsing the campaign for preparedness and in urging upon Congress the passage of the Officers' Reserve Corps law.

"The following instructions explain how it is intended to organize the engineer section of this corps:

"Each district engineer officer will be a member of a local board, so that the entire area of the country will be covered. The other members of the board will be one medical officer or medical reserve officer (who will be ordered to duty with the board by the department commander on request of the Chief of Engineers), and one officer of the Engineer Officers' Reserve Corps. If practicable it is desired that the Engineer Reserve officer be a member of the branch of the engineering profession to which the candidates belong, i. e., civil, mechanical, electrical, mining, and railway engineering professions. This will require having five separate boards when the number of applicants justifies it.

"When a sufficient number of applications have been received from any district, an examining board will be appointed for that district. Until such reserve officers have been commissioned and thus become available to act on the local boards, the latter will consist of two members only, i. e., the district engineer officer and the medical member."

Regarding the selection of the boards Lieut. Col. Winslow wrote:

"In appointing the boards, the senior officer of the Corps of Engineers on each board will be designated the President thereof; his office will be the office of record, although the junior member must nominally, at least, act as recorder.

"After each board has been appointed, it will endeavor to enlist the interest of each engineer in its territory in the Reserve Corps and will give all necessary information and render all possible assistance to persons desiring to join. The various engineering societies and the prominent technical newspapers and journals will be requested by this office to lay before their members and readers the importance of joining the corps. An order prescribing the regulations for the enlisted Reserve Corps is now in course of preparation.

"An Executive Committee will be formed to pass finally upon all applications for membership to the Reserve Corps of Engineers, and to recommend the grades in which successful applicants shall be commissioned and enlisted. This Executive Committee will be composed of the heads of divisions in the office of the Chief of Engineers; one member of the American Society of Civil Engineers, one member of The American Society of Mechanical Engineers, one member of the American Institute of Electrical Engineers, one member of the American Institute of Mining Engineers, one member of the American Society of Consulting Engineers, one railway operating official.

"After a sufficient number of officers and non-commissioned officers have been appointed, companies and battalions will be organized, officers and non-commissioned officers assigned thereto, and the other enlisted personnel thereof obtained. This will be made the subject of a later letter of instructions."

The principal requirements of the regulations that apply to the Engineer Officers' Reserve Corps are published in General Order No. 32, War Department, July 28, 1916, a copy of which will be furnished by the Chief of Engineers, U. S. Army, Washington, D. C., to any member of the Society on request. The Chief of Engineers will also furnish a form letter of application for commission in the corps.

All members of the Society are able to meet the professional requirements for a commission in this corps. For instance, a candidate for First and Second Lieutenant must be an engineer in the active practice of his profession,—members in the Junior and higher grades meet this requirement; a candidate for Captain must have been in the active practice of his profession for at least eight years and have had responsible charge of work as principal or assistant for two years,—members in the Associate-Member and higher grades meet this requirement; a candidate for Major must have been in the active practice of his profession for at least fifteen years, must have had responsible charge of work for five years and must be qualified to design as well as direct engineering work,—full members of five years standing meet this requirement.

A. A. STEVENSON PRESIDENT OF A. S. T. M.

Archibald Alston Stevenson, Mem.Am.Soc.M.E., vice-president of the Standard Steel Works Company, Philadelphia, was elected president of the American Society for Testing Materials at its recent meeting at Atlantic City. Mr. Stephenson was born in Allegheny City, Pa., in 1862. After being graduated from the high school at Rock Island, Ill., in 1878, he served for one year as rodman on a government survey, and then studied for two years at the University of Illinois. He spent four and one-half years in the service of the Southwark Foundry and Machine Company, Philadelphia, the last year as chief draftsman, and then entered the employment of the Cambria Iron Company, where for two and one-half years he divided his time between the chief engineer's office and the forge and axle plant. In 1888 he became engineer of the Standard Steel Works Company, and five years later superintendent; in 1908 he was elected vice-president of the company.

Mr. Stevenson was vice-president of the Association of American Steel Manufacturers from 1908 to 1911, and president from 1911 to 1914. He is a member of the American Institute of Mining Engineers, the International Association for Testing Materials, and the Engineers' Club of Philadelphia. He was elected to membership in the Society in 1888.

WATER POWER LEGISLATION

Both branches of Congress have passed bills for the granting of permits for power dams and plants in navigable streams. The Senate bill proposes that the Secretary of War shall have authority to grant power permits, under uniform and general terms, conditions and regulations prescribed in the measure. The House bill provides terms and conditions under which dams may be built, to be administered and enforced by the Secretary of War, with the condition that before any plans shall be approved or agreements entered into for the construction of such dams, Congress shall in each case pass a special enabling act granting its consent to the location and construction.

There are several differences of policy in the Senate and House bills on which a conference committee of the Senate and House is endeavoring to reach an agreement, so that a general dam bill can be approved by both houses and become law before the end of the present session of Congress. Some of these differences hinge on the wording of particular sections or clauses; other differences have to do with the question of Government charges and restrictions upon the business of grantees.

The Senate bill requires the grantee to construct any locks and other aids to navigation which may be required by the Secretary of War at the time the dam is built and to operate such locks, etc., without expense to the Government. The House bill requires that the grantee shall construct such locks as the Secretary of War or Congress may at any time deem to be necessary.

Both bills require the grantee to pay a charge for whatever increased water power may be created by improvements constructed by the Government for storage of headwaters of streams, and both bills provide that the grantee shall maintain lights, signals, fishways, etc., and shall pay a tax or rental for use of surplus waters where a power plant is built at a Government dam. In addition to these charges the House bill gives the Secretary of War authority to require the grantee to

pay a tax on the grant itself, the amount of which is left to the discretion of the Secretary and which may be readjusted by him at the end of twenty years and of each ten years thereafter.

Both bills provide that water-power grants shall be irrevocable for fifty years, except for cause, and that at any time after the expiration of fifty years the Government may take over the property, or authorize a new grantee to do so, at a valuation to be mutually agreed upon or fixed by the courts, with no allowance for any rights granted by the Government. The Senate bill, however, proposes that after fifty years the original grantee shall continue in possession, under the original terms and conditions, until the Government decides to take over the property or has a chance to make a better bargain with a new grantee. The House bill terminates the grant absolutely at the end of fifty years and provides that the Secretary of War then make a new grant upon such terms and conditions as existing laws may then require, or may do nothing.

The Joint Conference Committee of the National Engineering Societies wrote to the President of the United States urging that legislation be enacted at this session of Congress.

AMERICAN INDUSTRIAL COMMISSION TO FRANCE

There has just sailed from this country an Industrial Commission to France, which is to make a technical investigation of conditions there, leading to an interchange of ideas to determine by what reciprocal action the United States and France may best develop the resources of the two countries.

The undertaking of this Commission is based upon cordial proposals from the Government of the French Republic,—proposals which came entirely unsolicited and which were the outcome of a recent visit to this country by French commissioners for the purpose of studying conditions here.

The Commission is in charge of the American Manufacturers' Export Association, under whose authority an official report of its work will be issued in due course. Extraordinary and unprecedented facilities have been granted by the French Government to aid the Commission, affording every assurance of a successful outcome.

The investigation will cover all the industries of the United States concerned in French trade, under the following classifications: Prime movers; heavy machinery; machine tools, wire, transmission and textile machinery; milling machinery; electrical apparatus; transportation; importers; synthetic production of chemicals; bankers; factory architects, engineers and contractors.

The Commissioners are men of broad experience in their respective lines—men of national reputation whose coöperation imparts dignity and standing to the enterprise and guarantees a result both conclusive and effective.

Below is a partial list of the personnel of the Commission:

WILLIAM WALLACE NICHOLS, *Chairman*, Assistant Chairman Allis-Chalmers Manufacturing Co., Inc., 50 Church St., New York City.

E. V. DOUGLASS, *General Secretary*, Secretary American Manufacturers Export Association, 160 Broadway, New York City

J. G. BUTLER, Jr., Director Commercial National Bank, Youngstown, Ohio; Vice-President Brier Hill Steel Company.

SAMUEL W. FAIRCHILD, Vice-President Fairchild Bros. & Foster, 76 Laight St., New York City

A. B. FARQUHAR, President, A. B. Farquhar Co., Ltd., York, Pa.

GEO. BURDETT FORD, Member of Geo. B. Post & Sons, 101 Park Ave., New York City.

NOBLE FOSTER HOGGSON, President Hoggson Bros., Inc. (Contractors), 485 Fifth Ave., New York City.

F. J. LEMAISTRE, B.S., M.E., Consultant, E. I. du Pont de Nemours & Co., Wilmington, Del.

JOHN R. MACARTHUR, MacArthur Bros., 120 Broadway, New York City.

DR. C. O. MAILLOUX, Consulting Engineer, 20 Nassau St., New York City.

CURT G. PFEIFFER (Specially recommended by Mr. Maurice Damour), Vice-President Geo. Borgfeldt & Co., 16th St. & Irving Place, New York City.

E. E. RUSSELL, J. I Case Threshing Machine Co., Racine, Wis.

JAMES E. SAGUE, Vice-President Am.Soc.M.E., Former Vice-President American Locomotive Co., New York, and Public Service Commissioner; Address: Poughkeepsie, N. Y.

AMBROSE SWASEY, Hon. Mem.Am.Soc.M.E., President Warner & Swasey Co., Cleveland, Ohio.

E. A. WARREN, Vice-President Universal Winding Co., 95 South St., Boston, Mass.

ARIZONA MEETING OF A. I. M. E.

The American Institute of Mining Engineers will hold a meeting in Arizona from September 18 to 25, 1916. A special train will be provided to convey members and their guests from New York City and other points to Arizona for this meeting. The meeting will include a special train tour of the Arizona mining districts, technical sessions being held at several centers *en route*. Among the side trips is included an automobile ride over the Apache Trail and a visit to the Grand Canyon of the Colorado.

A cordial invitation to attend the meeting has been extended by the Institute to all the members of our Society, and the Secretary of the A.I.M.E., Mr. Bradley Stoughton, 29 West 39th Street, New York, will be glad to send a little booklet giving full information regarding the meeting and tour to any member of the Society interested.

A. I. E. E. PACIFIC COAST CONVENTION

The Pacific-Coast Convention of the American Institute of Electrical Engineers will be held in Seattle, Wash., September 5 to 9, 1916. At the technical sessions the following papers will be presented:

A Distributing System for Domestic Power Service from Commercial and Engineering Standpoints
Some Features of Domestic Electric Cooking and Heating
Temperature Rise of Insulated Lead Cables
Inductive Interference as a Practical Problem
Testing for Defective Insulators on High-Tension Transmission Lines
The High-Voltage Potentiometer
An Artificial Transmission Line with Adjustable Line Constants
Characteristics of Admittance Type of Wave-Form Standard
Insulator Failures Under Transient Voltages.

In addition to the technical sessions numerous entertainment features have been arranged. The program for the day sessions on the 7th will be supplied by the Northwest Electric Light and Power Association. At the evening session of that day a lecture on The Illumination of the Panama-Pacific Exposition will be delivered by W. D'A. Ryan.

Further information regarding this meeting may be obtained from the Secretary of the A.I.E.E., Mr. F. L. Hutchinson, 29 West 39th Street, New York City.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED ON AFTER OCTOBER 10, 1916.

MEMBERS are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every Member to promote. Unless objection is made to any of the candidates posted, by October 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary about November 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE MEMBER

ALPERN, MAXWELL,
American Engineering Co., Philadelphia, Pa.

ALMY, THOMAS R., JR., Plant Engineer,
Falulah Paper Co., Fitchburg, Mass.

ASHMEAD, CHARLES B., District Manager,
The Richardson-Phenix Co., Pittsburgh, Pa.

AYER, WILLIAM T., Superintendent,
McKinnan-Terry Drill Co., Dover, N. J.

BALDWIN, RAYMOND S., Buffalo Works Manager,
J. H. Williams & Co., Buffalo, N. Y.

BALZARI, ROBERT A., Engineer,
Westinghouse Electric & Mfg. Co., San Francisco, Cal.

BARNES, EUGENE L., District Manager,
American District Steam Co., Seattle, Wash.

BATES, HARRY H., Vice-President,
Joliet Oil Tractor Co., Joliet, Ill.

BEEBE, HERBERT A., Chief Draftsman,
Fitchburg Machine Works, Automatic Dept., Fitchburg, Mass.

BIDWELL, PAUL W.,
B. F. Perkins & Son, Inc., Holyoke, Mass.

BRANDT, CARL A. W., Mechanical Engineer,
Locomotive Superheater Co., New York

BROWN, HOLCOMBE J., Operating Manager,
Keystone Plaster Co., Chester, Pa.

BROWNE, THOMAS A., Employment Manager,
Ashcroft Mfg. Co., Bridgeport, Conn.

BRYANT, PERCY J., Heating and Ventilating Engineer,
U. S. Military Academy, West Point, N. Y.

BUERSTATTE, FRED W., Associate Professor,
Washington State College, Pullman, Wash.

BUGGE, SVEN B., Engineer,
Wausau Sulphate Fibre Co., Mosinee, Wis.

CALDWELL, CHARLES A., Consulting Engineer, Macon, Ga.

CARTER, ROBERT A., JR., Assistant Engineer of Manufacture,
Consolidated Gas Co. of N. Y., New York

CARTER, WILLIAM D., Designing Engineer, San Jose, Cal.

CONVERY, JOHN J., Consulting Engineer, New York

COOPER, ARTHUR, Chief Draftsman,
Manila Railroad Co., Manila, P. I.

COPONY, ALFRED, Master Car Builder,
Grand Trunk Rwy., Western Lines, Chicago, Ill.

COX, JOHN W., Chief Engineer,
Erie Malleable Iron Co., Erie, Pa.

CURTIS, ALLEN, Manager of Manufacturing,
International Paper Co., New York

DALLY, CHARLES A., Manager Reserve Natural Gas Co. of La.,

DAY, WILLIAM A., General Sales Manager,
The Frost Manufacturing Co., Chicago, Ill.

DENNIS, FREDERICK L.,
U. S. Local Inspector of Boilers, New Haven, Conn.

DETTE, ARTHUR E. L., Chief Engineer,
Alan Wood Iron & Steel Co., Conshohocken, Pa.

DIXON, J. ALFRED, Vice-President,
Safety Car Heating & Lighting Co., New York

DORSEY, WALTER A., Mechanical Engineer,
The Bonney Floyd Co., Columbus, Ohio
Shreveport, La.

DU BOSE, GEORGE P., Superintendent,
Holt Manufacturing Co., Stockton, Cal.

DUNLEVY, D. W., General Superintendent,
Colonial Steel Co., Pittsburgh, Pa.

DURAM, ARTHUR E., President and Chief Engineer,
The New York Steam Co., New York

ELA, EVERETT W., Research Engineer,
Waltham Watch Co., Waltham, Mass.

ENGEL, GODFREY, JR., Engineer in charge of Sugar Dept.,
Gerdes & Co., New York

ENTWISLE, EDWARD F., Mechanical Engineer,
Bethlehem Steel Co., Steelton, Pa.

FELGAR, JAMES H., Dean, College of Engineering,
University of Oklahoma, Norman, Okla.

FIELD, HENRY P., Assistant Mechanical Engineer,
American Car & Fdy. Co., Berwick, Pa.

FINCH, GEORGE L., Engineering Superintendent,
Hood Rubber Co., E. Watertown, Mass.

FREEMAN, HERBERT A., Chief Draftsman,
Crocker Wheeler Co., Ampere, N. J.

FREEMAN JULIAN B., Chief Engineer,
Webster Engineering Co., Chicago, Ill.

FOSDICK, WILLIAM P.,
With Walter G. Franz, Consulting Engineer, Cincinnati, Ohio

GALLAHER, CHARLES W., 1st Lieutenant,
Iowa Engineers, Brownsville, Tex.

GILLHAM, CHARLES A., Vice-President, Executive,
The New York Steam Co., New York

GODA, PETER H., Motive Power Inspector,
Penn. Lines, Fort Wayne, Ind.

GREENE, EDWARD A., Captain U. S. Marine Corps, Washington, D. C.

HADLEY, FREDERICK V., Chief Engineer,
American Incandescent Heat Co., Inc., Boston, Mass.

HAGENAH, RUDOLPH E., Chief Engineer of Plants,
New York Steam Co., New York

HANSON, EDWARD S., Editor,
The Cement Era, Chicago, Ill.

HAWKINS, PAUL D., Engineer,
Framingham Machine Works, Framingham, Mass.

HEULINGS, SAMUEL M.,
With Sheffield Farms-Slawson Decker Co., New York

HEWITT, CARL T., Engineer
Remington Arms Union Metallic Cartridge Co., Bridgeport, Conn.

HICKOK, WILLIAM O., 4TH, Goshen, N. Y.

HILL, ANTHONY S.,
With American Saw Mill Machinery Co., Hackettstown, N. J.

HULL, BURTON E., Department Engineer,
The Texas Co., Houston, Tex.

JACKMAN, CHESTER C.,
With Massachusetts Saw Works, Springfield, Mass.

JASCHKA, JOHN H.,
With The National Malleable Castings Co. of Cleveland,
San Francisco, Cal.

JANN, VICTOR,
General Electric Co., Cincinnati, Ohio

JERNEE, HOWARD B., Engineer,
E. I. du Pont de Nemours & Co., Barksdale, Wis.

JOHNSTON, A. LANGSTAFF, JR., Consulting Engineer,
Southern Associate of Moses, Pope & Messer, Cons. Engrs.,
Richmond, Va.

JOLINE, Emmet A., Factory Superintendent,
S. S. White Dental Mfg. Co., Prince Bay, N. Y.
JUDY, Wilbur H., Engineering Inspector,
City of San Diego, Cal.
KLAUDER, Louis T., Assistant Engineer, Mechanical Construction,
Philadelphia Rapid Transit Co., Philadelphia, Pa.
KNOWLTON, Edgar, Electrical Engineer,
General Electric Co., Schenectady, N. Y.
KOTZ, Emil F., Mechanical Engineer, Syracuse, N. Y.
KRISHNAIYENGAR, Halsur, Supervisor of Sloyd,
West Circle, Mysore, India.
LAY, Robert P., Superintendent of Inspection,
Curtiss Aeroplane & Motor Corp., Buffalo, N. Y.
LEATHERS, Harry H.,
With Schumaker-Santry Co., Boston, Mass.
LEHR, Charles E., Chief Engineer of Construction,
Bethlehem Steel Co., South Bethlehem, Pa.
LONGLEY, Francis B., Inspector.
Associated Pipe Line Co., San Francisco, Cal.
LOWMAN, Roy L., Ordnance Engineer,
Bethlehem Steel Co., Bethlehem, Pa.
McINTYRE, Melvil B., Secretary,
Steel Fabricating Co., Chicago Heights, Ill.
MACKAY, Alfred, Chief Engineer,
John Lang Paper Co., Philadelphia, Pa.
MAIER, Fred, Proprietor,
Mechanical Pattern Works, Los Angeles, Cal.
MAYO, Edmund C., General Manager.
Worcester Pressed Steel Co., Worcester, Mass.
MESERVE, Frank A., Superintendent of Construction Dept.,
Ashcroft Mfg. Co., Bridgeport, Conn.
MOSSMAN, Roy L., Chief Engineer,
Municipal Water & Power Plant, Humboldt, Tenn.
MOTTINGER, Byron T., Electrical Engineer,
Fort Dodge, Des Moines & So. R. R., Boone, Ia.
MUNRO, Robert E., Chief Inspector,
Hartford Steam Boiler Inspection and Insurance Co.,
Baltimore, Md.
NEIDIG, W. N., Mechanical Engineer,
Fred T. Ley & Co., Inc., Springfield, Mass.
NELSON, Marcus C., Manager,
R. B. Phillips Manufacturing Co., Worcester, Mass.
NEWMAN, Charles H., Designer,
209 Broadway, New York
NOBLE, A. C., Master Mechanic,
Empire Steel & Iron Co., Mt. Hope Div., Wharton, N. J.
OAK, James H., General Foreman, Production Dept.,
New England Westinghouse Co., Springfield, Mass.
OBERLIN, Edgar G., Lieutenant U. S. Navy, Engineer,
Republique d'Haiti, c/o Department of State, Washington, D. C.
PARKS, Edward F., Chief Engineer,
Universal Winding Co., Providence, R. I.
PEARSON, Samuel, President and Chief Engineer,
C. I. C. Engine Mfg. Co., Portland, Ore.
POGUE, George,
With Fulton Iron Works, St. Louis, Mo.
PRATT, Harold H., Assistant Consulting Engineer,
Phelps, Dodge & Co., Inc., Douglas, Ariz.
PRINCE, Duffield, Engineering Department,
N. Y. C. & H. R. R. Co., New York
RATHJENS, George W., Vice-President,
Twin City Brick Co., St. Paul, Minn.
REICHARD, George A.,
With Worthington Pump & Machinery Corp., Los Angeles, Cal.
RICKETSON, William E., Mechanical Engineer,
C., C., C. & St. L. Rwy. Co., Beech Grove, Ind.
ROBERTS, J. Edwards, Secretary,
L. L. Harr Corporation, New York, N. Y.
ROBERTS, Jno. D.,
With Pere Marquette R. R., Detroit, Mich.
ROUTH, G. H., Chief Operating Engineer, Niagara Falls Mill,
International Paper Co., Niagara Falls, N. Y.
SCHRANZ, Frederick G., Manager Hydraulic Department,
Southwark Foundry & Machine Co., Philadelphia, Pa.
SEABURY, George E., Engineer,
Edison Electric Illuminating Co., Boston, Mass.
SETTI, Sriram V., Superintendent,
Government Mechanical Engineering School,
Bangalore, Mysore State, India
SHAW, Benjamin C., Master Mechanic,
Warren Cotton Mills, West Warren, Mass.
SLATER, William A., Superintendent,
Fort Worth Refinery of Gulf Refining Co., Fort Worth, Tex.
SMITH, Preston M.,
With Allied Machinery Co. of America, New York
SOLOMON, Gabriel R., Consulting Engineer,
Solomon-Norcross, Altoona, Pa.
STEVENS, Ray P., President,
Mahoning & Shenango Railway & Light Co., Youngstown, Ohio.
STOELTZING, Harry E., Assistant Superintendent of Power,
Brooklyn Rapid Transit System, Brooklyn, N. Y.
STUART, Thomas E., Power Station Supt.,
Omaha Electric Light & Power Co., Omaha, Neb.
SWIFT, Henry, Chief Draftsman, Munitions Dept.,
American Steam Gauge & Valve Mfg. Co., Boston, Mass.
THAYER, Abbot A., Secretary,
Oakley Machine Tool Co., Cincinnati, Ohio
TOWNSEND, George R., Secretary,
East Jersey Pipe Corporation, Paterson, N. J.
VAN DER HOEVEN, Constant, Manager New York Office,
Lindeteves & Stokvis, at Amsterdam, Holland, New York
WADDELL, Tarver W., Southern Manager,
Pawling & Harnischfeger Co., Milwaukee, Wis.
WARD, Harry A.,
With Sterling Blower Co., Hartford, Conn.
WATEROUS, Charles A., Assistant General Manager,
Waterous Engine Works Co., Ltd., Brantford, Ont., Canada.
WATT, James, Mechanical Engineer,
Krebbiel Co., Chicago, Ill.
WELLS, Clement, Vice-President of Sarco Co., Inc., New York
WESTWATER, Andrew, Marine Engine Draftsman,
Moore & Scott Iron Works, Oakland, Cal.
WHITE, Harold C., Factory Manager,
The Holt Manufacturing Co., Stockton, Cal.
WHITESIDE, Samuel P., Mechanical Engineer,
Davison Chemical Co., Curtis Bay, Md.
WILDER, Frank E., Consulting Engineer,
Southworth Machine Co., Portland, M
WILLIAMS, Jarvis, Jr., Manager Commercial Div.,
U. M. C. Works, Remington Arms U. M. C. Co., Bridgeport, Conn.
WONFOR, William H., Specialist in Technical Advertising,
Dayton, Ohio.
WOODCOCK, John W., Head of Engineering, Drafting and Estimating Departments,
Crane Co., Bridgeport, Conn.
WOODWORTH, Carl B., General Foreman Locomotive Department,
Mt. Clare Shops, B. & O. R. R., Baltimore, Md.
WOOTTON, Harry C., Asst. General Inspector,
Hopkins & Allen Arms Co., Norwich, Conn.
WORK, David W., Draftsman,
Braden Copper Co., Rancagua, Chile
WRIGHT, Arthur C., Superintendent and Consulting Engineer,
East Springfield Plant, New England Westinghouse Co.,
E. Springfield, Mass.
WYANT, Robert E., Superintendent,
New Haven Gas Light Co., New Haven, Conn.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ARDILLA, Ricardo, Special,
N. Y. Central Railroad Shops, Depew, N. Y.
ABBEY, Frank H., Boston Manager,
Gifford-Wood Co., Boston, Mass.
BANGS, George H., Assistant Superintendent Machine Department,
H. B. Smith Co., South Side Works, Westfield, Mass.
BARCLAY, William, Chief Engineer,
R. & J. Dick, Ltd., Passaic, N. J.
BARNUM, Edwards W., Efficiency Engineer,
Winchester Repeating Arms Co., New Haven, Conn.
BEEHLER, Weyman P., Senior Engineer Officer,
U. S. S. Columbia, c/Navy Department, Washington, D. C.
BEEKLEY, Waldron C., Manager Heater Dept.,
Whitlock Coil Pipe Co., Hartford, Conn
BORNHORST, August H., Marine Engine Draftsman,
Navy Yard, Puget Sound, Bremerton, Wash.
BRANDEL, S. W., Factory Manager,
U. S. Ball Bearing Mfg. Co., Chicago, Ill.
BROOKS, Alfred A., Assistant Engineer,
Turbine Research Department, General Electric Co., Lynn, Mass.
BROWN, Wendell S., Engineer,
with F. P. Sheldon & Son, Providence, R. I.
BUCHANAN, Moses R., General Manager,
Silver City Power Co., Silver City, N. Mex.
BUCKLEY, Ambrose T., Electrician,
Department of Public Charities, Sea View Hospital, City of N. Y.
CHAMPNEY, Ralph P., Chief Engineer,
Constr. Department, The Graton & Knight Mfg. Co.,
Worcester, Mass.
COWELL, Franklin W.,
With The Great Western Sugar Co., Denver, Colo.
CREDO, Julius,
With Louisville Drying Machinery Co., Louisville, Ky.
CULLEN, James W.,
With Cambria, Midvale and Worth Bros. Steel Companies,
Pittsburgh, Pa.

CUMMINGS, Lawrence T., Member of Staff.
Miller Franklin & Co., Efficiency Engineers, New York
DEVINE, Charles P., Vice-President,
J. P. Devine Co., Buffalo, N. Y.
DODGE, James S., Secretary and General Manager,
Sulpho-Chemical Sprinkler Corporation, New York
DUSENBERY, Henry.
With Thos. P. Ford Co., Inc., New York
DYER, Horace T., Lieutenant U. S. N.,
Chief Engineer, U. S. S. Montana, New York
EVANS, David F., Assistant to Mechanical Superintendent,
Hopewell Works, City Point, Va.
FINK, John B.,
With Cosden Oil & Gas Co., Shamrock, Okla.
FITZPATRICK, Clarence J., Chief Engineer,
Cleveland Worm & Gear Co., Cleveland, Ohio
HAWLEY, Kent A., Assistant Engineer,
Gibbs & Hill, Pennsylvania Station, New York
GUNKEL, Frederick H., Jr., Member of Plant Engineers' Force,
American Telephone & Telegraph Co., New York
HEWLETT, Van Wyck, Jr., Draftsman,
J. Edward Ogden Co., Woodmere, L. I., N. Y.
HOOKER, Oliver W., Draftsman,
Birmingham Iron Foundry, Derby, Conn.
HORTON, Ralph, Chief Engineer,
Sheffield Farms-Slawson Decker Co., New York
HUGHES, Walter J.,
With Larimer-Hughes Co., Los Angeles, Cal.
KERR, Charles P.,
With The Goodyear Tyre & Rubber Co., Sydney, Australia
LEE, Clifford, Mechanical Engineer.
India Rubber Co., New Brunswick, N. J.
LEWIS, J. Clifford, Industrial and Mechanical Engineer,
Indianapolis, Ind.
LOVELY, John E., Mechanical Engineer,
F. R. Patch Manufacturing Co., Rutland, Vt.
LUETSCHER, Oliver P., Chief Engineer,
Ill. Zinc Co., Peru, Ill.
LUNDGREN, Sven E., Chief Engineer Stoker Section,
Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.
LYNDE, Charles C., Engineering Editor,
The National Iron & Steel Publishing Co., Pittsburgh, Pa.
MARTIN, Clifford A., Chief Draftsman,
J. H. Williams & Co., Brooklyn, N. Y.
MELONEY, Charles W., Assistant Engineer,
Henry I. Lea, Cons. Engr., Chicago, Ill.
MENGES, Harry P., Superintendent No. 12 Mill,
Jones & Laughlin Steel Co., Pittsburgh, Pa.
MURPHY, Walter B., Superintendent, Frankford Plant, Chemical
Dept., The Barrett Co., Philadelphia, Pa.
NORRMAN, Axel E., Designing Engineer,
Moulton Engineering Corp., Portland, Me.
POLGLAZE, Richard A., Superintendent Water Dept.,
City of Gadsden, Ala.
RAYMOND, Harold E., Consulting Engineer,
New Orleans, La.
REILLY, Charles J., Assistant to Superintendent,
The Sandusky Cement Co., Bay Ridge, Ohio
SCHIKENDANZ, Louis H., Assistant in Mechanical Department,
Cleveland Cliffs Iron Co., Ishpeming, Mich.
SERMULIN, Fred E., Resident Engineer,
Alpha Portland Cement Co., Manheim, W. Va.
SHAW, Max M.,
With Eston Dodson & Co., Inc., Bethlehem, Pa.
SOSSONG, Raymond A., Operating Manager,
Searchlight Co., Chicago, Ill.
SPECK, William C., General Inspector,
The Buckeye Steel Castings Co., Columbus, Ohio
SPIEGELHALTER, Charles, Designer,
The Pusey & Jones Co., Wilmington, Del.
STEPHENS, Fred S., Superintendent Engineering,
Chulas Tea Co., Ltd., Matelli, P. O. India
TOWNSEND, Arthur J., Chief Engineer,
Berger Mfg. Co., Canton, Ohio
VUILLEUMIER, Albert, Designing Engineer,
New Departure Mfg. Co., Bristol, Conn.
VICKERS, Chauncy H., Efficiency Draftsman,
American La France Fire Engine Co., Inc., Elmira, N. Y.
WEILER, Rudolph B., Mechanical Engineer,
The Sharples Separator Co., West Chester, Pa.
WETJEN, Henry W.,
With Alberger Pump & Condenser Co., New York
WICHUM, Victor,
With C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.
WILHELM, Captain Walter M., Vice-President,
Eddystone Ammuniton Corp., Eddystone, Pa.
WUESTNER, Clarence J., Mechanical Draftsman,
E. I. du Pont de Nemours & Co., City Point, Va.
YOUNG, John H., District Lubrication Engineer,
The Texas Co., Youngstown, Ohio

FOR CONSIDERATION AS JUNIOR

BAKER, Irving C.,
With American Blower Co., Detroit, Mich.
BALLANTINE, John H., Assistant Superintendent,
Neptune Meter Co., Long Island City, N. Y.
BARR, James A., Draftsman,
Pittsburgh Valve, Foundry & Construction Co., Pittsburgh, Pa.
BAYLIS, Roger V., Engineering Dept.,
Neptune Meter Co., Long Island City, N. Y.
BLIXT, Gustaf F., Jr., Designer,
J. Edward Ogden Co., New York
BOYLE, Walter W., Assistant to Superintendent,
Central Power Plant, Estate Henry W. Oliver, Pittsburgh, Pa.
BYRON, Leroy T.,
With Westinghouse, Church, Kerr & Co., New York
CATHER, William A.,
With Worthington Pump & Mchy. Co., Harrison, N. J.
COHEN, Edgar F.,
With Centrifugal Pump Dept., Worthington Pump &
Machinery Corp., Harrison, N. J.
CRONAN, Clifford B.,
With Remington Arms Co., Bridgeport, Conn.
DAHLSTRAND, Josef Y., Chief Engineer,
Kerr Turbine Co., Wellsville, N. Y.
DE YOUNG, Herman,
With Hopkins & Allen Arms Co., Norwich, Conn.
DREYER, Elmer J.,
With Illinois Steel Co. South Chicago, Ill.
DUVIC, Frank R., Inspector,
U. S. Engineer Office, New Orleans, La.
EDDY, Carlton W., Dorchester, Mass.
EDWARDS, Gilbert M., Draftsman,
Terry Steam Turbine Co., Hartford, Conn.
EICHENBERG, Mark A., Maintenance Dept.,
Bosch Magneto Co., Plainfield, N. J.
ELBELT, William H.,
With Chino Copper Co., Hurley, N. Y.
FLANNAGAN, Eric G., Engineer,
The W. Virginia Pulp & Paper Co., Covington, Va.
GEOTZENBERGER, Ralph L., Engineer, Power and Mining Dept.,
General Electric Co., Schenectady, N. Y.
GLOVER, John S., Office of Inspector Eng. Material, U. S. N.,
General Electric Co., Schenectady, N. Y.
GOEDKOOP, Walter C.,
With The New York Steam Co., New York
GREEN, Lloyd F.,
With Bethlehem Steel Co., Bethlehem, Pa.
GROSNER, Gerald D., Mechanical Engineer,
Sharpless Specialty Co., West Chester, Pa.
HOLMGREN, Frederick W., Mechanical Engineer, New York
HOYT, Albert J.,
With American Steel & Wire Co., Trenton, N. J.
HUBBARD, George M. C., Graduate Student, Higganum, Conn.
HUMMEL, Ferdinand G.,
With Babcock & Wilcox Co., Bayonne, N. J.
INMAN, Chester M.,
With Pratt & Inman, Worcester, Mass.
JACKSON, William G.,
With Spaulding & Jennings Works, Crucible Steel Co., of America,
Jersey City, N. J.
JACOBS, Adolph, Mechanical Draftsman,
United Printing Mch. Co., Boston, Mass.
JOHNSON, John B., Inspector Aeroplanes,
U. S. Government, S.S.L., Washington, D. C.
JUDE, Henry,
With Manning, Maxwell & Moore, Inc., New York
KEENAN, George M., Engineer, Service Dept.,
Washington E. & M. Co., Chicago, Ill.
KEET, Clarence T., Engineer,
With Schutte & Koerting Co., Philadelphia, Pa.
KENDALL, Edgar H., Assistant Engineer,
Standard Steel Works Co., Burnham, Pa.
KEOGH, Jere K., Erecting Engineer,
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
KOUWENHOVEN, Frank W., Brooklyn, N. Y.
KRAUT, Hans B.,
Joseph T. Ryerson & Sons, Chicago, Ill.
LANNING, John G.,
With The Ashcroft Mfg. Co., Bridgeport, Conn.
MARSHALL, Kenneth I., Mechanical Engineer,
The Western Precipitation Co., Los Angeles, Cal.

MERRIAM, Carroll F., Instructor,
Worcester Polytechnic Institute, Worcester, Mass.
MERRIAM, I. B., Jr., President,
Chattanooga Boiler & Tank Co., Chattanooga, Tenn.
MERSHON, John W., Mechanical Engineer,
Remington Arms & Ammunition Co., Bridgeport, Conn.
MULLER, Raymond W., Asst. Maintenance Engr.,
Bosch Magneto Co., Plainfield, N. J.
NEWCOMB, Benjamin R., Patent Attorney,
Washington, D. C.
NICE, Everett W., Mechanical Engineer,
Western Electric Co., Inc., Chicago, Ill.
NOYES, Jonathan A.,
With Sullivan Machinery Co., Chicago, Ill.
NORDHEIMER, Albert,
With New York Central Railroad, West Albany, N. Y.
O'BRIEN, Thomas C.,
With De La Vergne Machine Co., New York
OVERMIRE, Wilfred J., Assistant Fuel Inspector,
C. C. C. & St. L. Ry., Indianapolis, Ind.
PEASE, Maxfield,
With The Stanley Works, New Britain, Conn.
PETER, Albert G., Efficiency Engineer,
Chain Belt Co., Milwaukee, Wis.
PICCARD, Jules E., Student Graduate,
Polytechnic Institute, Brooklyn, N. Y.
PURDY, Asa R., Engineer,
With Martin & De Remer, Consulting Engineers, New York
RAYMOND, Thomas E., Engineer,
Metz Motor Car Co., Waltham, Mass.
RIKER, Fredrick, Assistant to Superintendent, Dept. of Distribution,
East River Gas Co., Long Island City, N. Y.
ROSEN, Carl G. A., Mechanical Engineer,
Dow Pump & Diesel Engine Co., Alameda, Cal.
RYDER, Frederick W., Efficiency Engineer,
Lehigh Valley Coal Co., Wilkes-Barre, Pa.
SAALFRANK, Royal B.,
With De Long Hook & Eye Co., Philadelphia, Pa.
SCHULTZ, Arthur F., Machine Designer,
Westinghouse Machine Co., E. Pittsburgh, Pa.
SEARLE, Dana A., Draftsman,
Ordnance War Dept., Washington, D. C.
SEMMEL, John W., Assistant Chief Operating Engineer,
New Jersey Zinc Co., Palmerton, Pa.
SMITH, Horace L., Jr., Secretary,
Horace L. Smith & Co., Inc., Petersburg, Pa.
SMITH, William H., Draftsman,
Alpha Portland Cement Co., Easton, Pa.
TROOP, Eugene F., Boiler Superintendent,
E. I. Du Pont de Nemours & Co., Hopewell, Va.
UEHLING Edward,
With Pittsburgh Valve & Fittings Co., Barberton, Ohio
VAN KENNEN, Harold H., Assistant to Elec. Engr.,
Rochester & Pittsburgh Coal & Iron Co., Punxsutawney, Pa.
WACHTLER, William B., Assistant to Engineer of Tests,
Hyatt Roller Bearing Co., Newark, N. J.
WORK, Clayton W., Erecting Engineer,
Westinghouse Elec. & Mfg. Co., New York

APPLICATION FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

BRAUN, Carl F., President,
C. F. Braun Co., San Francisco, Cal.

PROMOTION FROM JUNIOR

BALZ, George A., Vice-President, Manager and Treasurer,
Didier-March Co., Perth Amboy, N. J.
BROWN, Richard P., President,
The Brown Instrument Co., Philadelphia, Pa.
BURDSALL, Ellwood, Secretary,
Russell-Burdsall-Ward Bolt & Nut Co., Port Chester, N. Y.
BUSHNELL, James E., Engineer,
Robins Conveying Belt Co., New York
CASE, Albert H., Mining Engineer,
General Development Co., New York
CASE, Milo M., Consulting Mechanical Engineer, Chicago, Ill.
DEARBORN, William L., Resident Engineer,
Barclay, Parsons & Klapp, New York
DISERENS, Paul, Engineer of Tests, Laidlaw Works,
Worthington Pump & Mchy. Corp., Cincinnati, Ohio
FIELD-FRANK, Crosby, Chief Engineer,
Standard Aniline Products, Inc., Wappingers Falls, N. Y.
GFRÖRER, Albert H., Engineer, Indus. Truck Dept.,
Samuel L. Moore & Sons Corp., Elizabeth, N. J.
HIDER, George T., Partner,
Bell & Rider, Lake Providence, La.
HILDENBRAND, Harry, General Superintendent,
Houston Cotton Oil Mill, Houston, Tex.
NORTHRUP, Francis B., Charge of Drawing Room,
The Charles Burroughs Co., Newark, N. J.
PATTERSON, Peter C., Chief Engineer,
National Tube Co., Pittsburgh, Pa.
PULIS, William E.,
With H. L. Gantt, Consulting Engineer, as Industrial Engineer,
Newark, N. J.
REINICKER, Norman G., Assistant to Chief Engineer of Power Plants,
New York Edison Co., New York
RICHTER, Arthur W., Dean of Engineering,
University of Montana, Bozeman, Mont.
SONN, George P., Engineer,
Bridgeport Brass Co., Bridgeport, Conn.
WILLIAMS, Richard G., Special Investigator,
Norton Co., Worcester, Mass.

SUMMARY

New applications	258
Application for change of grading:	
Promotion from Associate-Member	1
Promotion from Junior	19
Total	278

SUMMARY SHOWING AVERAGE AGE AND POSITIONS OF APPLICANTS ON BALLOT CLOSING JUNE 29, 1916

Average age of applicants:	
Members	39
Associates	42
Associate-Members	32
Juniors	23
Chief Engineers and Asst. Ch. Engineers	5
Construction Engineers	5
Consulting Engineers	4
Designers	6
Draftsmen	6
Chief Draftsmen	4
Editors and Associate Editors	2
Estimator (Asst.)	1
Executives:	
Presidents, Vice-Presidents, Treasurers, Secretaries and Managers	11
Inventor	1
Instructors	2
Laboratory	2
Mechanical Engineers and Assistant Mechanical Engineers	14
Production Engineers	2
Professor	1
Professor (Associate)	1
Sales Manager	1
Superintendents	5
Superintendents (Assistant)	7
Students	1
Student Apprentice	2
Works Manager (Assistant)	1
Miscellaneous	17

GEOGRAPHICAL LIST

(Applications for promotion from any grade will be indicated by the initials of that grade)

Alabama
Gadsden—Polglaze, R. A.

Arizona
Douglas—Pratt, H. H.

California
Alameda—Rosen, C. G.
Los Angeles—Hughes, W. J.
Maier, F.
Marshall, K. I.
Reichard, G. A.
Oakland—Westwater, A.
San Diego—Judy, W. H.
San Francisco—Balzari, R. A.
Braun, C. F. (A. M.)
Jaschka, J. H.
Longley, F. B.
San Jose—Carter, W. D.
Stockton—DuBose, G. P.
White, H. C.

Canada
Brantford—Waterous, C. A.
Chile—Work, D. W.

Colorado
Denver—Cowell, F. W.

Connecticut

Bridgeport—Browne, T. A.
Cronan, C. B.
Hewitt, C. T.
Lanning, J. G.
Merchon, J. W.
Meserve, F. A.
Sonn, G. P.
Williams, J., Jr.
Woodcock, J. W.
Bristol—Vuilleumier, A.
Derby—Hooker, O. W.
Hartford—Beckley, W. C.
Edwards, G. M.
Ward, H. A.
New Britain—Pease, M.
New Haven—Barnum, E. W.
Dennis, F. L.
Wyant, R. E.
Norwich—DeYoung, H.
Wootton, H. C.

Delaware

Wilmington—Spiegelhalter, C.

District of Columbia

Washington—Beehler, W. P.
Greene, E. A.
Johnson, J. B.
Newcomb, B. R.
Oberlin, E. G.
Searle, D. A.

Georgia

Macon—Caldwell, C. A.

Illinois

Chicago—Brandel, S. W.
Case, M. M. (J.)
Copony, A.
Day, W. A.
Dreyer, E. J.
Freeman, J. B.
Hanson, E. S
Keenan, G. M.
Kraut, Hans B.
McIntyre, M. B.
Meloney, C. W.
Nice, E. W.
Noyes, J. A.
Sossong, R. A.
Watt, J.
Joliet—Bates, H. H.
Peru—Luetscher, O. P.

Indiana

Beech Grove—Ricketson, W. E.
Fort Wayne—Goda, P. H.
Indianapolis—Lewis, J. C.
Overmire, Wilfred J.

Iowa

Boone—Mottinger, B. T.

Louisiana

Lake Providence—Hider, G. T.
New Orleans—Duvic, F. R.
Raymond, H. E.
Shreveport—Dally, C. A.

Kentucky

Louisville—Credo, J.

Maine

Portland—Norrman, A. E.
Wilder, F. E.

Maryland

Baltimore—Munro, R. E.
Woodworth, C. B.
Curtis Bay—Whiteside, S. P.

Massachusetts

Boston—Abbey, F. H.
Hadley, F. V.
Jacobs, A.
Leathers, H. H.
Seabury, G. E.
Swift, H.
Dorchester—Eddy, C. W.
Fitchburg—Almy, T. R., Jr.
Beebe, H. A.
Framingham—Hawkins, P. D.
Holyoke—Bidwell, P. W.
Lynn—Brooks, A. A.
Springfield—Jackman, C. C.
Neidig, W. N.
Oak, J. H.
Wright, A. C.
Waltham—Ela, E. W.
Raymond, T. E.
Watertown—Finch, G. L.
Westfield—Bangs, G. H.
West Warren—Shaw, B. C.
Worcester—Champney, R. P.
Inman, C. M.
Mayo, E. C.
Merriam, C. F.
Nelson, M. C.
Williams, R. G.

Michigan

Detroit—Baker, I. C.
Roberts, J. D.
Ishpeming—Schikendanz, L. H.

Minnesota

St. Paul—Rathjens, G. W.

Missouri

St. Louis—Pogue, G.

Montana

Bozeman—Richter, A. W. (J.)

Nebraska

Omaha—Stuart, T. E.

New Jersey

Ampere—Freeman, H. A.
Bayonne—Hummel, F. G.
Dover—Ayer, W. T.
Elizabeth—Gfrörer, A. H. (J.)
Hackettstown—Hill, A. S.
Harrison—Cather, W. A.
Cohen, E. F.
Jersey City—Jackson, W. G.
Newark—Northrup, Francis B.
Pulis, W. E. (J.)
Wachtler, W. B.
New Brunswick—Lee, C.
Passaic—Barclay, W.
Paterson—Townsend, G. R.
Perth Amboy—Balz, G. A.
Plainfield—Eichenberg, M. A.
Muller, R. W.
Trenton—Hoyt, A. J.
Wharton—Noble, A. C.

New Mexico

Silver City—Buchanan, M. R.

New York

Albany—Nordheimer, A.
Brooklyn—Konwenhoven, F. W.
Martin, C. A.
Piccard, J. E.
Stoeltzing, H. E.
Wichum, V.
Buffalo—Baldwin, R. S.
Devine, C. P.
Lay, R. P.
Depew—Ardilla, Ricardo
Elmira—Vickers, C. H.
Goshen—Hickok, W. O.
Hurley—Elbelt, W. H.
Long Island City—Ballantine, J. H.
Baylis, R. V.
Riker, F.
New York—Blixt, G. F., Jr.
Brandt, Carl A. W.
Buckley, A. T.
Bushnell, J. E. (J.)
Byron, L. T.
Case, A. H. (J.)
Carter, R. A., Jr.
Convery, J. J.
Cummings, L. T.
Curtis, A.
Dearborn, W. L. (J.)
Dixon, J. A.
Dodge, J. S.
Duram, A. E.
Dusenbery, H.
Dyer, H. T.
Engel, G., Jr.
Gillham, C. A.
Goedkoop, W. C.
Gunkel, F. H., Jr.
Hagenah, R. E.
Hawley, K. A.
Heulings, S. N.
Holmgren, F. W.
Horton, R.
Jude, H.
Newman, C. H.
O'Brien, T. C.
Prince, D.
Purdy, A. R.
Reinicker, M. G. (J.)
Roberts, J. E.
Smith, P. M.
Van der Hoeven, C.
Wells, C.
Wetjen, H. W.
Work, C. W.
Niagara Falls—Routh, G. H.
Port Chester—Burdsall, E. (J.)
Schenectady—Glover, J. S.
Goetzenberger, R. L.
Knowlton, E.
Syracuse—Kotz, Emil F.
Wappingers Falls—Field, Frank C. (J.)
Prince Bay—Joline, E. A.
Wellsville—Dahlstrand, J. Y.
West Point—Bryant, P. J.
Woodmere—Hewlett, V. W., Jr.

Ohio

Barberton—Uehling, E.
Bay Bridge—Reilly, C. J.
Canton—Townsend, A. J.
Cincinnati—Diserens, P. (J.)
Fosdick, W. F.
Jann, V.
Thayer, A. A.
Cleveland—Fitzpatrick, C. J.
Columbus—Dorsey, W. A.
Speck, W. C.
Dayton—Wonfor, W. H.
Youngstown—Stevens, R. P.
Young, J. H., Jr.

Oklahoma

Norman—Felgar, J. H.
Shamrock—Fink, J. B.

Oregon

Portland—Pearson, S.

Pennsylvania

Altoona—Solomon, G. R.
Berwick—Field, H. T.
Bethlehem—Green, L. F.
Lowman, R. L.
Shaw, M. M.
Burham—Kendall, E. H.
Chester—Brown, H. J.
Conshohocken—Dette, A. E. L.
Easton—Smith, W. H.
Eddystone—Wilhelm, W. M.
Erie—Cox, J. W.
Palmerton—Semmel, J. W.
Philadelphia—Alpern, Maxwell
Ashmead, C. B.
Barr, J. A.
Boyle, W. W.
Brown, R. P. (J.)
Keet, C. T.
Klauder, L. T.
Mackay, A.
Menges, H. P.
Murphy, W. B.
Saalfrank, R. B.
Schranz, F. G.
Schultz, A. F.
Pittsburgh—Cullen, J. W.
Dunlevy, D. W.
Lundgren, S. E.
Lynde, C. C.
Patterson, P. C. (J.)
Punxsutawney—Van Kennen, H. H.
Steelton—Entwisle, E. F.
South Bethlehem—Lehr, C. E.
West Chester—Grosner, G. D.
Weiler, R. B.
Wilkes-Barre—Ryder, F. W.
Providence—Parks, E. F.

Rhode Island

Providence—Brown, W. S.
Parks, E. F.

Tennessee

Chattanooga—Merriam, I. B., Jr.
Humboldt—Massman, R. L.

Texas

Brownsville—Gallagher, C. W.
Fort Worth—Slater, W. A.
Houston—Hildenbrand, H. (J.)
Hull, B. E.

Vermont

Rutland—Lovely, J. E.

Virginia

City Point—Evans, D. F.
Wuesther, C. J.
Covington—Flannagan, E. G.
Hopewell—Troop, Eugene F.
Petersburgh—Smith, H. L., Jr.
Richmond—Johnston, A. L., Jr.

Washington

Bremerton—Bornhorst, A. H.
Pullman—Buerstatte, F. W.
Seattle—Barnes, E. L.

West Virginia

Manheim—Sermulin, F. E.

Wisconsin

Barksdale—Jernee, H. B.
Milwaukee—Keogh, J. K.
Peter, A. G.
Waddell, T. W.
Mosinee—Bugge, S. B.

Australia

Sydney—Kerr, C. P.

India

Matelli—Stephens, F. S.
Mysore—Krishnaiyengar, H.
Setti, S. V.

Philippine Islands

Manila—Cooper, A.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

ANNOUNCEMENTS.

HERBERT L. THOMPSON has accepted a position with the A. S. Cameron Steam Pump Works, St. Louis, Mo.

ROBERT B. BROWNLEE has accepted a position with the Reed-Prentice Company of Worcester, Mass.

W. M. ARMSTRONG has resigned his position as vice-president and sales manager of the Corrugated Bar Company, Buffalo, N. Y.

AUSTIN D. KEABLES has accepted the position of mechanical engineer for the Slatersville Finishing Company, Slatersville, R. I.

E. P. HAINES has accepted a position as mechanical engineer with the Curtis and Company Manufacturing Company of St. Louis, Mo.

DAN L. ROYER has been transferred from Milwaukee to the Chicago office of The Ocean Accident and Guarantee Corporation, Ltd.

ROBERT W. HUNT received the honorary degree of Doctor of Engineering at the recent commencement at Rensselaer Polytechnic Institute.

WILLARD C. BRINTON, consulting engineer, specializing on freight terminal and factory location work, recently returned from a business trip to China and Japan.

HARRY L. HORNING of the Waukesha Motor Company, Waukesha, Wis., has been nominated as one of the councilors of the Society of Automobile Engineers. He will serve for two years.

THOMAS H. ALLEN has withdrawn from the Hoshall Machinery Company, Memphis, Tenn., with which firm he was connected as a partner, and is now engaged in consulting engineering practice.

FRED G. LUNDGREN has been transferred from the Terre Haute, Ind., plant of the American Car and Foundry Company to the position of master mechanic at the Milton, Pa., plant of the company.

CHANGES OF POSITION.

ARTHUR L. LEWIS, formerly with L. F. Fales, Walpole, Mass., has accepted the position of superintendent with Sleeper and Hartley, Inc., Worcester, Mass.

P. J. FREEMAN has resigned from the professorship of applied mechanics in Kansas State College to become engineer of tests for the Pittsburgh Testing Laboratory.

L. S. RICHARDSON, consulting engineer with the Morgan Clark System Company, Rochester, N. Y., has become associated with W. S. Barstow and Company, Inc., New York, N. Y.

SAMUEL J. HOEXTER, instructor in mechanical engineering, University of Michigan, has been appointed manager of the Engineers' Society of Pennsylvania, Harrisburg, Pa.

ANTON HANSEN has severed his connection as chief draftsman with the Kelly and Jones Company, Greensburg, Pa., and has become affiliated with the Crane Company, Bridgeport, Conn.

THOMAS F. GITHENS, until recently associated with the American Sugar Refining Company, Brooklyn, N. Y., has become affiliated with the American Synthetic Dyes, Inc., Newark Transfer, N. J.

WALTER N. WALMSLEY, formerly general manager of the Sao Paolo (Brazil) Tramway, Light and Power Company, Ltd., has been appointed general manager of the Alabama Power Company.

JOHN W. MORTON, formerly of the designing department of the McIntosh and Seymour Corporation, Auburn, N. Y., has been appointed chief draftsman of the Baltimore Oil Engine Company, Baltimore, Md.

GEORGE S. WHEATLEY, formerly instructor of mechanical engineering, University of Pennsylvania, has become associated with the Cambria Steel Company, Johnstown, Pa., in the engineering department.

FERDINAND JEHLE has resigned his position as laboratory engineer with The Automobile Club of America, and has accepted the position of service engineer with The Aluminum Castings Company, Cleveland, O.

FREDERICK W. STARR, until recently publicity manager of The Pope Manufacturing Company, Westfield, Mass., has joined the force of the Toledo Scale Company of Toledo, O., with offices in Hartford, Conn.

MELBERT W. TABER, formerly construction engineer with the Packard Motor Car Company, Detroit, Mich., has been made manager of the Detroit office of the Asbestos Protected Metal Company of Pittsburgh, Pa.

FRANK G. BOLLES, formerly manager of *International Trade*, an export journal published in Chicago, has been elected vice-president of the Russian Trade Corporation of America, Maritime Building, New York City.

EDGAR E BURNET has entered the employ of the Western Mines Supply Company, San Francisco, Cal., in the capacity of Manager. He was formerly associated with the Judson Manufacturing Company of the same city.

LEWIS F. MOODY, for eight years a member of the faculty of Rensselaer Polytechnic Institute, has resigned as professor of hydraulic engineering and will act as consulting engineer for the I. P. Morris Company, Philadelphia.

W. F. ROCKWELL has resigned his position as chief industrial engineer of Clinton H. Scovell and Company, to become assistant general manager and works manager of The Torbensen Gear and Axle Company of Cleveland.

HENRY J. HANZLIK has resigned his position as mechanical engineer of the De Laval Steam Turbine Company, Trenton, N. J., and has accepted the position of consulting engineer of the Kerr Turbine Company, Wellsville, N. Y.

W. H. KAVANAUGH, who for 15 years has been a member of the faculty of the College of Engineering at the University of Minnesota, has accepted the professorship of experimental engineering in the Towne Scientific School of the University of Pennsylvania.

Q. R. NOLAN has assumed the duties of resident engineer at the LaGrange, Ga., works of the Hillside Cotton Mills. He was formerly connected with the Park A. Dallis Company, Atlanta, Ga., in the capacity of superintendent of construction in charge of surveys.

ARTHUR W. MACNABB has entered the employ of the National Meter Company, Brooklyn, N. Y., in the capacity of mechanical draftsman. He was formerly affiliated with the engineering department and inspection division of the Fidelity and Casualty Insurance Company, New York.

ALBERT T. KELLER, formerly identified with the Indiana Steel Company, Chicago, Ill., has accepted the position of chief engineer of construction for the Bethlehem Steel Company at Sparrows Point Md., and will have charge of the extensive new work at the Maryland plant.

DOUGLAS B. WRIGHT, formerly connected with the steam and chemical testing department of the Philadelphia Electric Company, Philadelphia, Pa., has accepted the position of test engineer in the steam engineering department of the Worth Brothers Company of Coatesville, Pa.

HENRY ANDERSON, JR., until recently connected with the New York Fire Insurance Exchange, New York, N. Y., as inspector of the automatic sprinkler department, has accepted a position with E. I. du Pont de Nemours and Company, Wilmington, Del., in the capacity of assistant engineer in connection with fire protection work.

George H. Blakeley, structural engineer with the Bethlehem Steel Company, has been made president of the newly organized Bethlehem Steel Bridge Company, which is to carry on the structural business of the Bethlehem Steel Company and the business formerly conducted by the bridge department of the Pennsylvania Steel Company.

John Calder has been appointed works manager and assistant to vice-president H. H. Pinney of the Bridgeport works of the Remington Arms-Union Metallic Cartridge Company, Inc. Mr. Calder has recently been associated with the banking house of Willett, Sears and Company of Boston, Mass., and has served as an advisory engineer to a number of New England industrial interests.

APPOINTMENTS.

S. E. Keefe has been appointed New York representative of The Franklin Oil and Gas Company, Bedford, Ohio.

Frank E. Leahy has been promoted to the position of steam and hydraulic engineer of the National Tube Company, Pittsburgh, Pa.

A. G. Williams, assistant master mechanic of the Pennsylvania Lines West, has been appointed assistant engineer of motive power, succeeding L. B. Jones.

E. J. Burdick, superintendent of power stations for the Detroit (Mich.) United Railways, has been appointed assistant general manager of the corporation.

Frank E. Howells, superintendent of shops of the Steelton plant of the Bethlehem Steel Company, has been advanced to the position of assistant mechanical engineer of the plant.

E. L. Mayall has recently been appointed plant engineer of the Holt Manufacturing Company, Stockton, Cal. Mr. Mayall was formerly connected with the company as head of the implement department.

George F. Swain, professor of civil engineering, Harvard University and Massachusetts Institute of Technology, has been chosen as one of three arbitrators of the dispute over the plans for rehabilitating the Galveston causeway, by the interurban railway and the county.

William H. Boehm was appointed vice-president of the Fidelity and Casualty Company, New York City, at a recent meeting of the board of directors of the company. Mr. Boehm still retains the superintendency of the departments of steam boiler and flywheel insurance.

Arthur N. Talbot, professor of municipal and sanitary engineering, University of Illinois, has been chosen as one of three arbitrators of the dispute that has arisen over plans for the rehabilitation of the Galveston causeway, by the three steam railways interested. The degree of Doctor of Engineering was conferred on Professor Talbot in June by the University of Michigan.

NECROLOGY

HARRY A. HAAS

Harry A. Haas was born at Tamaqua, Pa., on March 31, 1887. In June, 1902, he was graduated from the Tamaqua High School following which he became a clerk in his father's general store. In the summer of 1906 he entered Mount Herman School, in Massachusetts, from which he was graduated in August, 1907. He then entered Lehigh University and graduated with first senior mechanical honors in 1911. During the summer of 1909 he was employed as a teacher of science at Mount Herman School and during the summer of 1910, he was employed in the gun shop of the Bethlehem Steel Company. Following his graduation from Lehigh University, he entered the employ of the Winchester Repeating Arms Company which position he held up to the time of his death. He was employed in the capacity of equipment engineer for the cannon, case, annealing, washing and packing shops and for special machinery.

Mr. Haas was a member of Lehigh Alumni Association. He became a member of this Society in 1915. He was drowned in Lake Bantam on July 15, 1916.

AMOS GRANVILLE HOSMER

Amos Granville Hosmer was born in Hubbardston, Mass., on October 2, 1861. He received his early education in the home schools, and at the age of twenty, he learned the machinists' trade at the works of F. Copeland at Sterling, Mass.

He later became connected with the Arnold Print Works in North Adams, Mass., as mechanical engineer where he remained ten years. For the eight years following this, he was at Clinton, Mass., at the Lancaster Mills, also as mechanical engineer. In 1915, he moved to Lowell, Mass., where he held the position of mechanical superintendent for the Merrimack Manufacturing Company.

Mr. Hosmer was a member of several lodges and a member of the Cotton Manufacturers' Association. He became a member of this Society in 1906. Mr. Hosmer died following an operation on July 22, 1916.

JUDSON H. BOUGHTON

Judson H. Boughton was born at Rochester, N. Y., on January 10, 1881. He received his early education at the Fairfield Military Academy and was graduated from Cornell University in June, 1903.

From 1907 to 1915 he was interested in the operation of light, water, gas and street railways in the South and Southwest. During that time he was secretary and treasurer of the National Light Improvement Company, a New Jersey holding company; consulting engineer of the Ft. Worth Light and Power Company of Ft. Worth, Texas; president of the Citizens Railway Company and the Waco Gas Company of Waco, Texas; consulting engineer for the Hot Springs Water Company, the Hot Springs Gas Company, and the Hot Springs Street Railway Company of Hot Springs, Ark.; president of the National Light & Power Company, a New Jersey holding company; president of the Fulton Electric Light and Power Company of Fulton, Ky.; president of the Hickman Light and Water Company of Hickman, Ky.; president of the Prairie County Public Utility Company of Prairieville, Mo.; consulting engineer for the St. Francis Railroad of Mo.; and consulting engineer on various other properties. During the past two or three years, Mr. Boughton has been devoting his time to the boat industry and in this connection he organized and was president of the St. Louis Yacht and Boat Company and the Great Lakes Boat Building Corporation of Milwaukee to which he was giving all of his attention at the time of his death.

Mr. Boughton was a member of the American Institute of Electrical Engineers, the American Street Railway Association, the National Electric Light Association. He was also a member of the Racket Club, and the City Club of St. Louis, the University Club of Milwaukee and the Milwaukee Yacht Club and the Chicago Yacht Club. He became a member of the Society in 1903. He died at Milwaukee, Wis., on July 29, 1916.

CHARLES KIRCHHOFF

Charles Kirchhoff was born at San Francisco, on March 28, 1853. After receiving his education in the schools of this country, he completed his education in Germany where he was graduated from the Royal School of Mines at Clausthal, Saxony, in 1874.

Returning to the United States, he was employed as chemist at the Delaware Lead Refinery in Philadelphia until 1877. In that year, he became assistant editor of the *Metallurgical Review* and the following year he held the same position with the

Iron Age of which he afterward became editor and part owner for more than twenty years. He was also from 1881 until 1884 the assistant editor of the *Mining Journal*. In the latter year he became again associated with the *Iron Age*, this time as associate editor. When he relinquished this position in 1889, it was to become the editor in chief, a position which he held until 1910, when he retired from business. During the time he was in control of this magazine, it became one of the leading engineering publications of the country. During this time, also, he was for many years vice-president and general manager of the David Williams Company, retiring from this connection in 1910.

From 1883 until 1906 Mr. Kirchhoff was a special agent of the United States Geological Survey for the collection of statistics on the production of lead, copper and zinc. He was the author in 1910 of Notes on Some European Iron Districts.

Mr. Kirchhoff was a member of the American Institute of Mining Engineers, of which society he was president from 1898 until 1899. He also was a member of the American Iron and Steel Institute of Great Britain, the Verein Deutscher Eisenhuettenleute, and an honorary member of The Franklin Institute of Philadelphia. He was trustee and treasurer of the United Engineering Society of New York and last year was elected a trustee of the Engineers' Club of New York. He was also a member of the Century Club. He became a member of this Society in 1882. He died at his summer home in Wannamassa, N. J., on July 23, 1916.

EMPLOYMENT BULLETIN

THE Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed by the Society. Copy for notices should be in hand by the 18th of the month.

ENGINEER. Technical graduate preferred. Experienced in design of open feed water heaters, softeners, etc. Good position to right person. Write fully, giving details of experience and references. 102

SALESMAN AND DRAFTSMAN, on elevating and conveying machinery and light structural work. Preference given to men who would develop into salesmen after training in general work of company in order to become thoroughly familiar with product. Salary $1500 to $1700. Apply by letter with object of personal interview. Location New York State. 179

DETAIL DRAFTSMAN, on structural and mechanical work. Salary about $100 to $125. State experience and salary expected. Location Kansas. 231

TECHNICAL GRADUATE, age 30 to 35, with practical experience in manufacture and building of steam and hydraulic machinery. Man preferred with wide shop experience and capable of directing men. Location Ohio. Interview will be arranged only after examination of applicant's statement of qualification, records and compensation expected. 328

DESIGNER, technical graduate experienced in design of small intricate machinery. Location New York. 424

ASSOCIATE PROFESSOR for university in Missouri, to teach elementary and advanced steam machinery, steam turbines and advanced machine design. Salary about $1800. 427

ASSISTANT FOREMAN in sub-department for development of auto-starting batteries. One having storage battery experience preferred. Salary $21. Location New York State. 441

SUPERINTENDENT for machine shop and brass foundry. Liberal salary for A1 man. State qualifications, age and salary. 442

EXPERIENCED OFFICE MAN with executive training, capable of taking control of an entire office staff. Location Canada. 444

ASSISTANT WORKS MANAGER, exceptionally good opportunity. American parentage, technical education, not over 35, machine shop experience. 455

PRODUCTION SUPERINTENDENT. Man of exemplary habits and character; very dependable. Experience in manufacturing nad operation of machine tools, as planers, drills, forging machines, presses, etc. Hours from 7 a.m. to 5:30 p.m. Must be disciplinarian and good mechanic; 150 to 200 men employed. Location Middle West. 460

PRODUCTION MAN, for cartridge factory in Kansas. Salary $5 to $10 per diem. Main problems are discipline for mixed labor, scheduling orders, rate setting, etc. 465

YOUNG ENGINEER who has made specialty of cement plants, with three or four years practical work since graduation. To take charge of cement plant department of concern manufacturing, crushing and handling plants and cement plant parts. Location Kent, England. 467

YOUNG TECHNICAL GRADUATE, two to four years out of college, to train into sales work for New York concern. 469

ROLLING MILL EXPERT, thoroughly experienced. 470

DESIGNER in general line of conveying and materials-handling machinery, with practical knowledge of shop construction work. Position offers good opportunity for advancement. State age, experience, education, salary desired to start. 473

TEACHER for department of mechanical engineering in Southern University. Graduate engineer with machine shop experience. Work in the university will be instructing in machine shop and steam laboratory. Capable man should work to professorship either in mechanical engineering or machine shop practice. Salary $1500. 474

AGENCY desired for high grade Diesel type oil engine in territory surrounding Kansas City. 475

TOOL DESIGNER. Man who can design and make calculations on special tool jigs and fixtures. Preferably man with actual shop experience and technical education. 476

DRAFTSMAN, who has had considerable experience with the design and installation of boilers, stokers, coal bunkers and coal handling machinery. Capable of designing foundations for boilers and supports for concrete overhead coal bunkers. Liberal salary. Location Pittsburgh, Pa. 477

DRAFTSMAN, experienced on small tool, jig and fixture designing; preferably in connection with small arms and ammunition works. Location Canada. 478

SUPERINTENDENT AND CHIEF ENGINEER for Diesel engine central station of 500-h.p. units in Western state. Must be responsible, efficient superintendent and competent workman-like chief with some experience in Diesel engines. 479

CHIEF DRAFTSMAN OR ASSISTANT ENGINEER with following requirements: First, thoroughly familiar with metric system and able to convert to English units, or vice versa. Second, read and understand French language. Third, familiar with standard practice as applied to drafting, shop management and shop production. Fourth, thoroughly familiar with specifications as applied to materials, bills of materials, etc. Fifth, knowledge of tool design and methods used in production of small brass parts. 484

SHOP SUPERINTENDENT for old established foundry and machine works near New York. Investment desired. 482

DRAFTSMAN with valve experience. 485

SUPERINTENDENT with experience in factory manufacturing small brass parts and who thoroughly understands manufacture from design of tools to shipping. Name confidential. Apply by letter. 486

MECHANICAL ENGINEER AND DESIGNER OF HIGH GRADE MACHINERY who can follow latest machine shop foundry and pattern shop practice, be original, investigate present methods from data secured, develop machinery and conveyors, in proper sequence, to handle mechanically all material from raw stock to finished product. Four or five years experience in same line of work. State age, experience, education, nationality, former connections, salary received, references, when available. Confidential. Location Detroit. 492

SHOP ACCOUNTANTS of experience who have made good wanted for Canadian firm. 493

YOUNG ENGINEER, with fair knowledge of drafting and chemistry, to look after testing work in bleachery plant. Location New Jersey. 500

YOUNG TECHNICAL GRADUATE for planning department. Man with one or two years experience will receive preference. Location Massachusetts. 501

TOOL DESIGNER, experienced in jig and fixture work, for well known machine-tool factory in Massachusetts. 502

LIBRARIAN, for Engineering Library of Sibley College, Cornell University. Engineering graduate with ability to translate German fluently. In addition to routine work librarian would be expected to advise and assist students in use of library, abstract articles, make translations and render assistance to the faculty. Considerable portion of time would be available for study and other purposes. Salary for first year $800. Two months vacation during summer and several days during Christmas and Spring recesses. 503

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 18th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

MECHANICAL ENGINEER. Eight years experience in design and manufacture of stationary and aeronautical engines, including jig, tool and foundry work. Desires position as engineer-in-charge or superintendent of gas engine shop. I-288.

MECHANICAL ENGINEER. Eight years experience in heat-treating, testing, forging and micro-structure of steel. Desires position where experience may be used either as executive or semi-executive in production or purchasing department. I-289

BRANCH OFFICE MANAGER. Wide business experience, good negotiator of large or intricate transactions. Now trustee and managing director for large interests and operating several businesses. Desires position demanding general ability of high order. Available January 1, 1917. I-290

DESIGNER. 1897 graduate, age 38. Several years experience in designing Corliss engines, refrigerating machinery, ice plants and refrigerating plants. For past five years chief engineer for leading ice plant builder in middle west. I-291

PRODUCTION ENGINEER. Technical graduate, age 34. Strong disciplinarian and successful handler of men; organizing and executive ability; well versed in efficiency, rate setting, cost accounting and modern shop management. Desires position along lines of foundry, machine shop or sheet metal work. Compensation to be based on results. I-292

ASSISTANT SUPERINTENDENT. 18 years varied experience in interchangeable manufacturing. Now with concern employing 1800. Wishes connection with reliable company where growing opportunity is assured. I-293

MEMBER. Stevens graduate, age 37, married. Eleven years practical experience in U. S. and abroad in general power station design, engineering and construction. Also five years experience in engineering, administrative and sales department of manufacturing corporations. Desires connection with manufacturing company, with eventual investment of some capital. Knows German and French. At present employed. I-294

CHIEF DRAFTSMAN or ASSISTANT MECHANICAL ENGINEER or INSTRUCTOR IN ENGINEERING BRANCHES. Graduate. Experienced designer of machinery, structural iron and small automatic machines. I-295.

REPRESENTATIVE. Mechanical engineer, with extensive shop and office experience. Desires to become associated with, or represent in New York City, large industrial interests engaged in domestic and foreign trade. I-296

DESIGNER. Experienced on locomotives, gasoline motors, special machinery and tools: practical machinist; technical education; good personality; working knowledge of Spanish and German. Seeks opportunity to work into export sales. Salary moderate. Associate-Member, 32. I-297

SALES ENGINEER, SALES MANAGER or DISTRICT MANAGER. Age 35, graduate mechanical engineer. Ten years experience with constantly increasing sales; power plant equipment and power transmission lines. Salary or commission. At present employed, but ready to make change for position offering good prospects. I-298.

MECHANICAL ENGINEER OF COAL MINES. Ten years experience in design, installation and operation of mechanical equipment of coal mines. Specialist in boiler plant operation and as combustion engineer for coal sales department. I-299

MECHANICAL and MINING ENGINEER, speaking several languages and with wide experience in management of manufacturing and selling engineering specialties, such as time fuses, military rolling sticks, gold placer machines, structural steel, foundry works, water and gas meters, aluminum die-castings and automobiles, now employed in such a capacity, wishes a similar position. Would also entertain representation of manufacturing concern in Europe. Previously represented American concerns abroad as technical and commercial director for engineering specialties and ammunition. Best references furnished. Salary to start $6000 in America; $6000 plus expenses abroad. I-300

MANAGER, SUPERINTENDENT or SALES ENGINEER. M.E. (Lehigh University). Several years experience in management of mechanical and purchasing departments of railroad, coal mining, and industrial corporations: extensive experience as sales engineer in railroad equipment, organizer and executive. Qualified to fill position of manager of industrial plant or coal mining company, or superintendent of motive power of railroad. Can successfully represent manufacturers of machinery, power plant equipment, iron and steel. I-301

ENGINEER or MANAGER'S ASSISTANT. Junior member, graduate M.E., varied experience in power plants, shops, construction and design. Now chief draftsman. Desires to make a change where there is an opportunity for advancement. I-302.

SALES ENGINEER. Technical graduate. Twelve years selling experience, especially government work. At present in charge of office of large machinery manufacturer. Desires similar position in New York. I-303

MECHANICAL ENGINEER. Long experience in England, Germany and United States in design and construction of passenger and freight cars and structural ironwork. Desires responsible position; able to take charge of men. Age 38, married. I-304.

MECHANICAL ENGINEER. Technical graduate. Ten years experience in designing, constructing and operating steam, electric and ice properties; five years in active charge. Desires position as general manager or construction manager for public utilities corporation or consulting engineering firm. At present employed. I-305

MECHANICAL ENGINEER or EXECUTIVE. Graduate M.E., age 40, Associate-Member. 10 years practical experience as executive. Desires change; would consider manager or superintendency for firm desiring man familiar with heavy machine design, up-to-date plant methods, efficiency, organization. I-306

EXECUTIVE in semi-executive capacity. Mechanical, electrical engineer; member both societies; age 41. Superintendent of operations largest City electricity-supply system, East; 18 years responsibility, design, construction, operation. Successful organizer, main and sub-station economies, boilers, stokers, smoke abatement, transmission and distribution, energy supply to railways. Best recommendations, employing corporations. I-307

PRODUCTION ENGINEER. Associate-Member, age 32. Broad experience factory and foundry operation, organization, production equipment, accounting and cost covering stamping, shaping, plating and finishing; also machine parts on interchangeable basis. Vicinity New York. I-308

SUPERINTENDENT, CHIEF ENGINEER or SALES ENGINEER. Experienced in design, installation, operation, and testing of complete power plant and pumping equipment, including engines, boilers, mechanical stokers, coal and ash-handling machinery, high-pressure piping and all accessories. Age 39. I-309

MECHANICAL ENGINEER. Graduate M.E. and E.E. Junior Member, age 33. Thorough, resourceful and energetic, desires position with large firm. In following position during past twelve years as engineer—operating, testing, draftsman, in charge of station, designing, resident engineer on construction, power engineer. At present employed as mechanical engineer. Location in or near New York. Salary $2500. I-310

ASSISTANT TO EXECUTIVE or SALES MANAGER. Member, technical graduate, age 36, desires change of position. Experience covers testing, research, designing and commercial engineering, in connection with steam turbines, turbo-blowers and centrifugal pumps, with responsible charge of men. New York City or eastern location preferred. I-311

MECHANICAL ENGINEER, Graduate Columbia University, 1915, desires to locate with manufacturing or engineering concern in or near New York. Two years power plant, shop and drafting room experience. Experienced in power plant testing, automatic machinery, installation and layout of machinery. At present employed in maintenance department of concern manufacturing automobile auxiliaries. I-312

SUCCESSFUL DESIGNER of automatic paper-box, bag, envelope machines, printing presses, etc., desires change. First class references. Salary not under $2500. I-313

MECHANICAL ENGINEER. Junior member. Technical graduate, age 25. Now employed in engineering work involving design, charge of installation of textile machinery, plant operation and management. Capable of taking initiative. Desires permanent position in aggressive company. I-314

MECHANICAL ENGINEER, 41, technical graduate. Extensive experience erecting, operating and testing power plant machinery; sales engineer; five years in charge of water works pumping plant, including supply and filtration. Desires change; will go anywhere in United States. I-315

MECHANICAL ENGINEER. Associate-Member, age 28, technical graduate. At present employed, but desires responsible position with manufacturing concern. Nine years experience in design, development and experimental work, as well as maintenance and operation of industrial plants. I-316

STEAM or EFFICIENCY ENGINEER. Graduate Cornell University, M.E., 1908. Broad executive experience. Would be glad to consider position as superintendent or assistant superintendent of employment. I-317

MECHANICAL ENGINEER. Junior Member, Graduate Cornell University, age 25. Three years practical experience in marine work, including ship construction and hydraulic dredge erection. Desires position with engineering firm or dredging contractor. Holds marine engineer's license. Excellent references. Salary $1200. I-318

MANAGER or CHIEF ENGINEER. Technical graduate. Now assistant manager large plant manufacturing steel freight and passenger cars, also munitions and army transportation equipment. 18 years experience; 5 years railroad shops; 3 years engine and boiler works; 10 years car designing and manufacture. Experienced in shop management, planning and efficiency, also in sales and purchasing. Desires change as plant manager or consulting engineer in above lines. I-319

INDUSTRIAL ENGINEER, Junior member. Two years experience as designer of heavy machinery; one year as draftsman of industrial plants; for the past year and a half with large industrial plant as industrial engineer. Familiar with cost accounting, scheduling, time study work, etc. Desires change. Location immaterial. I-320

JUNIOR MEMBER of Am.Soc.M.E. and S.A.E. Graduate M.E. Experienced in design of efficient high speed gasoline engines; definite knowledge of the many points of design that make for high speed, high power, and smooth running, with ability to apply this knowledge in developing designs. Position desired in some engine manufacturing concern, preferably one contemplating new designs. Location, Detroit, Mich. I-321

ENGINEER, with exceptional inventive talent, desires position requiring such ability. Cornell graduate, M.E. (having specialized in E.E.), with M.S. from Union College. One year experience at General Electric Co. and two years as university instructor in electrical engineering. At present assistant engineer of chemical factory. Salary a distinct object. I-322

MECHANICAL ENGINEER, age 31, technical training. At present employed in executive capacity; wide experience in combustion engineering and in design and operation of boiler plants. Desires position with boiler or stoker manufacturer, or with large plant as power efficiency engineer. Can produce results and is not afraid of responsibility. I-323

MANUFACTURERS REPRESENTATIVE OR SALES MANAGER. Consulting Engineer with New York Office, large industrial and engineering acquaintance in Eastern territory, wishes to add to representation on commission basis only. New York, New England States and New Jersey. I-324

COMBUSTION ENGINEER. Graduate, age 32. Ten years experience in handling boilers and mechanical stokers. Would like to take charge of power proposition where saving in fuel is desired. Can show good record. At present employed in large central station holding record for fuel company. I-325

EFFICIENCY ENGINEER. Graduate, M. E., University of Pennsylvania, age 28. Junior Member. Four years machine shop experience, eight months designing safety devices, jigs, fixtures, etc., one year connection in various phases in production department of manufacturing concern. Inventive inclination, has made several practical inventions. Wishes to specialize in labor-saving devices and improving machines in connection with efficiency work. Will start at $100 per month where advancement is assured. I-326

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

Building Single Purpose Lathes in a Single Purpose Shop, Ethan Viall. Reprinted from American Machinist, May 11, 1916. Gift of L. I. Yeomans.

Connecticut Society of Civil Engineers. Papers and Transactions for 1915 and Proceedings of 32d Annual Meeting, 1916. *New Haven, 1916.* Gift of Society.

Henry Gannett, S. N. D. North. *1915.* Gift of C. W. Rice.

Illinois Society of Engineers. 31st Annual Report, 1916. *Wheaton, 1916.* Gift of Society.

Is Equal Justice Possible in Government Contracts? Wm. B. King. *Washington.* Gift of King & King.

Liquefying Air by Utilizing the "Joule-Thomson Effect" and Mechanical Liquefaction by an Expansion Engine, J. F. Place. *Glen Ridge, N. J., 1916.* Gift of author.

New Britain (Conn.) Board of Water Commissioners. 59th Annual Report, 1916. Gift of New Britain Board of Water Commissioners.

New Orleans. Sewerage and Water Board. 32d Semi-Annual Report. *New Orleans, 1915.* Gift of Sewerage and Water Board.

The Place Mechanical Process of Liquefying Air and the Separation of Liquid Air Into its Constituents Oxygen and Nitrogen, J. F. Place. Gift of author.

Reasonableness and Legal Right of the "Minimum Charge" and Public Utility Services, S. S. Wyer. *Columbus, 1916.* Gift of author.

El Sistema de Alcantarillado y Pavimentacion de la Ciudad de la Habana. (Revista de la Sociedad Cubana de Ingenieros. Edicion Extraordinaria.) *Habana, 1916.* Gift of Sociedad Cubana de Ingenieros.

Sturtevant War Letters from Members of the Staff. *London, 1916.* Gift of Sturtevant Engineering Co., Ltd.

GIFT OF WATER POWER DEVELOPMENT ASSOCIATION

An Answer to Gifford Pinchot. An open letter to the President of the U. S.

Criticisms of the Shields Bill Answered.

Steam vs. Water Power. Factors that have hindered the building of water power plants and how such obstacles can and should be eliminated, by H. W. Buck.

Water Power as a Natural Resource. Editorial from The Outlook, Feb. 9, 1916.

TRADE CATALOGUES

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ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY.

AEROPLANE ACCIDENTS.
AIR GUSTS.
SCIENTIFIC RESEARCH IN AEROPLANE CONSTRUCTION.
RESEARCH DEPARTMENT OF THE CURTISS COMPANY.
VULCANIZATION OF PLANTATION PARA RUBBER.
NITROGEN CONTENT AND CURE OF RUBBER.
PROTEIN DECOMPOSITION AND CURE OF RUBBER.
CURE OF SHEET RUBBER.
TOOL STEEL HARDENING AND GRINDING.
NORMALIZING OF TOOL STEEL.
FUNGUS GROWTH ON WOOD.
FIRE RETARDENTS.
CONCRETE, SOME PROPERTIES OF.
AMERICAN PETROLEUM OILS, DENSITY.
AMERICAN PETROLEUM OILS, THERMAL EXPANSION.
PRE-HEATED BLAST CUPOLA.
CASTING 8 IN. H.E. SHELL INGOTS.
FORGING ROUGH 8 IN. H.E. SHELLS.
PEAT AS FUEL.
GERMAN STEAM PLANT USING PEAT FUEL.
CYCLOIDAL CURVE LAW OF DISTRIBUTION OF VELOCITIES IN FLOW OF WATER IN PIPES.
ANTI-FRICTION BEARINGS IN AXLE GENERATORS.
ANTI-FRICTION BEARINGS ON BAGGAGE TRUCKS.
ANTI-FRICTION BEARINGS ON TRUCKS IN CREOSOTING PLANTS.
ALUMINUM WELDING.
DRAWING METAL BY HYDRAULIC METHOD.
HYDRAULIC PRESS SYSTEM FOR SHELL MAKING.
THERMALENE PRODUCTION AND PROPERTIES.
THERMALENE WELDING TORCH.
AEROPLANE CYLINDERS, MACHINING.
HYDRAULIC AND STEAM-HYDRAULIC FORGING OF SHELLS COMPARED.
STEAM-HYDRAULIC SHELL FORGING IN RUSSIA, TIME TABLE.
CHART, ENGINE FRAME LOADS.
ACCELERATING CHARACTERISTICS, CENTRIFUGAL PUMPS AND FANS.
THEORY OF ELASTICITY.
UNSYMMETRICAL RIVETED JOINTS, EFFICIENCY.
PLASTIC FLOW PHENOMENA.
PLASTIC FLOW OF STEEL AND CLAY.
COKE-OVEN GAS POWER PLANT.
COKE-OVEN GAS, CLEANING.
PRE-IGNITION THROUGH SULPHUR IN GAS ENGINES.
PRIME MOVERS FOR ISOLATED PLANTS.
INDICATOR DIAGRAMS FROM A COMPOUND CORLISS.
UNIFORM BOILER LAWS IN CANADA.
STEAM ECONOMIES ON FRENCH RAILROADS.
MALLEABLE AND CAST STEEL TESTING.
FIRE-BRICK TESTING.
HARDNESS TESTING OF NON-FERROUS METALS.
CHARTS.

There is in this issue of the Engineering Survey an abstract of a description of the Engineering Department of the Curtiss Aeroplane and Motor Corporation plant at Buffalo, N. Y. To many it will come as a great surprise. The industry was created less than five years ago, as the entire previous period of heavier-than-air flying was devoted to experimental work and exhibition flights exclusively. And nevertheless we find that the engineering department only of the Curtiss works employs 150 men, and we find further that the thoroughness of designing and construction in the manufacture of aeroplanes equals if not surpasses that in many older and far more established branches of the mechanical art.

In this connection, particular attention is called to the illustration on page 749, reproducing a working blueprint of an aeroplane wing. The data presented there are of no particular interest as such, but it is believed that engineers will be interested to note how carefully all the details of construction are worked out and how far aeroplane building has passed from the stage of guesswork and cut-and-try methods of the early days, "early days" which are, however, probably less than three years ago.

THIS MONTH'S ARTICLES

Lieutenant R. C. Saufley discusses the causes of aeroplane accidents with particular reference to the action of gusts. He gives also an interesting summing up of the present situation with respect to the position of the aerial branch of the Navy Service: "The developments of the last twelve months have left no doubt as to the naval advantage to be gained from the use of aircraft. . . . Ignorance, not unbelief, is our problem."

In the section Engineering Materials will be found the continuation of an abstract of the report on important experiments on the vulcanization of plantation Para rubber, in which the writer determines the cause of variability of curing and establishes its connection with the nitrogen content of the latex.

In the same section will be found an abstract of the report presented by the Tool Research Committee to the Manchester Association of Engineers. The most important conclusions to which their experiments led are that some of the tools showed a decided deterioration on regrinding only after a failure, which is contrary to general belief. Further, it was found that high speed steel is not injured by repeated heating at high temperature, such as that required for hardening, and that normalizing does not materially improve lathe tools.

There are two articles on the behavior of wood, one discussing the fungus growth on untreated wood and ties, and another the efficiency of fire retardents with special reference to their use on roof shingles. The last of these articles is of particular interest as it presents data of an experimental investigation carried out in a systematic manner.

From a scientific paper of the U. S. Bureau of Standards are abstracted some data on the strength and other properties of concrete as affected by the constituent materials and method of preparation. In the same section will be found an advance abstract of a Technologic Paper on the density and thermal expansion of American petroleum oils. Through the courtesy of Dr. S. W. Stratton, Director of the Bureau of Standards, The Journal has been accorded the valuable privilege of receiving advance notices of Technologic Papers published by the Bureau. Abstracts of these papers will in future be reported in the Engineering Survey at the earliest opportunity.

The casting of 8-in. H.E. shell ingots is discussed in the section Foundry.

B. F. Haanel, in a paper before the American Peat Society, considers the value of peat fuel as compared with coke, and among other things presents some interesting data on a large steam power plant (over 5000 h.p.) designed for the exclusive use of peat fuel in Germany. From the paper it appears that peat fuel can be used for power generation only where the

strictest economies are introduced in the manufacture and use of the fuel, and where further no other fuel is readily available.

The law of distribution of velocities in the flow of water in pipes is expressed by a cycloidal curve by Moignié, in a French official periodical.

Several letters and articles on the use of anti-friction bearings in railway axle generator service are reported from the *Railway Electrical Engineer*.

In the section Machine Shop attention is called to the several articles on forging, referring mainly to forging blanks for large shells either hydraulically or by steam presses. In the same section will be found an abstract taken from the *American Machinist* on the production, properties and use of thermalene, a new gas designed to take the place of acetylene for purposes of welding and metal cutting.

A chart for determining engine frame loads is reproduced from *Machinery* in the section Mechanics. In the same section will be found a brief discussion of the accelerating characteristics of centrifugal pumps and fans.

From the *London Philosophical Magazine* are briefly abstracted the main points of a very interesting mathematical discussion of some of the fundamental problems in the theory of elasticity, in particular those of elastic equilibrium under certain given conditions.

R. N. Blackburn's discussion of the comparative efficiency of symmetrical and unsymmetrical joints brings out the important distinction between apparent efficiency calculated from formulae under certain assumptions, and the actual efficiency of a riveted joint, such as would be determined by measurement. There ought not to be any difference between the two efficiencies if the assumptions on which the formula is based always held good in actual practice, and Mr. Blackburn claims that this is not the case. He also expresses the opinion that as far as the stresses in an unsymmetrical joint are concerned, the bending action is of more importance than the direct stress due to the pull on the plate.

The description of a plant for the production of power from coke-oven gas is abstracted from a British periodical. It contains some data on the purification of the gas, especially on the elimination of sulphur. The author calls attention to the comparatively little known fact that the presence of sulphur in the gas may cause pre-ignition of the charge during the compression stroke. Another point of interest is the fact that, by regular attention to exhaust analysis and methods of driving the engines, the gas consumption per month on the same load was reduced from 15 million cu. ft. to 12½ million cu. ft.

From tests made upon the high and intermediate cylinders of a triple-expansion Corliss engine, Prof. Victor R. Gage comes to the conclusion that the logarithmic analysis of the indicator diagrams cannot be applied under all conditions. On the other hand, he shows that the point of thermal equilibrium and the general behavior of the steam during expansion can be readily shown by means of the temperature-entropy diagram.

The application of the Brinnell method for regulating methods of manufacture of non-ferrous metal product is reported in some detail in an abstract of an article by Hugo Friedmann. He points out several useful applications of the hardness test. For example, for discovering whether the entire piece cooled at the same speed, or for determining in certain cases the properties of the metal at different distances from the surface. Likewise, for example, in the case of aluminum, a hardness test enables to determine whether the hardness of the metal is due to its chemical composition or to the mechanical treatment to which it has been submitted.

That firebricks tend to group themselves with respect to most of their mechanical properties according to their density is a practical conclusion arrived at from a number of tests. These tests also covered the subjects of spalling, slagging and compression strength of fire bricks.

Aeronautics

Aeroplane Accidents: Causes and Remedies,

Lieut. R. C. Saufley, U. S. Navy

The author attributes aeroplane accidents to three general causes, namely, (1) air conditions, (2) material, (3) personal error. In the first stages of aeroplane construction, when the factor of safety was small and the machines were slow and underpowered, casualties from causes (1) and (2) were frequent.

As regards air conditions, gust action may be classified as one of the great causes of aeroplane accidents. The general effect of gusts upon aeroplanes depends on the direction. Accidents due to *rear gusts* occur because the aeroplane flies suddenly into a region of air being accelerated in the direction of the machine's path. Were the air accelerations strong enough, the direction of air flowing through the wings would be momentarily reversed and the machine would drop precipitously. Fortunately, there are no records of air currents being accelerated to such an extent, as experiments have shown few air accelerations beyond 15 miles. What ordinarily happens in case of the real gust is that the velocity relative to the aeroplane is momentarily reduced and, the machine's inertia preventing an immediate absorption of the gust's speed, lift and control are lost. It must be said, however, that actually the gust cannot overtake an aeroplane, and the term "rear gust" is therefore a misnomer.

The author endeavors to explain the effect of a rear gust upon an aeroplane by assuming that the machine is sustained in normal flight, disregarding the consideration of air velocity. With this explanation, any variation in the conduct of the machine must be due to a variation of *gravity relative to the air*. This latter term has the following meaning: When a machine is being sustained in undisturbed air, *i.e.*, air whose velocity is constant, "gravity relative to the air" and "absolute gravity" are the same, but if the supporting medium is suddenly accelerated, the machine's equilibrium must be momentarily adjusted to the resultant of the two accelerations, gravity and the gust. This resultant is the new "gravity relative to the air," the direction of which is perpendicular to the air only when the air acceleration or gust is directly outward or downward.

While fatalities due to *downward gusts* have been less frequent than those due to rear gusts, this is only because few flights were attempted when this sort of gust was prevalent. Actually, the downward gust is doubly dangerous as compared with the rear gust, both on account of the dangerous absolute path of the machine and its critical incidence to the air when the gust is past. The downward gust accounts for the phenomenon observed in very disturbed air when the machine seems to be struck with such violence as to make a small wrench and pliers jump from the pilot's seat. To the downward gust, likewise, may be attributed many stalls that are ordinarily assumed to have arisen from other causes, and it has sometimes caused the smash of machines when they have been thrown bodily to the earth just after making a "getaway."

The danger of the *head gust* is due to the fact that its en-

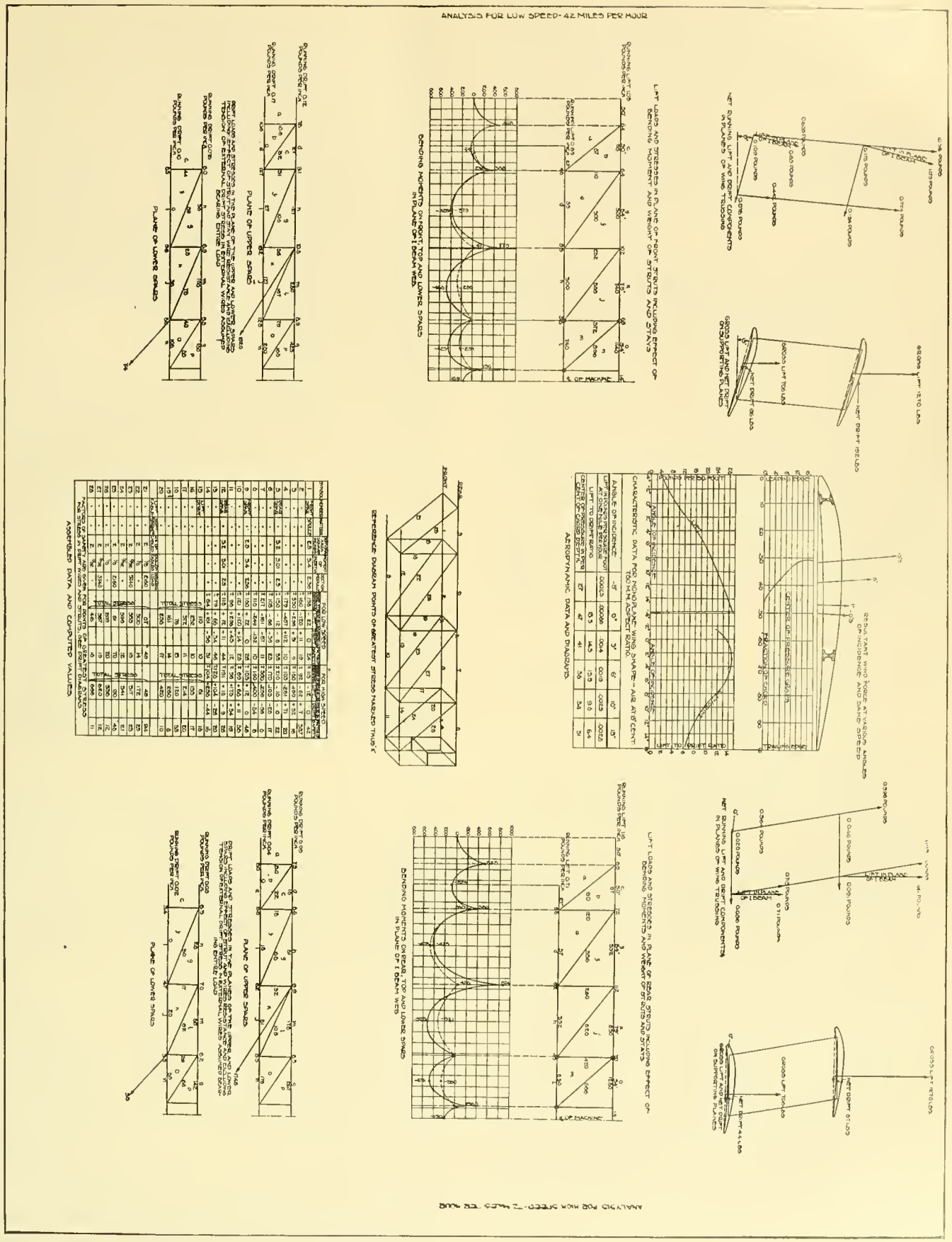


Fig. 1 A Complete Stress Analysis is Made of the Wing Framing of Each Type of Machine Made by the Curtiss Company

As shown in the above diagrams, the results are arranged on one sheet in convenient form, and consist of the following: 1. Shape of wing curve used, and its aeridynamic properties. 2. Diagram showing the lift and drift components in the planes of the wing trussing 3. Diagrams of the wing framing showing the lift and drift stresses. 4. Diagram showing the bending moments in the wing spars. 5. A summary giving the area, moment of inertia, section modulus, stresses and factor of safety of each member of the wing framing. 6. A reference diagram to accompany the summary.

counter momentarily increases the velocity of air under the lifting surfaces, thereby increasing the lift under the machine. The latter immediately starts to climb. When the gust is passed the machine, being pointed upward, retakes the undisturbed air at a larger angle than it can fly; hence a stall ensues.

Accidents due to ruptures of material have unquestionably been frequent, but a steady and rapid improvement in material is gradually reducing them. As regards ruptures due to propellers, the author calls attention to the fact that tractor-type military aeroplanes appear to suffer a good deal less than the pusher type.

There are many cases where ruptures of the gasoline tank have forced landings. Likewise several instances where backfires from the carburetor have caught in the drip from a gasoline leak and burned the machine completely. In one case the afterpart of the gasoline tank broke off bodily and struck the propeller.

The accidents due to the personnel are discussed in detail. Reviewing the whole situation, the writer comes to the following conclusion: "The developments of the last twelve months have left no doubt as to the naval advantage to be gained from the use of aircraft. The question now confronting us is not whether aircraft can accomplish their mission, but how soon and how well can the navy acquire their use. The seaplane is but a weapon, and, following the rule of weapons, it is dangerous to him who handles it without interest or without care. Ignorance, not unbelief, is our problem." (*United States Naval Institute Proceedings,* vol. 42, no. 164, p. 1117, July-August, 1916, 19 pp., 6 figs. *gtp.*)

Scientific Research in Aeroplane Construction at the Factory of the Curtiss Aeroplane and Motor Corporation

The Engineering Department of the Curtiss Aeroplane and Motor Corporation at Buffalo comprises over one hundred and fifty men and occupies a floor space of 30,000 sq. ft. in the factory, together with additional testing laboratories outside of the factory.

This department consists of four main divisions: First, the Motor Designing and Testing Department; second, the Aeroplane Designing Department; third, the Aeroplane Development Department; fourth, the Research and Test Department.

Some of the divisions of the last department are of particular interest. The mathematical division forms a very important part of it. Before commencing the working drawings of a new type of aeroplane, the Designing Department submits to the Mathematical Department the preliminary sketch of the proposed machine and secures an estimate of its efficiency and of the factors of safety of its various structural members. The working drawings are then made consistent with these estimates. As the design becomes more fully crystallized, the Mathematical Department makes a complete graphical analysis of the stresses and factors of safety in all the principal members of the aeroplane. It furthermore computes and presents in graphical form the air resistance of the proposed craft, the power required to drive it, the rate of climb, the range of speed and corresponding angles of incidence, the gliding angle, the conditions of stability, etc.

In the Structure Testing Laboratory, among other things, experiments are made to determine the mass distribution, strength and factor of safety of all the structural parts and of the assembled machine. For example, the moment of inertia of the entire machine loaded for flight is determined by suspending the machine from the ceiling of the laboratory and allowing it to vibrate about its three principal axes.

For determining the aerodynamical properties of full-scale aeroplanes and their structural parts, a special laboratory, 30 by 60 ft., has been set apart and provided with apparatus for generating a uniform current of air. A wind tunnel of the latest British pattern produces a uniform stream of air, 4 ft. sq. in section and 30 miles per hour in velocity. In this current various models are supported from the sheltered arm of a wind balance, which has its weighing beams outside the tunnel, and is adapted to measure accurately the lift of the model, the head resistance and the center of pressure at all different angles of incidence. The speed of the air is uniform to less than one per cent at all parts of the cross-section of the tunnel. The direction of the flow is parallel to the walls of the tunnel truly to a small fraction of a degree.

In developing a new type of propeller, a tentative draft is first made by the Propeller Division on a drawing board and subjected to mathematical analysis. From the given dimensions and speed of a propeller are calculated the thrust, torque and efficiency of each section of the blade, and from these results are computed the aggregate thrust, torque, thrust power, torque power and efficiency of the whole propeller. When these properties are finally made satisfactory, accurate scale drawings and blueprints are made and from these templates are constructed for use in the propeller factory.

Simultaneously, estimates are made of the structural strength of the blade and of the internal stresses due to centrifugal force and air pressure. From the resultant stresses within the blade, and from the predetermined tensile and compressive splitting strength of the wood the factor of speed of the blade is computed. In designing the sheet-metal propeller tips, the centrifugal force of each portion of the sheathing is computed and measurements are made of the resistance and strength of the rivets or nails which secure the metal to the wooden propeller tip.

An interesting section of the laboratory is the Photographic Studio. For many years the Curtiss Company has made and preserved photographs showing the development of all its important devices and constructions, and as far as possible the performance of its various types of aircraft. Experience has shown that many important details of structural development which have escaped the memory of the entire force at the factory are clearly disclosed in the photographs, both still and moving-picture. These photographs have, therefore, an engineering as well as commercial and historical value.

The Engine Testing Laboratory was planned on a very large scale. There are two large dynamometers, each of 300-h.p. rated capacity at from 1500 to 3500 r.p.m., and with standard overload rating. A feature of these dynamometers to which attention is called is the extension of both ends of the shaft instead of only one end as in former installations. The double end arrangement is claimed to be of advantage as it permits one engine to be set up and prepared for running while the test is in progress on another engine connected to the other end of the dynamometer shaft. The special test plates, engine support pedestals and gasoline support column are so arranged that all connections except the water inlet and outlet can be completed beforehand and moved up with the engine.

Fig. 1, showing a complete stress analysis of the wing framing, is here reproduced to demonstrate the thoroughness with which the engineering features are handled in modern aeroplane construction. (*Aerial Age Weekly,* vol. 3, no. 19, p. 562, July 24, 1916, 7 pp., 11 figs. *d.*)

Engineering Materials

Vulcanization Experiments on Plantation Para Rubber: The Cause of Variability and Some Contributing Factors, B. J. Eaton and J. Grantham

Continuation of the paper reported in The Journal (December, 1915, p. 725.)

Previous experiments have led the writers to the belief that the primary cause of variability in the rate of cure of plantation Para rubber lay in the accelerating action of a small quantity of some substance existing in the latex or produced subsequently in the raw rubber from some constituent present in the latex. The present series of experiments has, therefore, been directed to ascertain the nature of this substance and its behavior under different treatments. The writers have been able to isolate or prepare a substance or substances from the latex serum to which acceleration in rate of cure can be attributed, and have obtained evidence of the presence of a second substance which also has a similar effect. Hence it becomes possible, by adopting certain rigid methods of preparation of raw rubber, to obtain uniformity in rate of cure and also, if desired, to prepare various types of raw rubber having specific rates of cure.

Because of lack of space only a summary of this important investigation can be here reported.

1 The experiments and results contained in Part 1 of this paper show that one factor which causes variability in respect to rate of cure in plantation Para rubber is produced during the first six days after coagulation, and that the change which takes place in the coagulum is progressive during this period, while after this period no further change under ordinary conditions takes place.

2 The action of antiseptics, such as formalin, also heat and cold, are shown to inhibit this change, while soaking of the fresh coagulum in running water considerably retards the rate of cure.

3 The action of formalin is also shown to be partly though not to any great extent an action on the accelerating agent after its formation.

4 Experiments on the cold storage of freshly coagulated rubber show that while the change which produces rapidity of cure is inhibited as long as the coagulum remains in cold storage, if the rubber is removed again and allowed to remain, without machining, for a further period (13 days or possibly less) at ordinary atmospheric temperatures (about 85 deg. fahr. in the Federated Malay States), rapidity of cure is again brought about.

5 All the experiments in Part 1 suggest that the change which produces rapidity of cure in the rubber is caused by biological agencies, *i.e.*, micro-organisms entering the latex after collection and remaining in the coagulum, and that the change is probably a decomposition of the protein or nitrogenous substances present in the coagulum producing an accelerating agent which is a decomposition product of the proteins.

6 The experiments in Part 2 on the addition to slow-curing rubbers of various proteins and nitrogenous substances and their decomposition products, including the proteins from latex serum, decomposed by suitable methods after separation from the serum, confirm the conclusions arrived at from the experimental evidence contained in Part 1, and show that the original proteins have little or no effect under the conditions employed, while the decomposed proteins have a marked effect.

7 Experiments with undecomposed evaporated serum, after separation of the proteins coagulated by heat, suggest the presence of a second factor which accelerates the rate of cure, and due to some substance originally present in the latex.

8 In the case of our so-called "slab" rubbers possibly both factors are responsible for the acceleration in rate of cure, and it would appear that the second factor may be responsible for the actual superior tensile properties of the rubber; some evidence to this effect is contained in the comparatively poor quality of the rubbers to which the protein decomposition product has been added, in which the second factor has been removed, and also in the good quality in the case of the evaporated latex samples and the rubber to which the evaporated serum has been added. Further experiments are, however, necessary to confirm this.

9 Experiments with evaporated latex, which contains all the serum constituents and is dried sufficiently rapidly to prevent decomposition of the proteins, also confirm the presence of this second factor.

10 The nitrogen figures given in Part 3, still further confirm the decomposition theory, *i.e.*, the production of some substance from the protein which accelerates the rate of cure, the nitrogenous portion which becomes soluble in water and is removed on crepeing being non-essential. On the other hand, the high nitrogen content in rapidly curing rubbers produced by evaporation of the latex without decomposition of the protein, again confirms the evidence obtained as to a second factor which is probably of a non-nitrogenous nature.

11 These experiments and results also show why it has not been possible hitherto to connect the nitrogen content of a rubber with its rate of cure, since a rapidly curing rubber may have either a low or high nitrogen content, and indicate how previous workers have gone astray or not gone sufficiently far in their investigations in connection with the protein or nitrogenous constituents of latex and rubber.

12 Many other experiments on nearly 1000 samples of rubber which are not included in this present paper all confirm the above results and conclusions.

13 A further investigation is now being made as to the exact nature of the protein decomposition product which accelerates the rate of cure, and as to the nature of the second factor responsible for acceleration, together with the numerous subsidiary factors which influence rate of cure, a number of which have already been investigated.

Since this paper has been completed, the writers have found that the protein left in sheets of average thickness can be decomposed and so produce a more rapidly curing sheet rubber by simply rolling up the sheets after machining in order to retain a sufficient moisture content for the basterial decomposition, which demonstrates that the rapidity of cure of the so-called "slab" rubber is largely due to the decomposition of protein normally retained by the rubber even after rolling to sheet form. These results also show the importance of the rate of drying during early stages as a factor in the preparation of sheet rubber, in order to have a uniform rate of cure. (*Journal of the Society of Chemical Industry*, vol. 35, no. 13, p. 715, July 15, 1916, 14 pp., *etA*)

Tool-Steel Research

Abstract of an interim report presented by Mr. Dempster Smith on behalf of the Tool Research Committee of the Manchester Association of Engineers.

This Committee was appointed in 1914 to undertake tests in the heat treatment of tool steel to ascertain whether uniformity in results could be obtained in successive trials made under identical conditions.

The operations of the Committee included tests made to ascertain whether a tool that has failed in use is less serviceable after being simply reground, and if so whether heat treatment restores the tool to its original vitality. The report includes the opinion of several experts on the question of heat treatment and the possibility of obtaining uniform results, and deals with the effect due to carrying heat treatment to different stages, normalizing and tempering.

It was decided at the outset that only one grade of tool steel be used. The tools selected had a nose radius of 0.5 in., a cutting angle of 70 deg. in a plane at 45 deg. to the length of the tool, which is equivalent to a front and side top rake of 14.5 deg., and a clearance angle of 6 deg. The cutting speed was selected to be such as would give a 20-min. life to the tool when heat-treated according to the steelmaker's instructions. The heat treatment recommended by the maker was to raise the temperature slowly to about 800 deg. cent. and then quickly to 1275 deg.

For the cutting test the trials were made on a medium steel bar and without a lubricant. In all cases the test was continued until the tool failed. The results showed a slight improvement on rehardening tool No. 1 and the improvement in one case but not in another for tool No. 5. Tools Nos. 2 and 4 showed a decided deterioration on regrinding only after a failure. This result was contrary to expectations, it being generally understood that the performance of a tool improves after the first failure.

Another idea of which the credibility has been shaken by the present tests is that high-speed steel is injured by repeated heating to a high temperature such as that required for hardening (some engineers for this reason prefer to harden turning tools in the smith's hearth where the heat is concentrated at the nose of the tool). The result of these trials showed that two rehardenings do not appreciably impair the cutting quality of the steel.

Tools Nos. 2 and 4 were then normalized, reground, hardened and tested again. The normalizing process consisted in heating the tool slowly (about ten minutes) to a dull cherry red (800 deg. cent.), placing the tool in hot cinders, and allowing it to cool. The normalizing preceded the grinding and hardening processes. The results were in neither case equal to those obtained by these tools when new, and it could not be found generally that any benefit had accrued from normalizing. It was concluded that in the case of formed cutters which had been unequally strained in machining or in annealing, the normalizing process might tend to eliminate these strains, but it would hardly have any pronounced effect on a lathe tool which has not been cracked, and which has been carefully forged and not hammered after the temperature has fallen below a cherry red (*i.e.*, about 900 deg. cent.).

One other conclusion arrived at is that with freshly forged tools, hardened as stated and tested under identical conditions, it was possible to obtain results within 5 per cent of the mean and within an extreme difference of 9 per cent.

Among other things, the report contains advices from an authority on the heat treatment of tool steel.

As the methods of hardening adopted by experts show great variations as to furnace temperature and duration of treatment, the data collected in this report (not abstracted here) may be likewise of interest. (*The Foundry Trade Journal*, vol. 18, no. 175, p. 370, July, 1916, 2 pp. *eA.*)

Fungi which Grow on Untreated Ties or Untreated Wood, H. von Schrenk

Discussion of the Efficiency of Wood Treatment.

One of the conditions of wood treatment, which is often lost sight of, is that the material must be still in good condition before treatment and it is necessary to use the most rigid methods in handling such material before it is actually treated.

The only safe basis upon which one can rely in trying to tell the actual condition of wood is to saw off the ends of a considerable number of ties. A simple inspection of the back of a log does not tell anything.

Another important point in connection with the problem of the growth of fungi on treated wood is that for the prevention of this growth the entire piece must be treated. The author cites a case where beech ties 8 ft. long were treated. After treatment, these ties were sawed in the middle and used as tram ties. In other words, one end of each tram tie was the original treated end, and the other end was the part that had been sawed through and received no treatment. When inspected after about five years of service these so-called creosoted ties were found to have enormous bunches of fungi growing out at their ends. The significance of this lies in the fact that we have to deal with comparatively new points of view in treating industry, namely, the failure of the unprotected portion of the timber.

In treating paving blocks, it happens sometimes that the hardwood is thoroughly impregnated with black oil, while only a very small amount of oil gets into the sapwood. The author ascribes this not to the oil, but to the process under which the oil is injected into the block and the methods used to obtain such penetration. He believes that it is due probably entirely to the fact that the moisture contained in the sapwood prevents the proper penetration of this sapwood, while the hardwood, with a comparatively low moisture content, receives a very thorough impregnation. (*Loco*, vol. 7, no. 2, p. 122, August, 1916, 16 pp., 5 figs. *p.*)

Tests of Fire Retardents, with Special Reference to the Shingle Roof

Extracts from a bulletin by Herman and Arnold von Schrenk, comprising a report for the Engineering Bureau of the National Lumber Manufacturers' Association, Chicago.

Before beginning their investigation, the experimenters went over the numerous tests made in past years to demonstrate the efficiency of various compounds as fire-resisting materials. They found, however, that practically all of these tests have been made in an unscientific manner, and so did not permit the drawing of definite and reliable conclusions. Among other things, a point concerning which very little information of definite value is available was the permanence of fire-resistive wood, or the manner in which such wood resisted the action of wind and fire.

It was furthermore found that any discussion of the subject fell naturally into two divisions, one dealing with the problem as applied to building lumber and the other as applied to shingle roofs. The requirements for a successful fire-retardent were found to be very different for these two classes of use.

The apparatus used by the writers, and developed by the U. S. Forest Service, involved a furnace in which treated wood is tested under definite conditions identical for all the tests made. The tested sections are exposed at the same distance to a plate heated electrically to a constant temperature of 450

deg. cent. (832 deg. fahr.) The efficiency of the material tested was measured by the length of time it took, under the conditions described, to bring about ignition.

The conclusions so far reached indicate that several compounds are now available, which if properly applied will give a shingle roof a very high degree of fire resistance. These compounds have every guarantee of permanence. They are insoluble in water, and give a roof a pleasant appearance. The results indicate that there is every probability that a number of substances, not only practicable but fairly cheap, can with simple directions be applied by an ordinary house owner and give him a high degree of fire protection, whether on a roof or in a building. (*Railway Review*, vol. 50, no. 6, p. 192, August 5, 1916, 2 pp. *cp.*)

Strength and Other Properties of Concretes as Affected by the Materials and Methods of Preparation

R. J. Wig, G. M. Williams and E. R. Gates

Data of about 20,000 tests. Compressive and tensile tests were made upon mortars of different ages, including about 240 different sands and stone screenings, and compressive tests were made on concretes composed of 60 aggregates, including limestones, gravels, granites, cinders and trap rock, as well as tests of the physical properties of the sands, stone screenings and coarse aggregates. Only the conclusions of this important investigation can be reported here.

1 No standard of compressive strength can be assumed or guaranteed for concrete of any particular proportions made with any aggregate unless all the factors entering into its fabrication are controlled.

2 A concrete having a desired compressive strength is not necessarily guaranteed by a specification requiring only the use of certain types of materials in stated proportions. Only a fractional part of the desired strength may be obtained unless other factors are controlled.

3 The compressive strength of a concrete is just as much dependent upon other factors, such as careful workmanship and the use of the proper quantity of water in mixing the concrete, as it is upon the use of the proper quantity of cement.

4 The compressive strength of concrete may be reduced by the use of an excess of water in mixing to a fractional part of that which it should attain with the same materials. Too much emphasis cannot be placed upon the injurious effect of the use of excessive quantities of water in mixing concrete.

5 The compressive strength of concrete may be greatly redued if, after fabrication, it is exposed to the sun and wind or in any relatively dry atmosphere in which it loses its moisture rapidly, even though suitable materials were used and proper methods of fabrication employed.

6 The relative compressive strength of concretes to be obtained from any given materials can be determined only by an actual test of those materials combined in a concrete.

7 Contrary to general practice and opinion, the relative value of several fine aggregates to be used in concrete cannot be determined by testing them in mortar mixtures. They must be tested in the combined state with the coarse aggregate.

8 Contrary to general practice and opinion, the relative value of several coarse aggregates to be used in concrete cannot be determined by testing them with a given sand in one arbitrarily selected proportion. They should be tested in such combination with the fine aggregate as will give maximum density, assuming the same ratio of cement to total combined aggregate.

9 No type of aggregate such as granite, gravel or limestone can be said to be generally superior to all other types. There are good and poor aggregates of each type.

10 By proper attention to methods of fabrication and curing, aggregates which appear inferior and may be available at the site of the work may give as high compressive strength in concrete as the best selected materials brought from a distance, when the latter are carelessly or improperly used.

11 Density is a good measure of the relative compressive strength of several different mixtures of the same aggregates with the same proportion of cement to total aggregate. The mixture having the highest density need not necessarily have the maximum strength, but it will have a relatively high strength.

12 Two concretes having the same density but composed of different aggregates may have widely different compressive strength.

13 There is no definite relation between the gradation of the aggregates and the compressive strength of the concrete which is applicable to any considerable number of different aggregates.

14 The gradation curve for maximum compressive strength, which is usually the same as for the maximum density, differs for each aggregate.

15 With the relative volume of fine and coarse aggregate fixed, the compressive strength of a concrete increases directly, but not in a proportionate ratio as the cement content. An increase in the ratio of cement to total fine and coarse aggregates when the relative proportions of the latter are not fixed does not necessarily result in an increase in strength, but may give even a lower strength.

16 The compressive strength of concrete composed of given materials, combined in definite proportions and fabricated and exposed under given conditions, can be determined only by testing the concrete actually prepared and treated in the prescribed manner.

17 The results included in this paper would indicate that the compressive strength of most concretes, as commercially made, can be increased 25 to 100 per cent or more by employing rigid inspection which will insure proper methods of fabrication of the materials. (*Technologic Papers of the Bureau of Standards*, no. 58, June 20, 1916, 172 pp., 44 pp. *ex.*)

The Density and Thermal Expansion of American Petroleum Oils.

H. W. Bearce and E. L. Peffer

This paper gives an account of the experimental work on which are based the expansion tables of Circular No. 57, "United States Standard Tables for Petroleum Oils." It gives a detailed description of the methods and apparatus employed in the determination of the density and thermal expansion of petroleum oils from the various oil fields of the United States. (*Bureau of Standards, Technologic Paper* no. 77, preliminary abstract.)

Foundry

A Pre-Heated Blast Cupola, J. A. Parsons

Description of a cupola in which the blast is pre-heated.

The air blast, instead of getting into contact with the bed of the coke coals, is passed through a series of tubes in the top or chimney of the cupola, and reaches the coke bed at first

only slightly warm, and after a few minutes at a temperature that melts the lead, then at a temperature that burns zinc, and, after the blast has been on say twenty minutes, at approximately one-third of the total temperature required to be imparted to the iron.

With the device under description, it is not claimed that the evolution of carbon monoxide is altered, but that when it is burned into carbon dioxide in the top of the cupola the heat then evolved (10,220 B.t.u.) is to a large extent absorbed into the blast through the tubes instead of being allowed to waste.

Among other advantages it is claimed that the furnaces can be held up temporarily by diminishing the blast, notwithstanding which the balance of the blast comes in so hot that the melting time can be reduced in proportion and without holding down the furnace unduly. This allows for a greater flexibility of operation. (*Cassier's Engineering Monthly*, vol. 50, no. 1, p. 60. July, 1916, 3 pp., 1 fig.)

Casting 8-in. H. E. Shell Ingots and Forging the Rough Shells

Description of methods of casting and forging 8-in. shell blanks.

The requirements of shell specifications are quite strict, and to determine the quantity of the various materials so as to obtain certain results it is necessary to analyze first the scrap. In shell manufacture the bulk of the scrap has already been in the furnace for shell making, which makes it very much easier for the melter to calculate his charge.

In the plant to which the article mainly refers, in a 20-ton charge they use from 7000 to 7500 lb. of pig, 13,000 lb. of shell head scrap, 7600 lb. of plate scrap, and about 11,000 lb. of crop ends from the tops of the previous ingots. These, with the addition of iron ore, silicon and manganese, bring the total charge up to between 38,000 and 42,000 lb. Of the total charge of pig iron 75 per cent is placed in the furnace first, and as this begins to settle, the shell scrap, plate scrap and crop ends are added. When these have become partly melted, the remaining 25 per cent of pig is placed in the furnace. The time required to melt a charge of about 20 tons is from 4½ to 5 hr.; in addition, another hour or so elapses before the molten mass comes to a tapping condition.

When the heat is about ready, the tapping tests are made for carbon content by removing a small bar and breaking it. The trained eye of the melter tells him the amount of carbon by the exposed surface of the fracture. No chemical test is made of a charge until the metal has been poured into the molds.

The article describes in some detail the tapping and pouring of the molten metal. The tapping is done into a large ladle. The capacity of the 20-ton ladle will fill approximately 120 8-in. molds or 360 4.5-in. molds. In order to avoid any possibility of the metal freezing, it is advisable to have it very hot when working on the 4.5-in. ingots. As each ingot is poured the top surface is covered with floor sand to retain the heat and also to aid in the feeding of the metal as the billet solidifies. It requires about 10 or 20 minutes for the ingots to become solid.

When the crop ends of the ingots are cut off the billets are taken to another plant, where they are forged into the rough shell. The billets, 15 at a time, are placed in oil-burning Ferguson furnaces and are heated to about 2100 deg. fahr., this taking from 1¾ to 2 hr. When the billets are a little high in carbon they are allowed to soak a little longer, this slightly reducing the percentage of carbon.

A 350-ton Wood forging press has a capacity of approximately four hundred and fifty shells per day of 24 hr., and to maintain this production it requires the continuous operation of four 15-shell heating furnaces.

To insure satisfactory operation in forging the scale is removed from the surface of the heated billet by means of scrapers. This is not only necessary for the longer life of the dies but is essential to the uniform drawing of the shell, as the adherence of scale will often tend to produce a forging with eccentric walls.

Among other things, the article describes the preparation of the ladle and molds, ladle refitting and the operations of forging proper. (*Canadian Machinery*, vol. 16, no. 4, p. 81, July 27, 1916, 4 pp., 6 figs. *d.*)

Fuel

The Value of Peat Fuel, as Compared with Coal, for Production of Power, B. F. Haanel

Discussion of the subject of peat fuel manufacture and use, with special reference to the practice of a German plant.

The most important difficulty in the manufacture of peat fuel is the reduction of moisture to a permissible amount, which means a reduction from 90 per cent to about 25 per cent.

By a brief calculation the writer shows that this cannot be done by the application of artificial heat solely, because the quantity of heat required to reduce the moisture from 90 to 25 per cent is approximately 97,000 B.t.u., while the quantity of heat available in dry peat is only about 90,000 B.t.u.

By pressing in hydraulic presses the water content of the raw peat can be reduced to about 75 per cent, but a further reduction so far could not be effected economically because part of the water in the peat is held chemically. A larger amount, however, can be extracted by the so-called "wet-carbonizing process" of Ekenburg, but up to the present time this process has not proved to be commercially feasible.

The only process that appears at present to be commercially applicable is that dependent on the sun's heat and wind for the evaporation of the moisture. The conditions under which peat fuel in the opinion of the writer can compete with coal are principally the proximity of peat deposits to points of consumption and the high cost of coal owing to distance of coal mines from points of consumption. This applies to the production of power in gas producers without by-product recovery. When the latter is considered, new factors arise which may alter the comparative value of the two fuels.

Peat can be burned as efficiently as coal in properly designed steam generators. The principal disadvantages of peat fuel are its comparatively low heating value, larger volume occupied per heat unit, and the difficulty of handling and storing the requisite quantity of fuel for a period of operation. On the other hand, the amount of ash is small.

The only large steam-power plant designed for the exclusive use of peat fuel of which the writer has any details, is that of the Siemens-Schuckert Company on the Wiesmoor, in Ostfriesland, Germany. This plant is equipped with specially designed steam generators and steam turbines and has a capacity of over 5000 b.p. The steam generators are supplied with special grates with removable bars and large combustion chambers, similar to those of the Babcock & Wilcox boilers. With peat fuel costing $1.20 per ton, the price at which it is said the German Government sells the fuel to this company under contract, the steam plant is able to generate power more cheaply

than with coal including delivery costing $3.50 per ton.

Tests conducted at this plant showed that a thermal efficiency of 73.5 per cent could be realized for the steam generator; this is equivalent to an evaporation of 3.01 kilograms of water per kilo of peat, or 3.01 pounds of water per pound of peat. The average calorific value of the peat burned was 4.824 B.t.u. per pound, which, it might be remarked, is low compared with that determined for many of the Canadian peats so far examined. The moisture content of the peat fuel, of course, varies, but an effort is made to keep the average in the vicinity of 30 per cent.

The above results cannot be realized in every-day operation. Up to the time the plant was visited by the writer, it had been possible to attain a consumption of 2.4 to 2.8 kilos (5.28 to 6.16 pounds) per kilowatt-hour in rare and isolated cases. A consumption of 2.4 kilos (5.28 pounds) of peat has in fact been obtained. In wet weather the fuel consumption averages 3 kilos (6.6 pounds) per kilowatt-hour.

If the cost of peat per ton is taken as 5 marks ($1.20), a fuel consumption of 2.4 to 2.8 kilos (5.28 to 6.16 pounds) per kilowatt-hour would cost 0.3 to 0.35 cent per kilowatt, which at that place would be about the same price as when coal is burned.

From the foregoing it will be seen that peat fuel can be utilized in competition with coal for the production of power in steam plants, but only when the most rigid economies are introduced both in the manufacturing and handling of the peat fuel and in the conversion of its heat energy into useful work. (*Journal of the American Peat Society,* vol. 9, no. 2, p. 47, April, 1916, 15 pp., 5 figs. *dg.*)

Hydraulics

Cycloidal Curve Expressing the Law of Distribution of Velocities in Flow of Water in Pipes, M. Moignié

Discussion and experimental investigation of the distribution of velocities of flow of water in pipes, having for its purpose to prove that when water flows through pipes without the formation of eddies, the law of decrease of velocity from the center outwards may be conveniently expressed by a cycloidal curve.

The author refers the cycloidal curve to its axis and a line tangent to it at the apex.

Let $O\ y$ (Fig. 2) be the axis of a pipe of radius $B\ A = R$. Let us now plot the semi-cycloidal $O\ P\ A$ generated by the point P of the periphery of the circle of radius R/π rolling without friction along the radius $B\ A$.

When expressed as a function of the variable angle $P\ C\ E = \theta$ which the radius $C\ P$ makes with the axis $O\ y$, the coördinates of the point P may be written as:

$$X = \frac{R}{\pi}(\theta + \sin\theta)\,;\ y = \frac{R}{\pi}(1 - \cos\theta)$$

or they may be also expressed as follows: By multiplying all the ordinates by $\lambda\pi/R$, where λ is a numerical constant, we obtain the following parametric equations:

$$\begin{cases} x = \dfrac{R}{\pi}(\theta + \sin\theta) \\ y = \lambda\ (1 - \cos\theta) \end{cases}$$

which express a cycloidal curve.

In order that the last named equations express the law of decrease of velocities, it is sufficient to substitute

$$x = r, \qquad y = \frac{V - v}{U\sqrt{b}}$$

A curve proposed to express the distribution of the velocities will therefore finally be represented by the following equations:

$$\begin{cases} \dfrac{V - v}{U\sqrt{b}} = \lambda\ (1 - \cos\theta) \\ \dfrac{r}{R} = \theta + \sin\theta \end{cases}$$

where λ is a numerical coefficient which has to be determined experimentally.

The author describes then the experiments of Bazin, published in 1897, from the data of which he obtains the experimental values of $(V - v)/U$, which he expresses in the form of tables and curves. The curves are of interest in that they (there are six) form two clearly distinct groups, some of which are remarkable because of their slower decrease of velocities with the approach to the center of the tube. The author points out that this could have been foreseen because after the contraction which exists at the entrance to the tube, the relative velocities do not immediately attain the values which they attain later when a uniform flow is established. Moreover, twenty-five diameters, which was the distance from the entrance of the tube to the point at which the first series of measurements was taken, is not sufficient to eliminate the initial disturbance of flow.

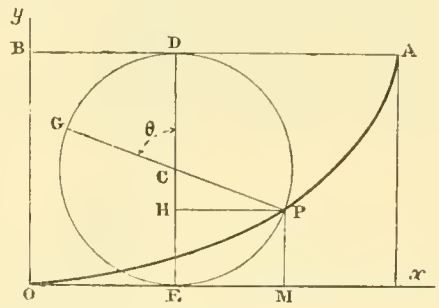


Fig. 2 Semi-Cycloidal Curve Illustrating the Law of Distribution of Velocities in the Flow of Water in Pipes

From the expression for the cycloidal curve, the author derives expressions for the mean velocity of flow. He finds values of V/U to vary from 1.1627 to 1.1667 and finds, therefore, that the value of $V/U = 1.1667$ derived from Boussinesq's formula represents very exactly the average of the experimental values obtained at one of the sections of the pipe.

The writer finally compares the ratios of maximum and minimum velocities to the mean velocity and finds for them the expressions

$$V/U = 1 + 8.93\sqrt{b},\ w/U = 1 - 14.27\sqrt{b},$$

as precise as the values obtained from the formula of Bazin and Boussinesq.

Notation:

V = velocity of the central water thread
v = velocity of a water thread at a distance r from the center of the tube
R = radius of the tube
J = gradient
U = average velocity
$b = RJ/U^2$

(*Courbe Cycloidale de Distribution des Vitesses dans les*

Tuyaux, M. Moignié, *Annales des Ponts et Chaussées*, Partie Technique, vol. 6, Tome 30, p. 303, November-December, 1915, 23 pp., 4 figs. *t.*)

Machine Parts

Anti-Friction Bearings in Axle Generator Service, J. R. Sloan

Discussion of anti-friction bearings from the point of view of maintenance cost of axle generator service in railway lighting equipment. Proper belt operation is a somewhat difficult matter with any type of generator; particularly with the truck mounted type the high initial belt tension necessary to prevent belt slipping is often applied by careless inspectors far in excess of the amount actually required, and causes very severe loads for the pulley end bearings. This, together with the stresses due to vibrations and irregularities of road, were the chief causes of the excessively high generator maintenance cost, in 1911 and 1912 as compared with what they are now. The net generator cost per car per month was in 1911, $23.30; in 1912, $24.12 and in 1914 and 1915 respectively, $10.22 and $10.86 which reduction of cost was due practically entirely to the rather extensive application of anti-friction bearings.

Of the total, 734, there have been but 4 ball bearing failures reported or approximately ½ of 1 per cent per annum which is an extremely good showing in comparison with the frequent failures of plain bearings. In no case, however, were the armature or field coils damaged, a frequent occurrence when sleeve bearings failed and let the armature down on the pole pieces. (*Railway Electrical Engineer*, vol. 7, no. 14, p. 409, July 1916, 1 p., 1 fig., *cp.*)

Application of Anti-Friction Bearings, T. V. Buckwalter

Description of the installation of ball bearings on baggage trucks of a light weight design and on trucks for creosoting plants.

The baggage trucks are equipped with Timken bearings on all four wheels, the bearings being mounted to take thrust in all directions and to take the load equally. The bearings have a rating at constant normal loading of 625 lb. each and carry 545 lb. per bearing, or 87 per cent of the normal constant loading; in addition to this load due to weight, there is some thrust load taken by these bearings due to road shocks and curving but these thrust loads are considered negligible. There are no reports of failures of any of the bearings on this type of truck.

The next type described are trucks for creosoting plants. These trucks must be moved by hand with a load approximating five tons for short distances which makes the use of plain bearings inadvisable.

These trucks are made in two general types, namely tie trucks with four wheels and integral bolsters and timber trucks with four wheels and swinging bolsters, the latter to facilitate the loading of long timbers.

The bearings are of the Hyatt flexible roller type adapted to take radial load only. The thrust on the timber treating trucks, which is considerable, is taken directly on the hubs of the wheels on plain surfaces formed on the bearing housing. These bearings are loaded up to 50 per cent above their normal capacity and in the five years they have been in service (a total of 200 trucks) there are no reported failures.

No provision was made to lubricate the bearings on these trucks. The only lubrication they receive is the immersion in creosote at each treatment of their load of timber or ties. (*Railway Electrical Engineer*, vol. 7, no. 14, p. 418, July 1916, 2 pp., 5 figs. *d.*)

Anti-Friction Bearings in Car Lighting Generators

Three letters from H. C. Meloy, Engineer of Electrical Appliances on N. Y. C. Lines, West, E. C. McNab, Car Lighting Engineer of the Canadian Pacific and A. E. Voigt, Assistant Electrical Engineer, Santa Fe. All reported in favor of ball bearings as compared with sleeve bearings. The last named letter reports comparative statistical data on ball and sleeve bearing failures, with results likewise in favor of ball bearings. (*Railway Electrical Engineer*, vol. 7, no. 14, p. 408, July 1916, 1 p., *ps.*)

Machine Shop

Aluminum Welding, Harry B. Hoover

The process of welding aluminum is somewhat difficult to learn but it can be applied to work which would be difficult to repair by any other means. The writer describes a method which after several years of successful experience he found to be the most practical.

Some of the most difficult things to contend with in aluminum welding are the rapid oxidation of the metal, the low fusion point, rapid conduction of heat, contraction and expansion, shrinkage, and in some cases warping which makes it difficult to keep the work in perfect alignment.

As regards oxidation, the writer points out that any fluxes used must be chemically active and then one has to reckon with the after-effects of the flux which sometimes do not develop until some time after. It is therefore important that the work be thoroughly brushed in boiling water to remove remnants of the flux and prevent chemical action after the welding has been done. At times the use of flux is exceptionally difficult. It is, however, necessary in sheet aluminum work.

For practical purposes the puddling system is by far the best. This is done by the use of a paddle made from a small steel rod flattened at one end like a flat screwdriver and ground or filed off smooth, the edges being left sharp. As aluminum, unlike some other metals, does not change color when it becomes hot it is necessary to watch it very closely during the process of welding and at the time when the edges begin to fuse the paddle is used to puddle them together.

The contraction and expansion of aluminum are greater than of any other metal and if they are not properly taken care of a case which is being welded will warp or shrink out of alignment to such an extent that it is entirely useless. The shrinkage and warping may be taken care of to a certain extent by proper preheating say by a preheating torch. The author describes in detail several cases of typical welding. (*Machinery*, vol. 22, no. 12, p. 1032, August 1916, 4 pp., 5 figs. *dp.*)

Drawing Metal by Hydraulic Method, G. R. Smith

The principal difficulty encountered in drawing metal over dies in heavy presses is the tendency for the metal to fail at certain points where excessive stresses are produced by the stretching action of the dies. This makes it necessary to use only sheet metal of high tensile strength, which adds to the cost of production.

The present article describes a method of hydraulic shell-drawing which is claimed to overcome this difficulty. Two blanks are clamped at the edges between two dies. When hydraulic pressure is applied between them, the blanks are forced outward to the contour of the dies. Since the metal is

only held at its outer edge, practically the entire area is subject to stretch. Thus the stresses are distributed evenly and excessive local strains are eliminated.

It is claimed that the initial cost of the hydraulic equipment for the presses is low, while the cost of maintenance is very materially reduced through the fact that dies are not subject to the heavy wear imposed by impact as in the usual type of presses. (*The Iron Trade Review,* vol. 59, no. 5, p. 213, August 3, 1916, 1 p., 2 figs. *d.*)

Hydraulic System in Modern Shell Plant, F. L. Prentiss

Description of the pumping equipment and other features in the new shop of the Hydraulic Press Steel Co. of Cleveland, O.

The plant has been built mainly to take care of orders for shell forging, but has been laid out with the view of converting it to other hydraulic press work as soon as the demand for shell forgings ceases. The shell plant is equipped with six units, each consisting of a piercing and drawing press, and its capacity is for a daily output of 15,000 3-in. shrapnel forgings.

The pumps are located in a row along one side of the pump house. One attendant and two oilers are able to take care of the entire pumping equipment.

Overhead piping is eliminated by having the water supply lines run from the header through the shop in tunnels. The water is carried from the high-pressure header through a 10-in. main pressure line, from which 8-in. branch lines are carried through the shop, each branch line serving three units and each unit consisting of a piercing and drawing press. One main shut-off valve is provided on the 10-in. line, and there is another valve for each press with an 8-in. line. This small line is provided with a shock valve which acts as an equalizer, and a three-way operating valve. The shock valve takes the place of the usual overflow chamber and has the advantage of taking less space than is required for the latter.

Among other things an equalizing device is being provided to insure the equal travel of all accumulators, giving a high-pressure water capacity of 1500 gal. per minute. The maximum intensified pressure used in the plant is 6000 lb. per square foot.

Specially designed tool boxes are provided for tools used in changing the tools in the presses. These boxes have three drawers each. The plant operates at three 8 hr. turns and a tool box is provided for each press, each of the foremen having a separate set of tools which he keeps under lock in one of the drawers. In this way the man in charge of the press gang is responsible for his own tools, and the trouble of having tools lost or mislaid when handled by separate sets of men is eliminated. (The *Iron Age,* vol. 98, no. 5, p. 231, August 3, 1916, 4 pp., 4 figs. *d.*)

Production, Properties and Use of Thermalene

Thermalene is a new gas which may be used for welding, heating, lighting and other purposes. It is a combination produced by the decomposition of calcium carbide and hydrocarbon oils, the heat generated by the carbide being used to vaporize the oil. It is a discovery of K. F. L. Wolf, of Zurich, Switzerland.

The article describes the method of producing the gas. The physical properties of the gas are different from those of either oil gas or acetylene. Its density is 1.1, taking air as unity. Its specific heat is a little over one-eighth that of acetylene. Thermalene liquifies at a pressure of between 1400 and 1500 lb. per sq. in. at room temperatures, and in its liquid state is not explosive. The maximum flame temperature has been found to be about 6500 degrees. It does not explode as readily as acetylene and so can be mixed with greater proportions of air. The upper and lower explosive limits are 12 per cent and 30 per cent.

When used for welding thermalene does not require an excess of oxygen, and for this reason does not absorb carbon from the iron. The flame, therefore, produces a soft weld, especially in cast iron. When welding with it less sparks are thrown off than when using acetylene. It can be also used at a lower pressure, owing to its higher specific gravity.

The torches used were also designed by K. F. L. Wolf, and under all sorts of tests showed no tendency to flash back. The construction of these torches is shown in detail in Fig 3. The oxygen nozzle is at *C*. Screens are placed at *D*. No flashback into the oxygen nozzle can occur in this type of torch. The gas chamber is comparatively large, while the orifice leading from the gas chamber to the mixing chamber is restricted and elongated. This orifice is enlarged abruptly to the mixing chamber in the nozzle, so as to form sharp corners at *E*. The mixing chamber gradually contracts to the outer opening in the nozzle. As a result, if flashback should occur it will

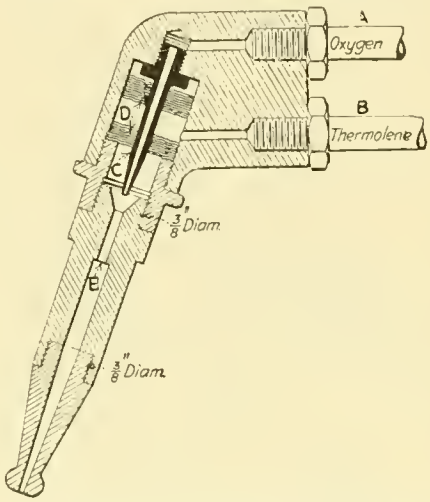


Fig. 3 Wolf Torch for Use with Thermalene Gas

cause an eddy at *E*, which in itself will prevent the flame from running back through the restricted channel; moreover, such propagation of the flame into the mixing chamber will cause the gas in the chamber to be pressed back by the increased expansion and pressure, so that there will be only burnt gas in the restricted channel and around the oxygen tip. Further, the pure oxygen discharged from the nozzle of *C* will cool off and blow out the flame. The result is that the flame will die out in the restricted channel between the gas and mixing chambers, so that a cutting flame is never formed at the oxygen nozzle. It is necessary, however, that these torches should be properly proportioned to obtain the desired results.

Table 1 gives a good idea of the amount of thermalene and oxygen used per hour for different thicknesses of metal, the torch being fitted with the proper nozzle in each case. (*American Machinist,* vol. 45, no. 6, p. 221, August 10, 1916, 5 pp., 10 figs. *d.*)

Methods Used in Machining an Aeroplane Cylinder, Robert Mawson

Description of tools and methods used in machining the cylinders for the eight- and twelve-cylinder Ashmusen aero-

TABLE 1 TABLE OF QUANTITIES OF THERMALENE AND OXYGEN USED PER HOUR IN WELDING OPERATIONS

Tip No.	Thickness of Metal in Inches	Consumption of Thermalene, Cu. Ft.	Consumption of Oxygen with Thermalene, Cu. Ft.	Oxygen Pressure, with Thermalene, Lb. per Sq. In.
1	1/64 to 1/16	2.15	2.55	1.0
2	1/16 to 3/32	3.32	3.99	2½ to 3
3	3/32 to 1/8	5.51	6.52	3 to 3½
4	1/8 to 3/16	8.29	10.11	3½ to 4½
5	3/16 to 5/16	11.78	14.21	5 to 5½
6	5/16 to 7/16	16.48	20.10	6½ to 7½
7	7/16 to 5/8	21.40	27.51	10 to 11
8	5/8 to 3/4	25.00	35.01	11 to 12
9	3/4 to 7/8	33.60	54.21	15
10	7/8 to 1¼	48.05	75.30	20 to 22
11	1¼ to 1⅝	70.35	101.62	25 to 28
12	1⅝ to 2	91.10	159.20	25 to 30

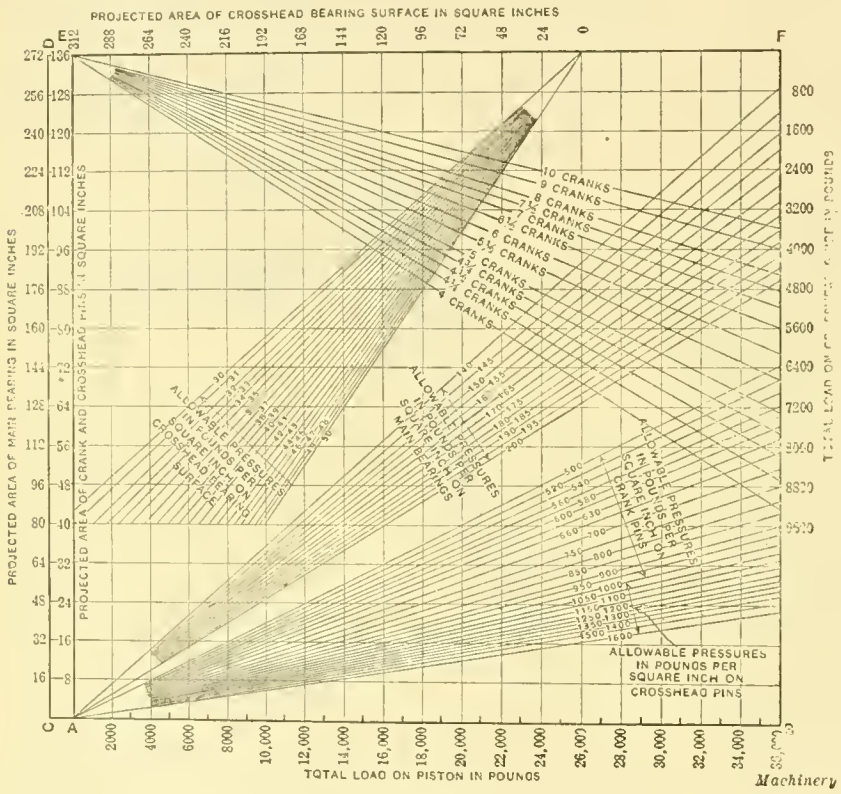


Fig. 4 Chart for Use in Rapidly Determining Loads on Important Engine Frame Members

plane engines made by the Ashmusen Manufacturing Company, Providence, R. I.

The article briefly describes and illustrates the tools used, and also the main operations, step by step. (*American Machinist,* vol. 45, no. 6, p. 230, August 10, 1916, 2 pp., 6 figs. and one plate. *d.*)

Purely-Hydraulic and Steam-Hydraulic Forging of Steel Compared, A. Myslin

The paper compares the purely hydraulic process of forging with the steam-hydraulic from the point of view of consumption of power per unit of weight of output. The investigation is based on the working of a steam-hydraulic forging press at the Upper Toorin works in northeastern Russia.

The author had before him a purely hydraulic press of 90 tons capacity, working with an accumulator and forging sheet plates with an output of about 17 tons daily.

The steam-hydraulic press has a capacity of 5000 tons and is used for forging 6-in. trotyl shells from ½-ton cropped steel ingots. This press has a daily output of about 35 tons.

Sometime near the beginning of the year 1914 a thorough stop-watch study of movements was made at the plant as a preliminary to the introduction of the Taylor system of shop management. At that time the following table was obtained covering the forging of one 50-pood (1 pood = 36 lb.) ingot having after cropping a weight of 35 poods. This ingot is forged into a 6-in. billet having a section of the shape of an octagon inscribed into a circle of 167 mm. (6.57 in.).

Time Necessary for Forging	*Minutes*
1. Withdrawing ingot from furnace, conveying it to the press and locating it in the correct position for forging	1.5
2. Time required for the forging of the ingot	10.75
3. Time required for straightening	3.5
4. Time consumed in the interruption between the end of the forging of one ingot and the beginning of the withdrawing from the furnace of the next one (during this time some of the men are occupied in taking the ingot out from the press for conveying it to the sand bath)	1.5
5. Time lost by the men in changing the hammer heads and falls and tightening them up (average per forging)	5
6. Time lost by the men because of trouble with the cranes (average per forging)	0.5
Total time necessary for forging one ingot under normal conditions	22.75

At present the works have reached the stage of forging 21 ingots in an eight-hour shift.

The article gives a detailed account of the steam consumption for the forging. (*Sravneniye rabot kovki chistahydravlicheskava kovochnava, v smysle raskhoda energiyi na pood godnava prodookta i raboty parohydravlicheskikh pressov i detalnoye izlsedavaniye kovki parohydravlicheskava pressa Verkhne-Toorinskava Zavoda v svyazi s raskhodom paravoy energiyi i opredeleniye poslednyava roskhoda,* Uralskiy Tekhnic, *Uralian Engineer,* in Russian, vol. 10, no. 4-5, p. 70, April-May, 1916, 8 pp., 1 plate of drawings. *ep.*)

Mechanics

Chart for Determining Engine Frame Loads, Ernest A. Andrews

The chart shown in Fig. 4 is for finding the loads on the following members of an engine: (1) main bearings; (2) crank pins and crosshead pins; (3) crosshead guides. The horizontal line AB represents various values of the total load

on the piston in pounds; the vertical line CD indicates the projected area of the main bearings in square inches; and the horizontal line EF shows the projected area of the crosshead bearing surface in square inches.

To determine the proper area for the crosshead bearing surface it is necessary to know the ratio of the length of the connecting rod to the radius of the crank circle.

The total load on the crosshead guide is represented on line BF at the right hand margin of the chart and is found by moving across the chart to the right from the point of intersection of the piston load line and the radial line representing the ratio of connecting length to crank radius. (*Machinery,* vol. 22, no. 12, p. 1056, August 1916, 1 p., 1 fig. *d.*)

Accelerating Characteristics of Centrifugal Pumps and Fans, B. W. Jones

The author emphasizes how the different load characteristics affect the amount of control apparatus necessary in the case of centrifugal pumps and fans driven by electric motors.

The external conditions under which the pump may be worked may be represented by two extreme cases. First, the pump may be discharging against a very low static or actual head, the friction head being the principal factor. A pump used for dredging is a very good example of this condition. Here the pump starts discharging at a very low speed and the speed torque requirements of the driving motor are shown in Fig. 5, curve A. This is the worst starting condition and requires the largest amount of control apparatus to keep the starting current peaks below a required amount. The second extreme case to be considered is that of a pump discharging against a very high static or actual head, the friction head being the minor factor. A good example of this condition is a centrifugal pump used for pumping water out of a deep mine where the lift is several hundred feet. A check valve or a foot valve is placed in the pipe line and this is seated when the pump is at rest. The motor speed at which this valve will open depends upon whether the pump has a flat or a steep characteristic curve. If this valve or the discharge opening be kept closed, then the speed-torque characteristic of the driving motor during starting is shown in Fig. 5, curve B.

What has been said of centrifugal pumps starting up under various external conditions holds true with proper variations for centrifugal fans. Hence it is not sufficient information for the industrial control engineer to know that the motor is to start a centrifugal pump or fan. The conditions under which they will accelerate should also be known. Without this information it is necessary to design the control equipment to meet the worst conditions whereas if the necessary details were known the equipment might be made to accelerate under the most favorable conditions. (*General Electric Review,* vol. 19, no. 8, p. 703, August 1916, 3 pp., 4 figs. *p.*)

Mechanics of Materials

On Two Fundamental Problems in the Theory of Elasticity, C. E. Weatherburn

The writer shows how the theory of vector integral equations which was presented by him some time ago in the Transactions of the Cambridge Philosophical Society, may be directly applied to the solution of the fundamental problems of elastic equilibrium requiring the determination of the displacement at any point of an elastic body when the value of the surface displacement or that of the surface traction is known.

The author generalizes the problem by the introduction of a special parameter. Then by the use of vector analysis he constructs, from Somigliana's integrals of the equations of equilibrium, dyadics which form the basis of displacement functions whose properties exactly resemble those of ordinary simple and double stratum potentials. Corresponding theorems are established concerning the magnitude and the reality of the singular parameter values. The treatment of the fundamental problems in elasticity is thus recast.

The author derives in this way vector equations with dyadic kernels and dyadic resolvents and shows that the kernel does not become infinite of too high an order to be treated by the methods of vector integral equations. (*The London, Edinburgh and Dublin Philosophical Magazine,* vol. 32, no. 187, p. 15, July, 1916, 24 pp., *tm*)

Efficiency of Unsymmetrical Riveted Joints, R. N. Blackburn

Discussion of the strength of riveted joints, particularly those not symmetrical in form. Exception is taken to the rule

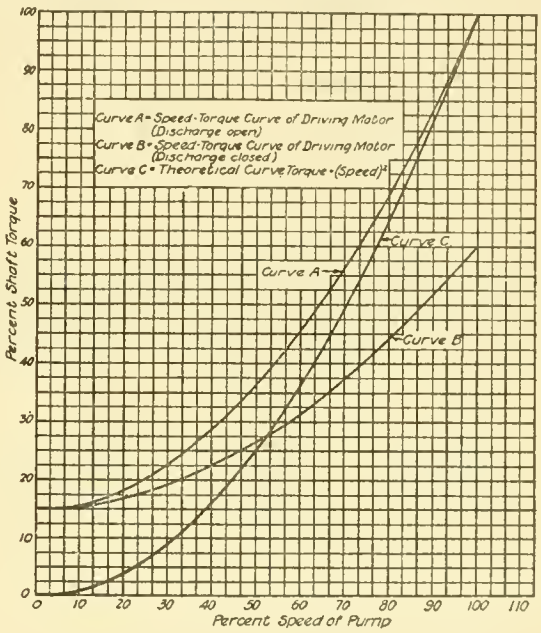


Fig. 5 Pump Characteristic Curves

for such a joint, contained in the Boiler Code of the American Society of Mechanical Engineers. In the Code, examples are given of riveted joints having apparent efficiency of from 57.6 to 96.3 per cent. The writer believes that it is doubtful whether so high an efficiency as the latter figure is ever obtained, and that the actual efficiency of the joint will be less than the calculated efficiency. The apparent efficiency is calculated by certain formulæ usually based on certain assumptions that are not strictly proved. It is assumed, for example: First, that the total load is uniformly distributed over the rivets; second, that the stress in the shell plate along a line of rivet holes parallel to the joint is uniformly distributed over the net section of the plate; third, that no bending stresses are produced in the plate by the pull on the joint due to the internal pressure in the boiler.

The first assumption is seldom true, the second one never true and the third can only be true for symmetrical joints, such as butt joints with straps of equal width and with all the rivets in double shear.

In an example cited, the writer shows that if the nominal

efficiency of the rivet section, based on the assumption that the load is equally distributed over the rivets, is say 70 per cent of the strength of the solid plate, the actual efficiency is only 52.5 per cent. Further, the relative thickness of the butt strap to that of the plate materially affects the efficiency of the joint, a factor not usually taken into account in rules for calculating the efficiency of riveted joints.

A simple experiment will show the untruth of the second condition assumed in formulae for the efficiency of the riveted joints, namely, that the stress is uniformly distributed over the net section of the plate. If a narrow strip of elastic rubber be secured to a board by a nail near the end of the strip, a pencil line having previously been drawn across the rubber as shown in Fig. A, and if the strip be then pulled in the direction of the arrow, the pencil line will assume a position shown by the dotted line, clearly showing that the stress is much greater near the nail than at the outer edges of the rubber strip. Owing to the greater flexibility of rubber as compared with steel, the stress appears more concentrated near the nail than it would be in a boiler plate, but there is no essential difference in the two cases.

The writer believes that the stress in a boiler plate around

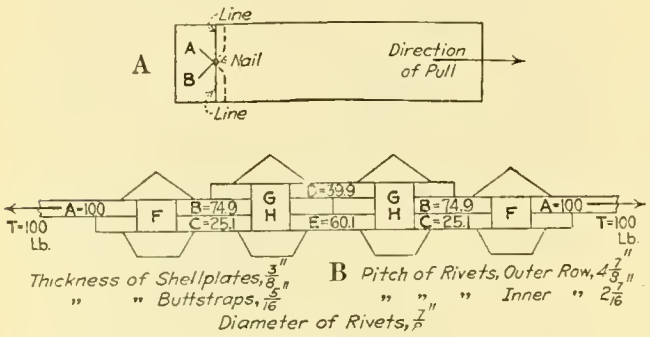


Fig. 6 A, Experiment with Rubber Strip and Nail to Show that Stress is not Uniformly Distributed over Net Section of Plate; B, India-Rubber Model of a Riveted Joint

(Numbers denote percentage of load carried by respective parts of joint.)

the riveted hole is so distributed that the stress at any point in a line drawn at right angles to the direction of the pull in the plate through the center of the rivet hole varies inversely as the distance of the point from the center of the rivet.

The author calls attention to the magnitude of the bending stresses produced in an unsymmetrical joint. In fact, he believes that the bending action is of more importance than the direct stress due to the pull on the plate. Other considerations affecting the strength of riveted joints are the bending stress produced by the load of the rivets and sometimes also tensile stresses. From this the writer comes to the conclusion that the nominal efficiency of riveted joints bears no exact relation to their real efficiency. He considers that the use of lap-riveted joints for large boilers is quite properly prohibited by The American Society of Mechanical Engineers, but as regards butt joints with inner and outer straps of equal width, he expresses a regret that the four examples of butt joints given in the Code to illustrate the method of calculating the efficiency of riveted joints are all unsymmetrical joints in which severe bending stresses are produced.

It occurred to the writer that a fairly correct estimate of the stresses in a riveted joint of this type could be obtained by measuring the elongation under stress of the several parts of an india-rubber model of the joint. From the measurement thus taken, the stress on each part of the joint can be readily calculated, and its efficiency determined. Several tests were made and the main results obtained are shown in Fig. B. The numbers in the sketch denote the percentage of the total load carried by the respective parts of the joint. A proposed method of estimating the stress is submitted.

The importance of this discussion lies in the fact emphasized by the writer, that unless some distinction is made between the two classes of joints, manufacturers will naturally adopt the type having the higher nominal efficiency, in spite of the fact that such efficiency is largely imaginary; and the unsymmetrical butt joint will thus become the standard used in preference to the more efficient symmetrical butt joint. (*Power*, vol. 44, no. 6, p. 203, August 8, 1916, 4 pp., 5 figs. *tc.*)

Investigation of Plastic Flow Phenomena, W. Trinks

The paper points out the similarity between the plastic flow of clay and that of steel, based mainly on tests described in Scientific Paper No. 278 of U. S. Bureau of Standards (E. C. Bingham).

The tests referred to in this paper were made with clay as a plastic material. Of particular interest to the steel man is the experimental determination of the relation between shearing stress and velocity of deformation. It was found that a certain minimum pressure is required to start deformation, and that velocity of deformation is proportional to the difference between actual pressure and said minimum pressure, the relation being apparently strictly linear. (*Blast Furnace and Steel Plant*, vol. 50, no. 8, p. 362, August 1916, 2 pp., 2 figs. *e.*)

Power Generation

The Economical Production of Power from Coke-Oven Gas, G. Dearle

Discussion of the general subject of coke-oven gas engines and description of a plant operated under the supervision of the author.

This installation consists of 300 to 500 b.h.p. vertical tandem gas engines, direct-coupled to 3-phase alternators generating current at a pressure of 440 volts and a frequency of 50 cycles per second.

The gas engines are of the single-acting type, 4-stroke cycle, the cylinders being so arranged that the suction stroke of one cylinder is the explosion stroke of the other cylinders on the same line. By this arrangement each crank receives one impulse per revolution, each down-stroke being a working impulse of either the upper or the lower cylinders. On the upstroke the inertia of the moving parts is absorbed by the compression of either the top or the bottom cylinder, and part of the inertia is absorbed on the downward stroke by the buffer cylinder formed under the upper piston.

By means of this arrangement the connecting rod is always in compression, and little or no strain is thrown upon the connecting rod bolts. This is an important feature, as, according to the reports of the various insurance companies, more breakdowns to engines are caused by the failure of these bolts than by any other cause.

There are eight cylinders on each engine, the upper four having a diameter of 16.5 in. and the lower ones 15.5 in., with a stroke of 16 in. The speed is 300 r.p.m. and the full load is 500 b.h.p. The object of making the upper cylinders 1 in.

larger than the lower ones is so that the whole line of pistons may be removed together; by this arrangement the dismantling of the engine for cleaning purposes becomes very simple.

The gas supplied is obtained from a battery of 110 Otto ovens; 60 of these are waste-heat and 50 are of the regenerating type. From the former about 15 per cent of the total gas is available and from the latter about 40 per cent. The average gas pressure is approximately 10 in.

The writer emphasizes the great importance of the further purification of the gas after it leaves the by-product plant. When the gas leaves the benzole scrubbers it contains about 900 grains of sulphuretted hydrogen in every 100 cu. ft. If this sulphuretted hydrogen were allowed to go through the engines, a considerable amount of trouble would be experienced. The moisture in the exhaust gases condenses as the engine cools down, and there immediately forms sulphuric acid which, in its turn, would attack the inside of the cylinders and the exhaust valves.

A further effect is that the presence of sulphur causes a certain amount of pre-ignition of the charge during the compression stroke. A possible reason for this is that the presence of a small portion of the sulphuretted hydrogen acts as an igniter, it being more liable than the rest of the gas to spontaneous combustion under compression.

The gas is therefore purified by oxide of iron in a set of four purifiers of the Wilbourne type, each 20 ft. square by 5 ft. deep. The boxes hold about 30 tons of oxide in two tiers of ordinary grids. These boxes are worked on what is known as the "backward rotation" principle. Air to the extent of 2½ or 3 per cent is drawn in at the exhauster, and this air supply plays a very important part in the re-vivifying of the oxide in the purifiers; prior to the introduction of this air the oxide in the purifiers was changed at the rate of one box for every four weeks. After the introduction of the air, the period between the changes was extended from four weeks to four months. The total sulphur contained in the gas after passing the purifiers is less than 50 grains per 100 cu. ft., and the further advantage of the purifiers is that they eliminate absolutely the last traces of any tar which may be left in the gas after passing the benzole scrubbers.

During the initial running of the plant, some trouble was experienced due to the difficulty of obtaining satisfactory mixing of the gas and air. The usual method has been to dilute the mixture with a certain amount of exhaust gas. The writer considered this method somewhat inefficient and resorted to the following expedient:

The main gas pipe to each engine was reduced for a distance of about 10 ft. to an internal diameter of 2½ in., and on reaching the engine was led into the mixing chamber for a distance of about 6 in. Entering the mixing chamber at right angles to this pipe, and about 3 in. above its end, was an auxiliary air supply controlled by a diaphragm governor. The gas admitted through the mixing chamber was then diluted by a certain quantity of air. A further air supply, controlled by a hand lever from the driving platform, was led direct into the chamber of the governor valve where the diluted gas and air met. After passing through the chamber of the governor valve the mixture was given a rotatory motion by means of a set of vanes, and was also very thoroughly mixed by being passed through a set of perforated plates. With this device over-heating or pre-ignition were eliminated and the engines could be run up to and above their rated capacity without trouble.

During March, 1914, a maximum of 15 million cu. ft. was used. During that period the author had been unable to pay the necessary attention to the question of gas consumption. The matter was then taken up and by regular analyses of the exhaust gases combined with instructions to the drivers to drive by the pressure gage, the gas consumption was reduced to 12½ million cu. ft. at the end of May, and was still further reduced later on, the load remaining approximately the same. The present consumption is approximately 39 cu. ft. per kw.-hour. For the most tried part of a gas engine of the type described, the exhaust valve, nickel steel was found to be the best material. (*The Journal of the Institution of Electrical Engineers,* vol. 54, no. 260, p. 646, June 1916, 10 pp., 2 figs. *de.*)

How to Select Prime Movers for Industrial Electrical Generating Plants, H. T. Luscomb

Discussion of the merits of Corliss engines, newer types of small steam units, producer-gas engines and various types of oil engines, all with a view to service in isolated-plant installations. The discussion is accompanied by tables obtained from actual tests of representative installations.

The writer emphasizes the fact that in considering the advisability of any type of prime mover there are two distinct phases to the question: First, the handling of the engine itself, and second, the conditions under which it is operated. There are no "fool-proof" machines, and any engine can fail if it does not get proper care. Certain types of engines are, however, more dependent upon attention for successful operation than are others. Thus, a producer-gas plant requires more diversified skill in handling than does a steam engine.

The ordinary piston or slide-valve high-speed engine and medium-size turbine with generator and necessary piping, wiring, switchboard, foundations and erection charges, cost from $50 to $90 per kilowatt of generator capacity, with a tendency to be considerably higher at the present time; for Corliss and four-valve medium- and low-speed engines, similar prices run from $75 to $100 per kilowatt of generator capacity.

Certain types of steam engines, comparatively new in this country, such as the uniflow, poppet-valve and locomobile, show high steam economies. The poppet-valve in particular, which is very popular in large plants in Europe, allows the use of superheated steam at high pressure and shows low steam consumption, but both the poppet-valve and the uniflow engines operate most economically at steam pressures higher than those generally found in isolated plants. As to cost, a recent installation of these engines consisting of three units, aggregating about 800 kilowatts, cost for the engines alone approximately $18 per kilowatt. The uniflow type costs considerably more than the Corliss type. A 140-kilowatt unit recently installed in a plant near New York cost $5000 for the engine alone, or $36 per kilowatt.

The locomobile unit is a self-contained power plant comprising boiler, superheater, preheater and compound-condensing engine, condenser, soot blower and feed heater. The guaranteed coal economy is exceptionally low. The cost varies from $79 for a unit of 300 kilowatts to $102 for one of 50 kilowatts.

In general, where any considerable proportion of the exhaust steam can be utilized, the amount of steam charged to the generation of electrical energy is little less with the uniflow, poppet-valve or Corliss engine than with the high-speed slide-valve engine. The author gives a comparison of two cases which show how the question of utilization of the exhaust steam affects the prospective economy from the prime mover selected.

The writer is anything but optimistic about producer-gas

installations for isolated plants. Since the first producer-gas electric plant was installed in New York City, about fourteen years ago, thirteen other plants have been added, and of them only four plants appear to be operating satisfactorily and are reliable enough to be depended upon exclusively. The main trouble with producer-gas plants seems to be with attendance.

The writer calls attention to the very important fact that in most factories the cost of power is a very small percentage of the cost of the finished product, while a shutdown, even for a short time, is usually an extremely costly matter. For this reason owners prefer comparative security from breakdown, even at some slight increase in the cost of power. The writer gives operating data obtained from three producer-gas electrical plants in New York City, together with a brief description of the apparatus installed in each.

In each of these three plants, which probably represent the best producer-gas practice, the reported operating cost per kilowatt hour is extremely low, ranging from 0.7 cent in the largest plant with 24-hr. operation to 1.48 cents in the smallest plant operated on a 12-hr. schedule, while the total costs,

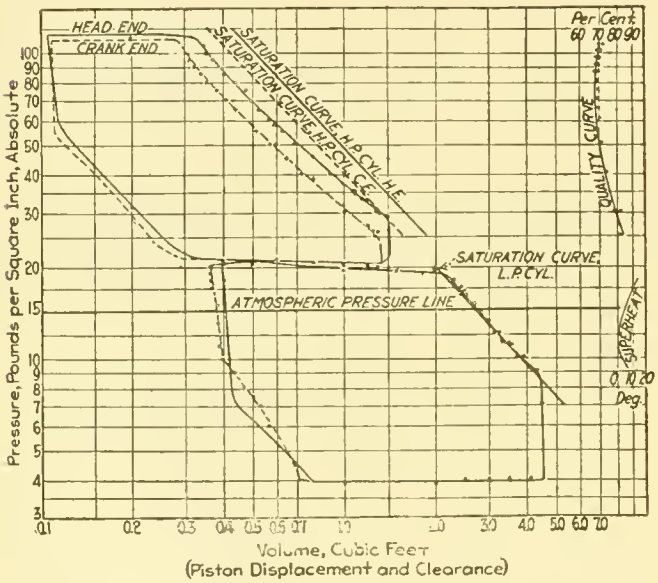


Fig. 7A Average Diagrams Plotted to Logarithmic Scale

including fixed charges, range from 1.14 to 2.54 cents per kilowatt-hour. In this case, however, the amount of labor charged against the producer-gas plant is exceptionally low on account of various individual conditions.

The article concludes with the discussion of oil engines for isolated plants. (*The Engineering Magazine*, vol. 51, no. 5, p. 705, August, 1916, 12 pp. 2 figs. *eps.*)

Steam Engineering

A Study of Indicator Diagrams from a Compound Corliss Engine, Professor Victor R. Gage

Data of tests made upon high and intermediate cylinders of a triple-expansion Corliss engine with a view to obtaining a series of average indicator diagrams together with saturation and superheat curves.

The interest of the tests lies in the fact that the diagrams taken from the engine at comparatively light load show that the logarithmic analysis cannot be applied under all conditions. On the logarithmic PV diagram, Fig. 7A, the expansion lines are not straight but curved. The curved form of the expansion lines might be attributed to leakage or possibly to faulty application of the indicators. Neither of these explanations, however, seems logical in this case, and the probable explanation is cylinder condensation and re-evaporation. The saturation curves are straight lines within the limits of the pressure range of the diagrams. If expansion lines also had this same form of equation and n (in equation $PV^n = K$) had the same numerical value, the two lines would be parallel or coincident and the quality or condition of the steam would remain unchanged during expansion.

If thermal equilibrium between the steam and the surfaces does not occur until some point on the expansion line is reached, it is not possible for the expansion line to plot as a straight line upon the logarithmic diagram. This point of thermal equilibrium and the general behavior of the steam during expansion are shown readily if the temperature-entropy diagram is employed.

On the temperature-entropy diagram, as plotted for this test, only the expansion lines appear, as well as the condition of the steam supplied and exhausted from each cylinder. (See Fig. B.) That portion of the expansion line which is of con-

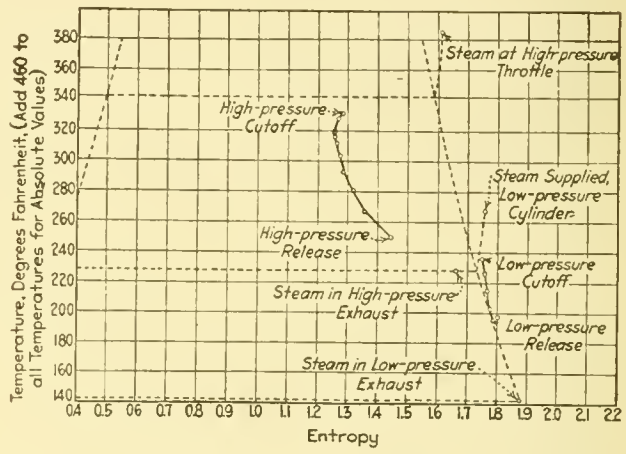


Fig. 7B Temperature-Entropy Applied to Diagrams

stant entropy (vertical) indicates the period of thermal equilibrium during which the net interchange of heat between the steam and the surface is zero. From the high-pressure cut-off to the point of equilibrium the expansion line slopes downward and to the left, with entropy decreasing, indicating transfer of heat from the steam to the surface, continuing below this point to release the transfer is in the opposite direction. The quantity of heat transferred per pound of steam may be obtained by evaluating the area under the selected portion of the expansion line down to absolute zero.

There is a slight inherent error in computing the heat interchanges in this manner. The values of entropy are based upon the total energy required to bring 1 lb. of water to the condition shown by a point on the diagram. When the cylinder is a closed vessel, the only heat energy available to do the work is the "intrinsic" or "internal" energy of the steam. Thus the heat interchanges as computed from the temperature-entropy diagram are based upon "total energy," whereas when computed by means of Hirn's analysis, only the "intrinsic" energy is used. Numerically the errors introduced in this way are probably not greater than the experimental errors. (*Power, vol.* 44, no. 6, p. 196, August 8, 1916, 2 pp., 4 figs. *et.*)

Uniform Boiler Laws

A Power Show was held at Montreal during the week of July 24th.

One of the exhibits in the show was a complete set of forms, application blanks, blueprints, forms relating to boilers of all descriptions, piping plans, drawings and forms relating to boiler accessories, gages, valves, etc. In this connection it is stated that there is now a possibility that Quebec will join with British Columbia, Alberta, Saskatchewan and Ontario in having a uniform boiler inspection law. (*The Canadian Manufacturer*, vol. 36, no. 8, p. 23, August, 1916, 1 p. *g.*)

Compounding and Superheating on French Railroads, L. Baclé

The article discusses the economies of fuel utilization in France through the use of compounding and superheating on railroads, and among other things gives a brief history of compounding on railroads in France. It is based on the information contained in *Questionnaire sur la Construction et la Conduite des Locomotives à Vapeur,* by Herdner.

The article contains an interesting calculation of the amount of coal saved by the French railroads through the use of compounding and superheating. This saving as compared with the amount consumed in saturated-steam operation is from fifteen to twenty per cent. The author takes 17.5 per cent as an average of saving. On January 1, 1914, there were on the French trunk lines 13,691 locomotives, of which 5751 were equipped with either compounding or superheating or both of them simultaneously.

Locomotives so equipped made in the course of the year runs amounting to a total of about 300 million kilometers (roughly 200 million miles).

The coal consumption of modern locomotives on the Midi railway system (one of the most important French railroad companies) amounts to about 15.67 kg. per kilometer. Locomotives having the same output but working with saturated steam and without compounding would, therefore, under the same conditions of service, consume about 19 kg., or an excess of about 3.33 kg. per kilometer.

Applying this calculation to the entire system of French trunk lines with their total runs of 300 million kilometers, one gets a saving of about one million metric tons per year.

In view of the fact that the greater part of the coal consumed on French railroads comes from England, the importance of this saving becomes especially great at the present time and with the present scarcity of bottoms. The writer shows further that it would require the work of twenty coal carriers for a year to transport a million of tons from Cardiff to France, to which must be added the additional work of the railroads. (*Le Génie Civil,* vol. 69, no. 4, p. 54, July 22, 1916, 3 pp. *gs.*)

Testing Methods

Testing Malleable and Cast Steel, Andrew Harley

The paper is an address delivered before the Birmingham Branch of the British Foundrymen's Association on December 4, 1915. What the author has to say applies more particularly to the production of light castings in malleable iron and mild steel such as are made for the automobile and cycle trade.

In the production of malleable a uniform composition in the hard state is of the utmost importance. Irregularities in the hard metal lead to most of the difficulties in annealing. The writer used the following means to obtain the control of the composition of the molten metal, confining himself mainly to the question of the raw materials.

Pig iron is bought to specification and adequately checked, each separate consignment being given a reference number used in all subsequent records. Scrap is graded according to analysis, the silicon content being sufficient as a rule. As a certain portion of the metal is of necessity melted over and over again, scrap from one mix is accumulated so long as that particular mix is in use. If the silicon has been kept fairly regular, this heap of scrap can be safely incorporated in the mix at a subsequent date.

Coke of the best quality must be used, with sulphur as low as possible. Allowances must be made for the changes that take place in the composition of the metal during the melt. With silicon, for instance, the loss in the writer's practice at the beginning was 0.23 per cent. This would diminish fairly regularly until 0.14 per cent only was recorded. Then just at the end there was a sudden jump back to 0.21 per cent. Sulphur acts in nearly the same way; at the beginning there was an increase of 0.07 per cent, but towards the end this was reduced to 0.003 per cent.

With reference to soaking, theoretically a continuous fire is no doubt possible, but practically soaking is considered advantageous. The size and shape of the pans, strength of ore used, temperature and time taken, must be all adjusted to the end of establishing an equilibrium. The writer in his works uses gas-fired round ovens and makes his own pans (a pan should be made of metal which resists annealing) and the analysis of good annealing ore should be as follows: ferric oxide, 84 to 90 per cent; silica, 8 to 13 per cent; lime should be absent; ferrous oxide, not more than 1 per cent.

The paper is accompanied by illustrations showing, among other things, the shrinkage of malleable iron. While this in the white casting only varies slightly in low and high silicon iron, the annealing produces a further shrinkage in the low silicon and an expansion in the high silicon iron, a fact of the utmost importance both to pattern-makers and molders. Any cast malleable of high silicon content, in which a large amount of carbon is left in the graphitic and combined form, is unsuitable. Even a black heart malleable containing no combined carbon is hardened considerably after quenching.

As regards quenching, the author points out that where oil quenching is resorted to it is advisable that it be followed by a tempering treatment. The lead bath is the most effective method of performing this operation, and five hours at a temperature of 550-570 deg. is a suitable treatment. (*The Iron Trade Review,* vol. 59, no. 3, p. 121, July 20, 1916, 7 pp., 25 figs. *epA.*)

Practical Methods for Testing Fire Brick, C. E. Nesbit and M. L. Bell

Paper outlining conditions, apparatus and findings for various methods of determining brick qualities.

Previous tests have shown that bricks are not always the same at both ends. *Spalling* was next studied. In brick work such a condition is usually the result of thermal changes, often accelerated by mechanical pinching.

After trying various tests, it was decided to place the brick to be tested in the wall of the furnace so that only one end was exposed. The testing temperature was 1350 deg. cent.; time of heating, one hour, and cooling in water for three minutes. It was found that to produce a measurable spall ten operations are necessary.

The *slagging test* is important because failure of brickwork due to the corrosive action of slags is more prevalent than from any other cause. Experiments were made to determine the effect of fineness of the slag, time of exposure to heat and the effect of destroying the surface texture by drilling.

A *compression test* was made to determine the ability of brickwork to stand up under loads when highly heated. A comparative test, consisting of a modified Brinell ball test, was made by heating the brick to 1350 deg. cent., removing from the furnace and then forcing a 2½-in. steel ball into the brick under a pressure of 1600 pounds.

As a result of a large number of tests, it was found that firebricks tend to group themselves according to density. In general, all other factors being equal, bricks of high density have the most desirable qualities, namely, least abrasion, good resistance to slag and least compression.

An appendix describes in detail the apparatus and methods used in the tests. (*Blast Furnace and Steel Plant*, vol. 50, no. 8, p. 369, August 1916, 5 pp., 3 figs., end of serial article. *dep.*)

Testing Non-Ferrous Metals for Hardness, Hugo Friedmann

Discussion of the application of the Brinell method in regulating methods of manufacture of non-ferrous metal products.

It is difficult to secure accurate results from hardness tests of castings as ordinary castings of brass, aluminum or bronze which have not been subjected to some mechanical treatment do not show clearly defined circular impressions when it is attempted to determine their hardness by the Brinell method. The circumference of the impression is irregular, making it a difficult matter to measure the diameter accurately. A microscopic investigation carried out by the writer failed to reveal any relation between the irregularities of the outline of the impression and the crystalline structure of the metal, and it seems likely that the indentations in the outline of the impression are caused by minute holes in the metal rather than by crystalline structure.

In addition to that, unless the metal is annealed, hardness tests on castings are likely to show varying results on different parts of the same casting owing to the differences in the speed at which the metal cooled. Hence only information regarding the general characteristics of the metal can be secured by hardness tests of castings. On the other hand, where castings of similar appearance but composed of different metal mixtures have been accidentally mixed, the application of the hardness test enables one to rapidly sort them out.

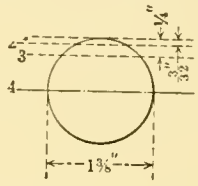
A useful application of the hardness test of non-ferrous metals is in the investigation of the influence of mechanical and thermal treatment on such materials. Hardness tests may also be profitably employed as a means of guidance in the purchase of factory supplies. For instance, sheet metal is frequently ordered in various degrees of stiffness. If complete standards are established a hardness test will definitely indicate whether the material meets the required standard.

Another application of the hardness test is shown by the following. The diameter of a rod of electrolytic copper was reduced by cold drawing from 1½ in. to 1⅜ in., then it was tested at different distances below the surface, as shown in the diagram of Table 2. The results clearly show that the drawing operation had the greatest effect on the physical characteristics of the metal near the surface of the rod, but that even a comparatively slight reduction of the diameter by drawing, as in the present case, does affect the properties of the metal at the center of the bar. The difference between the properties of the metal at different distances from the surface cannot readily be determined by other methods, as shown from the results of the following experiments. Standard tensile bars were taken from the same copper rod and turned to diameters of 1¼ in., 1 in. and ⅝ in. respectively, the purpose being to remove different amounts of metal from the surface. It might be expected that when these bars were subjected to a tensile test they would show differences in ultimate strength, but as a matter of fact all the bars were broken by the application of the same unit stress.

There is sometimes a tendency for the hardness test impressions to be elliptical in shape rather than round. Such impressions are usually formed when the material has been subjected to severe mechanical treatment in one direction only and they are usually found in cold rolled sheet metal. The difference between the long and short axes of the impression affords an indication of the amount of cold treatment to which the metal has been subjected; for example, if an aluminum sheet shows considerable hardness it may be judged from the appearance of the impression whether it is pure hard rolled aluminum or an alloy in which the hardness is due to the chemical composition of the metal rather than to the mechanical treatment to which it has been subjected. Table 3 gives an indication as to the relation which exists between the dimensions of these elliptical impressions and the other properties of the material. It shows that the strength of the material in the direction of the fibres is less than its strength across the fibres. Similarly the larger diameter of the impression indicates a lower degree of hardness and strength and is usually found in the direction in which the rolling was done.

On the other hand experiments have shown that there is no definite relation between the hardness of the metal and its resistance to wearing by friction. (*Machinery*, vol. 22, no. 12, p. 1026, August, 1916, 3 pp., *ep.*)

TABLE 2—HARDNESS OF COPPER ROD AT DIFFERENT LEVELS, SHOWING THE EFFECT OF DRAWING.



Level No.	1	2	3	4	Test on Annealed Metal at any Level
Diameter of impression made by ball, millimeters	2.85	3.05	3.15	3.25	3.55 *Machinery*

TABLE 3 RELATION OF HARDNESS, TENSILE STRENGTH AND PER CENT ELONGATION, NON-FERROUS METALS

	Length of Long Axis of Elliptical Impression made by Ball, Millimeters	Tensile Strength, Pounds per Square Inch	Elongation, Per Cent
In same direction that rolling was done	3.55	53,480	4
In opposite direction to that in which rolling was done	3.42	57,680	4

SELECTED TITLES OF ENGINEERING ARTICLES

AERONAUTICS

Dynamical Stability of Aeroplanes, Jerome C. Hunsaker. Aerial Age, vol. 3, no. 19, July 24, 1916, 2 pp., 1 fig.

Scientific Research in Aeroplane Construction at the Factory of the Curtiss Aeroplane and Motor Corporation. Aerial Age, vol. 3, no. 19, July 24, 1916, 6 pp., illustrated.

First Steps in Standardization Taken Under the Auspices of the War Department. Aerial Age, vol. 3, no. 21, 3 pp., 6 figs.

Aeroplane Accidents: Causes and Remedies, Lieutenant R. C. Saufley, U. S. Navy. U. S. Naval Institute Proceedings, vol. 42, no. 164, 18½ pp., 6 figs.

Report of the Committee on the Royal Aircraft Factory. Engineering, vol. CII, no. 2639, 2 pp., 2 figs., illustrated.

Le Mécanisme de tir du Fokker, Jean Lagorgette. L'Aérophile, 24 Annee, no. 11-12, 3¼ pp., 9 figs.
Fokker biplane firing mechanism.

CONVEYING

The Economics of Material Handling in Manufacturing Plants, Belt Conveyors, Reginald Trautschold. The Engineering Magazine, vol. 51, no. 5, August 1916, 12½ pp., 14 charts.

DIESEL ENGINES

Diesel Engine Crankshafts, Philip H. Smith. The Mechanical Engineer, vol. XXXVIII, no. 966, 2 pp., 6 figs.

ENGINEERING MATERIALS

Vulcanization Experiments on Plantation Para Rubber. II. The Cause of Variability and Some Contributory Factors, B. J. Eaton and J. Grantham. Journal of the Society of Chemical Industry, vol. 35, no. 13, July 15, 1916, 13½ pp., 6 figs.

Testing Malleable and Cast Steel, Andrew Harley. The Iron Trade Review, vol. 59, no. 3, July 20, 1916, 7 pp., 25 figs.

Zeppelin Alloys. Brass World, vol. 12, no. 7, July 1916, ½ p.

Testing Non-Ferrous Metals for Hardness, Hugo Friedmann. Machinery, vol. 22, no. 12, August 1916, 2¼ pp.

Fungi Which Grow on Untreated Ties or Untreated Wood, Dr. H. von Schrenk. Loco, vol. 7, no. 2, 8½ pp., illustrated.

Tests of Fire Retardents, with Special Reference to the Shingle Roof. Extracts from a bulletin by Hermann von Schrenk and Arnold von Schrenk, consulting engineers. Railway Review, col. 59, no. 6, 1 p.

Effect of Sugar on Concrete. Concrete, vol. 9, no. 2, ½ p.

Manufacture of Copper-Coated Steel. The Iron Trade Review, vol. LIX no. 6, 1½ pp., illustrated.

Drawing Metal by Hydraulic Method, G. R. Smith. The Iron Trade Review, vol. 59, no. 5, August 3, 1916, 1 p

FIRING AND FUELS

Burner for Simultaneous Gas and Coal-Firing. Engineering, vol. 101, no. 2634, June 23, 1916, ½ p., 2 figs.

Chauffage à poussière de tourbe d'une locomotive à marchandises de l'etat suédois. Le Génie Civil, vol. 58, no. 25, June 17, 1916, 2 pp., 5 figs.
Description of a locomotive (Swedish State railroads) with pulverized peat firing.

Apparatus for Washing Smoke and Fumes from Furnace or Boiler Flues. The Mechanical Engineer, vol. 37, no. 960, June 16, 1916, ½ p.

Burning Pulverized Culm at the Mines, Reginald Trautschold. Coal Age, vol. 10, no. 3, July 15, 1916, ¾ p.

The Value of Peat Fuel, as Compared with Coal, for Production of Power, B. F. Haanel. Journal of the American Peat Society, vol. 9, no. 2, April 1916, 14½ pp., illustrated.

FOUNDRY

A Pre-Heated Blast Cupola, J. A. Parsons. Cassier's Engineering Monthly, vol. 50, no. 1, July 1916, 2½ pp.

Some Scientific Aspects of Steel Founding Practice, W. A. Naish. Canadian Machinery, vol. xvi, no. 6, 4 pp.

HEATING

Heating Factories by Forced Hot Water Circulation, Albert O. Duncan. The Canadian Manufacturer, vol. 36, no. 8, 4 pp., 5 figs.

HYDRAULICS

On the Flow of Compressible Fluid Past an Obstacle, Lord Rayleigh. The Philosophical Magazine, vol. 32, no. 187, July 1916, 6 pp.

Distribution des Vitesses dans les Tuyaux, M. Mougnié. Annales des Ponts et Chaussées, vol. 6, no. 30, 21 pp., 4 figs.
Distribution of velocities of flow in pipes.

Flow of Water Into Wells; Approximate Theory, N. Werenskiold. Engineering News, vol. 76, no. 6, 1¼ pp, 2 figs.

MACHINE SHOP AND TOOLS

The Rolling of Screw Threads, James Steelman. Cassier's Engineering Monthly, vol. 50, no. 1, July 1916, 11 pp., illustrated.
Welding Tubing by Oxy-Acetylene. The Iron Trade Review, vol. 59, no. 3, July 20, 1916, 3 pp., illustrated.

The Sand Blast, James Steelman. Brass World, vol. 12, no. 7, July 1916, 5½ pp., illustrated.

Electric Spot Welding, Douglas T. Hamilton. Machinery, vol. 22, no. 12, August 1916, 5 pp., 7 figs.

Aluminum Welding, Harry B. Hoover. Machinery, vol. 22, no. 12, August 1916, 3½ pp., 5 figs.

Manufacture of Ball Bearings. Machinery, vol. 22, no. 12, August 1916, 4½ pp., 17 figs.

Portable Machine Shops for the United States Army, W. S. Doxsey. The Iron Trade Review, vol. 59. no. 5, 1½ pp., illustrated.

Ball Bearing Manufacture in a Specialized Canadian Plant. Staff Article. Canadian Machinery and Manufacturing News, vol. 16, no. 5, 3 pp., 13 figs.

Methods Used in Machining an Aeroplane Cylinder, Robert Mawson. American Machinist, vol. 45, no. 6, 2 pp., 7 figs.

Sandblasting and Sandblast Machines, J. J. Richardson. The Mechanical Engineer, vol. xxxviii, no. 967, 2¼ pp.

The Production of Patterns for Internal-Combustion Engines, Joseph G. Horner. The Foundry Trade Journal, vol. 18, no. 175, 6 pp., 13 figs.

Tool-Steel Research. The Foundry Trade Journal, vol. 18, no. 175, 2 pp.

Board Drop-Hammers, Dixie. Machinery, vol. 22, no. 12, August 1916, 8½ pp., 20 figs.

MECHANICS

Accelerating Characteristics of Centrifugal Pumps and Fans, B. W. Jones. General Electric Review, vol. 19, no. 8, August 1916, 3 pp., 4 figs.

Accelerating Force of Reciprocating Parts, Hubert L. Watson. Machinery, vol. 22, no. 12, August 1916, 2 pp., 4 figs.

Investigation of Plastic Flow Phenomena, W. Trinks. The Blast Furnace and Steel Plant, vol. 50, no. 8, August 1916, 2½ pp., 2 figs.

The Performance of Flexible Staybolts. Railway Review, vol. 59, no. 6, ¼ p.

Belts—Selection and Care to Secure Greatest Efficiency, C. J. Morrison. The Canadian Manuacturer, vol. 36, no. 8, 4½ pp.

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MUNITIONS

Uses of Gas in Munition Making. The Engineering Review, vol. 30, no. 1, July 15, 1916, 4 pp., 7 figs.

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Albert Ball's Magazine Rifle of 1863, Guy Hubbard. Machinery, vol. 22, no. 12, August 1916, 3½ pp., 6 figs.

POWER GENERATION

The Economical Production of Power from Coke-Oven Gas, G. Dearle. The Journal of The Institution of Electrical Engineers, vol. 54, no. 260, June 1916, 9½ pp.

Das Kraftwerk an der Vièze bei Monthey, L. Kürsteiner. Schweizerische Bauzeitung, vol. 67, no. 26, June 24, 1916, 4½ pp., 6 figs. Vièze hydro-electric plant in Switzerland.

Electric Drive for Reversing Rolling Mills, Wilfred Sykes and David Hall. The Blast Furnace and Steel Plant, vol. 50, no. 8, August 1916, 6½ pp., 6 figs.

How to Select Prime Movers for Industrial Electrical Generating Plants, H. T. Luscomb. The Engineering Magazine, vol. 51, no. 5, August 1916, 11½ pp.

Power Cost in Paper Mill, Thomas Wilson. Power, vol. 44, no. 6, 3 pp., 2 figs.

Oil Engines and Steam Engines in Combination, Geoffrey Porter. The Mechanical Engineer, vol. xxxviii, no. 965, 4 pp., 1 fig.

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Triplex Articulated Compound Locomotives for the Erie R. R. Railway Review, vol. 59, no. 4, July 22, 1916, 4 pp., illustrated.

American Railway Association's Co-operation with the Military Authorities. Railway Review, vol. 59, no. 5, July 29, 1916, 1½ pp.

L'Emploi de la détente Compound et de la surchauffe. Le Génie Civil. Tome lxix, no. 4, 2 pp.
Compounding and superheating and their economics on French railroads.

Four Wheel Trucks for Passenger Train Coaches, Roy V. Wright. Railway Gazette, vol. xxv, no. 4, 4 pp., 3 figs.

Le gabarit d'espace libre et du matériel roulant des chemins de fer suisses a voie normale, R. Winkler. Bulletin Technique De La Suisse Romande, 42 Annee, no. 14, 3 pp.
Clearance and track gage for rolling stock on Swiss trunk lines.

REFRIGERATION

A Suggestion to Prevent the Loss of Ammonia at Stuffing Boxes, Louis Block. A. S. R. E. Journal, vol. 3, no. 1, July 1916, 3 pp., 1 fig.

A New Departure in Ammonia Compression, Charles H. Bromley. Power, vol. 44, no. 7, 4 pp., 4 figs.

SAFETY ENGINEERING

Piping for Steam-Generating Plants from a Safety Point of View. The Travelers' Standard, vol. iv, no. 8, 7¾ pp., 7 figs.

Red Book of the British Fire Prevention Committee. Edited by the Executive. London 1912 edition.

STEAM ENGINEERING

The Ljungstrom Turbine and Its Application to Marine Propulsion, Ronald S. Portham. Cassier's Engineering Monthly, vol. 50, no. 1, July 1916, 12½ pp., 10 figs.

Multiple-Jet Ejector Condenser. The Engineer, vol. 122, no. 3159, July 14, 1916, ½ p., 2 figs.

A New Type of Steam Safety Valve, George H. Clark. A. S. R. E. Journal, vol. 3, no. 1, July 1916, 5 pp., 1 fig.

Efficiency of Unsymmetrical Riveted Joints, R. N. Blackburn. Power, vol. 44, no. 6, 3½ pp., 5 figs.

A Study of Indicator Diagrams from a Compound Corliss, Victor R. Gage. Power, vol. 44, no. 6, 2 pp., 4 figs.

Design of Superheaters, W. C. Strott. Power, vol. 44, no. 6, 2 pp.

STRENGTH OF MATERIALS

Graphical Analysis of Continuous Beams by the Use of the Principle of Continuity, Cyril Provo Hubert. Vol. 7, no. 8. Western Engineering, 4 pp., 10 figs.

To Find Graphically the Position of Unit Load Giving Zero Stress in any Web Member of a Girder, John Edmonson. Engineering, vol. cii, no. 2639, 4 pp., 6 figs.

La détermination des élements nécessaires au calcul de la poussée des terres. Le Génie Civil, Tome lxix, no. 5, Samedi 29, Juillet 1916, 3 pp.
The determination of the elements necessary for the calculation of the earth pressure.

THERMODYNAMICS

Entropie générique et mélanges gazeux, Edouard Guillaume. Bibliothèque Universelle, Tome xli, no. 6, 12 pp.
Generic entropy and gaseous mixtures.

Effect of Velocity and Humidity of Air on Heat Transmission Through Building Materials, J. A. Moyer. A. S. R. E. Journal, vol. 3, no. 1, July 1916, 8½ pp.

TRACTORS

Interesting Type of Canadian Built Oil-Driven Tractor. Staff Article. Canadian Machinery and Manufacturing News, vol. 15, no. 22, 2 pp., 11 figs.

VARIA

Underwriters' Laboratories' New Hydraulic Laboratory, R. W. Hendricks. Quarterly of the National Fire Protection Association, vol. 10, no. 1, July 1916, 7 pp., illustrated.

Russian Measures and Equivalents, Edward L. Stenger. Mining and Scientific Press, vol. 113, no. 5, July 29, 1916, 2 pp.

What Manufacturers Look for in Engineering Graduates, E. H. Fish. The Engineering Magazine, vol. 51, no. 5, August 1916, 5 pp.

Rectangular Storage Tanks for Liquids, H. Eisert. Monthly Journal of The Engineers Club of Baltimore, vol. 5, no. 2, August 1916, 12½ pp., 3 figs.

The Casting of Clay Wares, Taine G. McDougal. Loco, vol. 7, no. 2, 11½ pp., 6 figs.

Les nécessités de l'enseignement technique supérieur. Revue générale des Sciences, 27 Annee, no. 13, 4 pp.
The needs of higher technical education.

La rééducation professionnelle des blessés et des amputés de la guerre. Le Génie Civil, Tome lxix, no. 5, July 29, 1916, 2¾ pp., 5 figs.
Re-education from a professional point of view of men wounded and crippled in the war.

Mechanical Engineering in a Synthetic Phenol Plant, Frederick Pope. Metallurgical and Chemical Engineering, vol. xv, no. 4, 7 pp., illustrated.

CHARTS

Accelerating Force of Reciprocating Parts, Hubert L. Watson. Machinery, vol. 22, no. 12, August 1916.

Chart: For use in obtaining unit forces due to inertia of reciprocating parts of an engine.

Chart for Determining Engine Loads, Ernest A. Andrews. Machinery, vol. 22, no. 12, August 1916.

Chart: For Use in Rapidly Determining Loads on Important Engine Frame Members.

The Economics of Material Handling in Manufacturing Plants, Belt Conveyors, Reginald Trautschold. The Engineering Magazine, vol. 51, no. 5, August 1916.

Charts:
1. Capacities of Standard Belt Conveyors, Economically Loaded and Operated.
2. Horsepower Requirements of Belt Conveyors.
3. Average Cost of Standard Troughed Rubber Belt Conveyors with Grease Lubrication.
4. Average Cost of Discharging Devices for Belt Conveyors.
5. Annual Depreciation of Standard Belt Conveyors.
6. Capacities of Standard Flight Conveyors, Economically Loaded and Operated.
7. Horsepower Requirements of Flight Conveyors.
8. Average Cost of Conveyors with Sliding Shoe Flights.
9. Average Cost of Conveyors with Roller Flights.
10. Depreciation Factors for Standard Flight Conveyors.
11. Capacities of Standard Screw Conveyors, Economically Loaded and Operated.
12. Horsepower Requirements of Screw Conveyors.
13. Average Cost of Screw Conveyors.
14. Depreciation Factors for Standard Screw Conveyors.

The Value of Peat Fuel, as Compared with Coal, for Production of Power, B. F. Haanel. Journal of the American Peat Society, Inc., vol. 9, no. 2, 13¼ pp.

Curves illustrating effect of increase of nitrogen content on cost of generating power from heat.
A. Cost of producing 1 brake horsepower-year with non-by-product recovery peat producer gas plant.
B Cost of producing 1 brake horsepower-year with by-product recovery peat producer gas plant.
C Cost of producing 1000 cubic feet of gas with by-product recovery peat producer gas plant.
D Cost of producing gas for 1 brake horsepower-year with by-product recovery peat producer gas plant.
E Net cost of recovering ammonium sulphate per ton of absolutely dry peat gasified.
Curves A show the effect of increase of fuel cost of power.
Curve B shows the nitrogen the fuel must contain to permit by-product recovery plant to compete with non-by-product recovery producer-gas power plant.
Curves A showing cost of 1000 cubic feet of gas when peat costs $0.50 to $3.00 per ton.
Curves B showing cost of sulphate when peat costs $0.50 to $3.00 per ton.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

EFFICIENCY OF PROPULSIVE MACHINERY AND LATE DEVELOPMENTS IN NAVAL ENGINEERING

BY LIEUTENANT-COMMANDER H. C. DINGER[1], U. S. N., WASHINGTON, D. C.

Non-Member

IN January, 1912, Capt. C. W. Dyson presented a paper before the Engineers' Club of Philadelphia, entitled Propulsive Machinery and Oil Fuel in the U. S. Navy, which was followed later in the same year with a paper entitled Engineering Progress in the U. S. Navy, read by the then Engineer-in-Chief, Rear-Admiral H. I. Cone, before the American Society of Naval Architects and Marine Engineers at their annual meeting in New York City.

The first of these papers contained a comparison of the performances of the reciprocating-engined vessel *Delaware* and the Curtis turbine-engined vessel *North Dakota,* while the second paper contained a comparison of the performance of the *Delaware* and the Parsons turbine-engined vessel *Utah.* In both of these comparisons the decided superiority in economy of the reciprocating engine over the turbine for battleship propulsion was fully demonstrated.

That this apparent superiority was due to faulty practice in the design of propellers in the case of the Parsons turbine, and to both turbines and propellers in the case of the Curtis turbine, has been demonstrated by the trials of later vessels, in which the turbine revolutions have been very considerably reduced; and in the cases of Curtis turbines the turbine design has been radically changed in quite a number of particulars. In the cases of the latest two turbine-engined vessels, the economy has been still further improved by fitting cruising turbines driving the main shafting through mechanical reduction gear.

Since the trials of the *Delaware, North Dakota, Utah* and her sister ship *Florida,* the following vessels have been completed and tried and commissioned: *Arkansas, Wyoming, New York, Texas, Oklahoma, Nevada* and *Pennsylvania.* Of these vessels the *Arkansas* and *Wyoming* are sister ships and are fitted with Parsons turbines on four shafts. The *New York* and *Texas* are alike and have reciprocating engines on two shafts. The *Oklahoma* and *Nevada* are also sister ships, the first having reciprocating engines while the other has Curtis turbines with cruising turbines and reduction gear. Both vessels have two shafts. The latest vessel, the *Pennsylvania,* is also fitted with Curtis turbines and with cruising turbines and reduction gear, but the power is divided among four shafts.

In tracing the advance in economy in turbine propulsion, that vessel of each pair of sister ships showing the better trial performance will be considered in order to eliminate favoritism of one type over the other, and with this object in view the following vessels will be used in the argument:

1 Reciprocating-engined vessels *Delaware, New York, Oklahoma.*
2 Parsons-turbine-engined vessels *Utah, Arkansas.*
3 Curtis-turbine-engined vessels *North Dakota, Nevada, Pennsylvania.*

In order to furnish a proper understanding of the conditions of operation of the machinery, the characteristics of the vessels' hulls, their machinery and their propellers, must be at hand for reference; and these characteristics are given in Tables 1-3.

The following is a detailed description of the turbines of the *Nevada* and *Pennsylvania:*

[1] Bureau of Steam Engineering, Washington, D. C.

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SYNOPSIS

In papers read early in 1912 by Rear-Admiral H. I. Cone and Capt. C. W. Dyson, U. S. N., comparisons were made of the performances of turbine-engined and reciprocating-engined naval vessels that demonstrated the superiority of the latter for battleship propulsion. That this superiority was only apparent, however, and was due to faulty design of turbines and propellers, has been shown by the trials of vessels since constructed.

In tracing the advance in economy in turbine propulsion the author selects as good examples of modern practice the reciprocating-engined vessels *Delaware, New York* and *Oklahoma;* the Parsons-turbine-engined vessels *Utah* and *Arkansas;* and the Curtis-turbine-engined vessels *North Dakota, Nevada* and *Pennsylvania.* He gives tabulated details regarding the hulls and machinery of these vessels and also curves plotted from their trial-trip data.

In one set of curves shaft or indicated horsepowers are plotted against effective horsepowers, giving curves of relative propeller efficiency which indicate graphically the improvement in propeller design made in succeeding vessels, and which show the reciprocating-engined vessels to be decidedly superior above 12,000 effective h.p. In another set B.t.u. per effective horsepower are plotted against effective horsepowers, giving a comparison of combined engine and propeller efficiencies. In a third set revolutions per minute are plotted against effective horsepowers.

So far as economy at the different speeds is concerned, the curves show that there is but slight choice between the different types of machinery when they have proper propeller efficiency. At very low powers the reciprocating engine is about as economical as the geared cruising turbine, and both of these are more economical than directly connected cruising turbines; and it is evident that matters other than economical performance should decide the question of type of prime mover. When losses are guarded against it is the range of temperature that really counts in securing efficient propulsive machinery; hence the most effective measures are obviously the use of superheat and the highest practicable vacuum, the best possible utilization of feed-heating apparatus, and the economical operation of auxiliaries. These latter can become very wasteful, but in the best cases the percentage of available heat used by them has been reduced to about 5 per cent of the total at full power.

The geared turbine and the electric drive are recent innovations which show decided economy and a material saving in weight over directly connected units. For large capital vessels the electric drive is to be preferred on account of (1) greater flexibility in shaft and piping arrangements, (2) better economy at cruising ranges, (3) better arrangement of generator rooms, boilers, etc., (4) better handling conditions and greatly improved power for backing, and (5) the practicability of using high superheat; also (6) parts of machinery can undergo repair while other parts are in operation at a very large percentage of the total power of the vessel. Gearing is more suitable for light, high-powered vessels of the destroyer or scout type.

The paper discusses briefly recent improvements in auxiliary machinery, making special mention of the adoption of the small steam turbine for driving forced-draft blowers, and of the use of gearing for turbine-driven generators, pumps and blowers. Attention is also called to the fact that the problem of the naval engineer is largely one of saving weight and space, and that as the principal method of accomplishing this is to install high-efficiency machinery, the desirability of coöperation of naval engineers with the industrial engineers of the country is obvious.

U. S. S. Nevada Turbine Data.—The high-pressure turbine has five wheels and two drums, the 5th-stage wheel being secured to the forward drum, the steam being divided after leaving the wheel stages. The wheels are separated from each other by diaphragms containing the steam nozzles. There is one stage on each wheel with two rows of buckets each, except the 1st-stage wheel which has four rows, all having a pitch diameter of 132 in. The forward drum, 6th to 14th stages, inclusive, has nine rows of buckets with a pitch diameter of 119 in., and the after drum, 15th to 30th stages inclusive, has 16 rows of buckets with a pitch diameter of 118⅝ in.

The low-pressure turbine has one drum of 38 stages and 38 rows of buckets for ahead conditions, and one wheel and one drum for backing. The backing wheel, one stage, has four rows of buckets with a pitch diameter of 137.55 in., and the drum, nine stages, has 11 rows of buckets with a pitch diameter of 120 in. The backing wheel and drum are separated by a diaphragm containing steam nozzles.

Pennsylvania Turbine Data.—The high-pressure ahead turbine has three wheels and two drums, the 3d-stage wheel being secured to the forward drum. The wheels are separated from each other by diaphragms containing the steam nozzles. There is one stage on each wheel, with three rows of buckets (132 in. P. D.), except the 1st-stage wheel which has four rows of buckets. The forward drum has 18 rows of buckets and the after drum 21 rows of buckets (both 120 in. P. D.).

The low-pressure ahead and astern turbine has two drums. The forward drum has 42 rows of buckets for ahead conditions (138 in. P. D.), and the after drum 13 rows of buckets for astern conditions (120 in. P. D.). The high-pressure astern turbine has three wheels and one drum; each wheel has three rows of buckets except the first stage, which has five rows, (108 in. P. D.). The drum has 17 rows of buckets (84 in. P. D.).

The high-pressure cruising turbine has four wheels, two rows of buckets on each, except the first has three (30 in. P. D.). The low-pressure cruising turbine has six wheels, two rows of buckets on each (30 in. P. D.).

The cruising turbines for the *Nevada* were designed to give requisite power to pass steam through them up to a speed of 15 knots. Those for the *Pennsylvania* were designed to pass steam through them up to a speed of 12 knots. They were, however, used up to 15 knots by making use of special by-passes. In both vessels the cruising turbines may be used at higher speeds than those originally designed by keeping the cruising turbines in operation and at the same time admitting some live steam into the main high-pressure turbines.

TABLE 1 HULL CHARACTERISTICS OF VESSELS

	Delaware	*North Dakota*	*Utah*	*Arkansas*	*New York*	*Oklahoma*	*Nevada*	*Pennsylvania*
Length on load water line	510 ft. 0 in.	510 ft. 2¼ in.	510 ft. 0 in.	554 ft. 0 in.	565 ft. 0 in.	575 ft. 0 in.	575 ft. 0 in.	600 ft. 0 in.
Beam	85 ft. 2⅝ in.	85 ft. 2½ in.	88 ft. 2½ in.	93 ft. 2⅝ in.	95 ft. 2⅝ in.	95 ft. 2⅝ in.	95 ft. 2⅝ in.	97 ft. ½ in.
Draught on trial	27 ft. 2 in.	26 ft. 11⅜ in.	27 ft. 10⅞ in.	27 ft. 11 5/16 in.	27 ft. 9½ in.	28 ft. 6 in.	28 ft. 3 1/16 in.	28 ft. 9¾ in
Displacement on trial, tons	20,209	20,051	21,268	25,496	26,300	27,500	27,222	31,400
Coefficient of fineness, block	0.6000	0.6000	0.5837	0.6220	0.6100	0.6170	0.6080	0 6460
Coefficient of fineness, mid-section	0.9798	0 9810	0.9792	0.9850	0.9900	0.9840	0.9820	0.9820

TABLE 2 MACHINERY CHARACTERISTICS OF RECIPROCATING-ENGINED VESSELS

	Delaware		*New York*		*Oklahoma*	
Engines: type	Vertical, inverted, 4-cylinder, triple-expansion					
Engines: number	2		2		2	
Cyl. diam., in.: high pres.	38.5		39		34.98	
Cyl. diam., in.: medium pres.	57		63		59.	
Cyl. diam., in.: low pres.	(2) 76		(2) 83		(2) 78	
Stroke, in.	48		48		48	
Clearances (total per cent)	Top	Bottom	Top	Bottom	Top	Bottom
High-pres. cyl. (H.P.)	15.57	16.77	14 29	13.54	7.226	9 586
Med.-pres. cyl. (M.P.)	12 71	14.43	12.18	14.85	9.284	12.499
Low-pres. cyl. (L.P.)	11 91	13.04	13.75	16.30	8.900	12.400
Ratio H.P.:M.P.	2.22		2.61		2.890	
Ratio M.P.:L.P.	3.58		3.47		3.508	
Ratio H.P.:L.P.	7.92		9 06		10.130	
Valves: type	Piston, with short, straight ports.					
Valves: number	1 H.P., 2 M.P., 4 L.P.		1 H.P., 2 M.P., 4 L.P.		1 H.P., 2 M.P., 4 L.P.	

TABLE 3 MACHINERY CHARACTERISTICS OF TURBINE-ENGINED VESSELS

	Arkansas, Utah and Florida	*North Dakota*	*Nevada*	*Pennsylvania*
Type of turbines	Parsons reaction	Curtis, wheel stages only	Curtis, wheels and drums	Curtis, wheels and drums
Number of shafts	4	2	2	4
Rotor diameters, in.*				
High-pressure	71	144	132-138⅝	132–120
Low-pressure	97	..	120	138
High-pressure cruising	71	..	38–41	30
Intermed.-pres. cruising	70	..	....	.....
Low-pres. cruising	..	..	....	30
High-pressure astern	71	..	137.55	84–108
No. of Stages: high-pres.	6 (91 rows)	9	5 wheel 25 drum	4 wheel stages 39 rows on drums
No. of Stages: low-pres.	6 (39 rows)	..	38	55 " " "
Revolutions per minute	320	280	212	210
Steam pres., lb. per sq. in.	200	250	250	250

* All pitch diameters except in second column.

COMPARISON OF ECONOMICAL PERFORMANCES

The curves in Figs. 1 and 2 have been plotted in order to establish a definite basis of comparison of the economical performances of the different vessels, and it is believed that the comparison thus made is very easily comprehended. The curves are plotted from the trial-trip data of the various vessels, which are believed to be reliable, but which cannot be taken with the refinement of a laboratory experiment.

CONSTRUCTION OF CURVES

Fig. 1, lower part, gives the effective horsepower and revolution curves for each of the several vessels. Fig. 1, upper part, gives the effective horsepower and indicated or shaft horse-

power curves for each of the several vessels. As plotted they are really curves of relative propeller efficiency, and the closer the curve comes to the horizontal the greater the propeller efficiency. The curves indicate graphically the general improvement in propeller design made in succeeding vessels. It will be seen that curves of the two latest vessels, the *Oklahoma* and *Pennsylvania,* run fairly close together up to an effective horsepower of 12,000, though one is a turbined vessel running at 181 r. p. m., and the other a reciprocating-engined vessel running at 118 r. p. m.; but above this point the reciprocating engine propellers are decidedly superior.

Fig. 2 gives the effective horsepower and B.t.u. utilized, obtained by plotting the value of $W\,H \div (E.H.P.)$, where

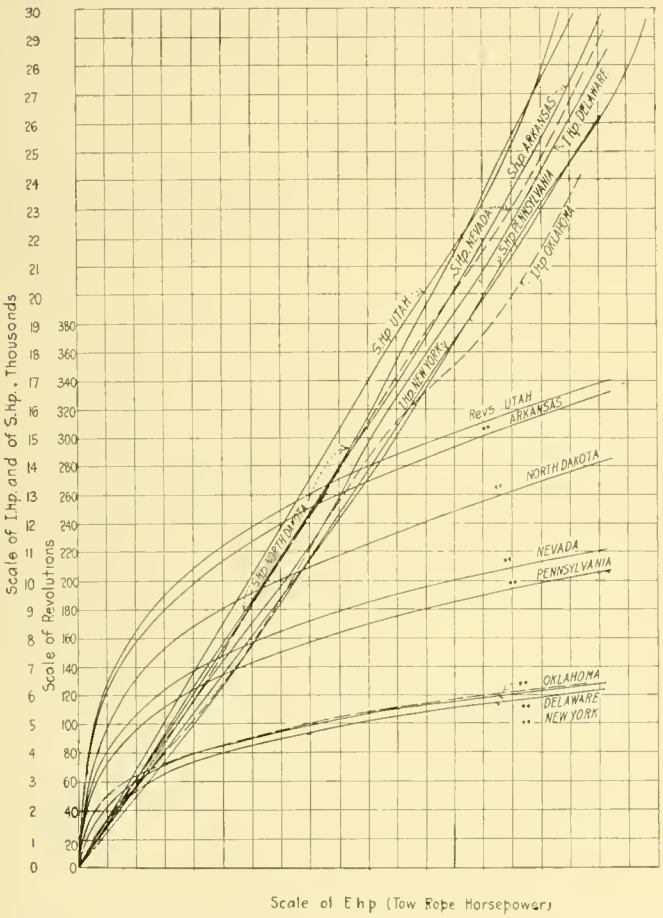

Fig. 1 Comparative Performances of Naval Vessels

W = total water consumption per hour at point where the effective horsepower (E. H. P.) mentioned is used, and H = total heat of one pound of steam at boiler less feed temperature. These curves, therefore, give a comparison of combined engine and propeller efficiency, eliminating the boilers. Similar curves might be plotted showing the engine efficiency only. But as the type of machinery affects the propeller efficiency, it is a better comparison to have the combined efficiency of engines and propellers.

In plotting these curves, where saturated steam is used the steam is assumed to be dry. Where superheated steam is used the temperature of steam recorded is employed. It is believed that the curves are truly comparable graphs of the economical efficiency of the machinery of the different vessels, and are unique in this particular, since they take into account propulsive work performed per heat unit supplied in the steam to the engine. They also take into account water for all purposes, except for the *North Dakota* the water for dynamos is excluded.

Any other vessels for which the water consumption, steam pressure, feed temperature, shaft horsepower and effective horsepower are known, can be compared in the same way and the relative efficiency of the machinery shown.

The disclosures from the curves of the B.t.u. per effective horsepower are extremely interesting. The *New York* here shows the best performance, and this represents the combination of efficient propellers, good reciprocating engines, and the use of a moderate degree of superheat. In comparing the *Delaware, New York* and *Oklahoma,* we find their propeller efficiencies stand in the following order: 1 *Oklahoma;* 2 *New York;* 3 *Delaware.* The order of their economical efficiencies is: 1 *New York;* 2 *Delaware;* 3 *Oklahoma.* Both the *New York* and *Delaware* have superheat; the *Oklahoma* has none. The relative standing of the *New York* and *Delaware* is largely accounted for by the difference in propeller efficiency. The *Oklahoma* has better propeller efficiency and fully as good, if not better, engines, hence one is easily led to the conclusion that the falling off in the economical efficiency of the *Oklahoma* is due to the non-use of superheat. Similarly the performance of the *Nevada* and of the *Pennsylvania* could have been improved nearly 10 per cent by using superheat.

The *Nevada* and the *Pennsylvania* are fitted with geared cruising turbines. The superior economy secured by these over other turbine vessels is clearly shown by the curves. The curves also indicate that the Parsons vessels at high speeds give about the same economical result as the Curtis-turbined *Nevada* and *Pennsylvania.* The propeller efficiencies of the

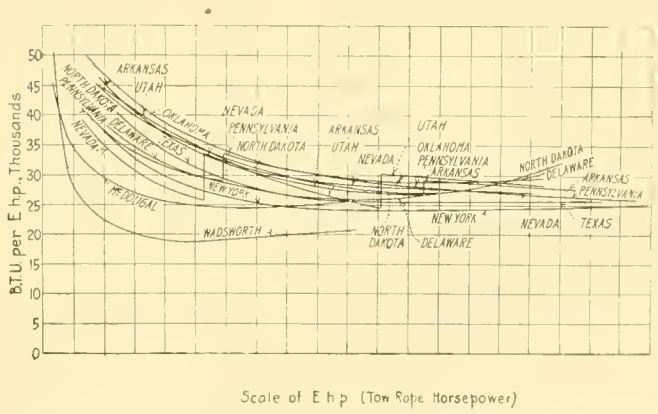

Fig. 2 Comparative Performances of Naval Vessels

Nevada and *Arkansas* are about the same. However, within the range of the intermediate-pressure cruising turbine the Parsons vessels are superior, while at very low speeds the economy in the turbine vessels is about the same. The *Pennsylvania* at high power shows slightly better economy than the *Nevada,* this being expected since it is a later and somewhat better design, and better propeller conditions due to the use of four screws running at same revolutions are obtained. At low power the *Nevada* gives better economy results. The curves of the *Utah, Arkansas, Nevada* and *Pennsylvania* are really a series of curves, as they jump from one combination of turbines to another.

In plotting the curves, that for each condition is laid down and carried up to the point where the next combination of turbines comes in. Actually, by means of by-passing steam, the results will not follow the separate lines; but, as the limit

of one combination is reached, by-passing is resorted to and a better result secured than if a complete shift to the next combination were made.

As far as economy at the different speeds is concerned, there is not much choice between the different types of machinery when they have proper propeller efficiency. At very low powers the reciprocating engine is about as economical as the geared cruising turbine, both of these being more economical than directly connected cruising turbines. The use of superheat would improve the performance, however, especially that of the reciprocating engine and impulse turbine.

The foregoing indicates that when all advantages of design are used, about the same economical results are secured with either reciprocating engines, Parsons turbines or Curtis turbines, and that other matters besides mere economical performance should decide the choice of prime mover as between the several types. It also goes to show that when the losses are properly guarded against it is the range of temperature that really counts in securing efficient propulsive machinery. Therefore, the most effective measures that can be applied are those which increase the range of temperature that can be used and those which conserve the use of the heat units supplied. Hence we have reasons for use of superheat, the employment of the highest possible vacuum practicable, the best possible use of feed-heating apparatus, and economical operation of auxiliaries.

The curves of the destroyers *McDougal* and *Wadsworth* have also been plotted, Fig. 2. Owing to large differences in hulls and speeds, the destroyers are not directly comparable with the battleships, but they are comparable with each other, and the curves indicate the general efficiency of the propulsive machinery of representative destroyers, and strikingly show the economical advantage secured by use of gearing.

STEAM USED BY AUXILIARIES

A number of tests have recently been made to determine the percentage of total steam used by the auxiliaries of naval vessels, and following are given the approximate values obtained from averaging these results:

Capital vessels	Speed, knots	10	15	19	21	..
	Per cent of total steam	38	30	18	14	..
Destroyers	Speed, knots	12	16	20	25	30
	Per cent of total steam	27	21	17	13.5	12

It will be noticed that the percentage of steam used by the auxiliaries in the case of the destroyers is considerably less than that used by the large vessels. This condition accounts for the fact that the destroyer machinery proves to be more efficient than that of the capital vessels. The above are average results for certain average conditions, but it is believed that the steam consumption of the auxiliaries can, by special care and attention, be reduced from 10 to 25 per cent below the average conditions which obtained when the water consumption was measured.

The auxiliary exhaust that is not used in the feed heaters is used in the low-pressure turbines, so that under the conditions of actual operation the auxiliaries do not use the full extent of this percentage, and all over about 10 per cent is used in the low-pressure turbine, where it will give approximately half the return that the same amount of live steam entering at the throttle would give. Therefore, strictly speaking, the auxiliaries, except electric generators, should be charged with only about half of the above percentages, since they exhaust at about 10 lb. pressure, and this exhaust is used effectively both in the feed heater and in the turbines. The following table has been compiled to show the approximate steam consumption of various auxiliaries on large vessels for full-power conditions. The amounts of steam used are quite variable and depend not only upon the design of the auxiliaries but also on the method of operation. The following gives the percentages of steam used by the auxiliaries.

	Per cent of total steam
Feed pumps	3.0 to 5.0
Circulating pumps	1.5 to 2.5
Air pumps and condensate pumps	0.2 to 0.6
Forced-draft blowers	1.5 to 3.0
Lubricating pumps	0.1 to 0.2
Oil-fuel pumps	0.2 to 0.4
Total for auxiliary machinery necessary to operate main engines	6.5 to 11.7
Bilge pumps, ice machines, steering engine and other miscellaneous machinery	1.0 to 4.0
Dynamo plant other than forced-draft blowers	1.0 to 2.0
Total	8.5 to 17.7

Evaporating plant, depending on rste of use.

The principal steam users among the auxiliaries are the feed pumps, circulating pumps and forced-draft blowers; the other auxiliaries of naval vessels use a relatively very small percentage of steam.

The introduction of turbine-driven centrifugal feed pumps will reduce the steam consumption for feeding. The consumption of circulating pumps is reduced by the use of scoop injection for condensers on destroyers and scouts, and on other vessels where this is practicable. The consumption for forced-draft blowers is reduced by using larger blower units and by having arrangements made whereby two blower units are compounded. Compounding has actually been made use of in several instances.

Electric forced-draft blowers have been used on a considerable number of large vessels. While this practice is fairly economical, the desired speed regulation is not secured, and electrically driven blowers are not well-suited to oil-burning installations. The objections to the electrically driven blowers are:

(1) Difficulty in obtaining as variable a speed as is desirable and necessary with oil fuel. With steam-turbine drive minute regulation is possible.

(2) Additional generating units have to be started when a considerable number of blowers are started.

(3) Starting and stopping of blowers creates a very variable load, and in order to accommodate this load extra generators have to be kept in operation.

(4) Electrically driven blowers cannot be efficiently operated at low speeds, and in many cases a low speed is desirable to suit the boiler output at any one time.

(5) Circuit breakers are likely to blow, and if this happens flare backs may take place and all steam generation be stopped until the blowers are again started. With steam-turbine drive it is very unlikely that all blowers would stop at the same time.

It must be remembered that the auxiliary exhaust is now invariably used for feed heating and in some instances for distilling, so that the actual heat used by the auxiliaries is really from 4.5 to 9 per cent of the total instead of from 8.5 to 18 per cent.

The auxiliaries can, by lack of care in design, condition and operation, become very wasteful, so that they do, in cases, use two or three times the amounts stated. But in our best per-

formances we are reducing the percentage of available heat used by the auxiliaries to approximately 5 per cent of the total at full power. By improvement in design and operation this figure can be still further reduced, but no very marked further saving in steam used for auxiliaries is practicable.

NEW TYPES OF MACHINERY

In the search for economy and efficiency there are new types of naval machinery to deal with which are causing both the directly connected turbine and the reciprocating engine to be superseded. These are the geared turbine and the electric drive. The hydraulic transmitter has also been considered abroad. These innovations, which have actually been tried in quite a number of cases both on naval vessels and in the merchant marine, will secure an advantage in economy of 10 to 15 per cent as compared with the directly connected units, as well as a material saving in weight. In this connection note the position of the curves of the *Wadsworth*, our first U. S. geared destroyer. For certain types of vessels the geared turbine has the advantage over the electric drive. For other types the reverse is the case. For large capital vessels of high speed the electric drive appears to have the advantage for the following reasons:

(1) There is much more flexibility so far as arrangement and shaft and piping connections are concerned.

(2) Better economy at cruising ranges is secured.

(3) Generator rooms, boilers, piping, etc., can be more adaptably arranged. The necessity for bringing large steam pipes through boiler compartments and back to the engine room is avoided, electric conductors taking the place of these large pipes.

(4) Parts of machinery can be undergoing repair while other parts are in operation at a very large percentage of the total power of the vessel.

(5) Much better handling conditions are secured, and a greatly improved power for backing is present without the complication caused by the use of backing turbines.

(6) It is entirely practicable to use a high degree of superheat.

GEARING VS. ELECTRIC DRIVE

Gearing is more suitable than the electric drive for light, high-powered vessels of the destroyer or scout type, because it is more compact and, within the limitations of these vessels, is lighter than the electric drive. It is a little more economical at high power but not as economical at cruising and intermediate speeds. Gearing is more suitable for light, high-powered installations where weight and space are cut to the minimum and where the power is not so great but what the leads of steam piping and shafting can be satisfactorily handled. The turbine-reduction-gear layout does not permit of as much protection to the machinery, and the handling arrangements and flexibility are not as good. In the scout and destroyer designs, machinery of the following characteristics may be applied: Powers up to 25,000 shaft h.p. on one reduction gear set, two pinions being utilized. Water consumption of 10.5 to 11 lb. per shaft h.p. at full power; machinery weight, total, about 40 lb. per shaft h.p. Such machinery contemplates the use of scoop injection condensers, and also the possible use of steam ejectors or kinetic tanks in place of air pumps. Such machinery also requires the reduction of all the auxiliaries to the lowest limit that is practicable.

A comparison of gearing and electric drive on various points is given below. The advantage is not all one way, and the special conditions of vessel and her service requirements will govern the choice of one type or the other.

GEARING	ELECTRIC DRIVE
Weight	
The initial advantage rests with the gearing, since the gear will not weigh as much as the generator and motor combined. As very large powers are used and a multiplicity of shafts, this advantage is lessened.	The saving of weight by using gearing will, however, not be a very large percentage of the total machinery weight, probably not more than 1 or 2 per cent. However, considerable weight in piping is saved by means of the electric drive, so that for large vessels the weight of machinery is about the same for either gearing or for electric drive.
Space	
The advantage will rest to a slight extent with gearing, so far as the cubical contents are concerned.	The space can, however, be in many cases more advantageously utilized. The generator can be placed at some distance from the motor. The shaft can be greatly shortened. This advantage shows up specially on large vessels. Superior boiler-room arrangements can be utilized.
Racing	
The gear and turbine will be subject to the racing action of the propeller.	There will be no racing. The motor will govern the propeller and maintain even speed. This fact may possibly produce a slight gain in propulsive efficiency.
Handling	
Handling is satisfactory.	The advantage rests with the electric drive, especially with regard to backing power. See Jour. A.S.N.E., February, 1916, Stopping, Backing and Turning Ships, by Lieut. S. M. Robinson, U. S. N.
Adaptability to Best Conditions for Efficient Propulsion	
The gear ratio having been adopted it can not be changed. If the effective horsepower and propeller efficiency have not been accurately estimated, an improper ratio will be present which may prevent the turbine from securing its most efficient speed. Unless very high gear ratios are employed the most economical turbines can not be used.	The relative speed of propeller and turbine can be altered to any extent. The turbine can therefore run at its most efficient speed without reference to the propeller speed. This enables a very-high-speed turbine to be used, which allows of greater economy. The design can utilize the very best propeller conditions without affecting the design or limitations of the turbine.
Facility for Repair	
No special advantage. Whole engine plant has to be run when under way. At present large gears can only be cut by very few firms.	In case of accident generator and motor parts can be renewed more easily than gear can be repaired. One generator can be repaired while other works to full power. This will give about three-quarter-speed.

Repairs to be Expected

Repairs to gearing will be little or nothing; but if damaged to any extent, however, gear will have to be replaced. A spare gear should be at hand to replace one damaged by accident.	The repairs to generator and motor may be of considerably greater extent and may cost more than those to gear, but they can be more readily made, and actual experience with the *Jupiter* does not indicate that there will be large repair bills.

Economy

With the same boilers and turbines gearing has an advantage of about 5 per cent at full power. The same turbines may, however, not be feasible, since the turbine to be used must accommodate itself to the gear that is being used.	Owing to ability to use only one generator at below half power, the ability to run generator at practically constant speed and the flexibility of the electric bond to adjust itself to any speed ratio, it is likely that the initial advantage of gearing in economy will disappear at cruising speeds, and at low speeds the electric drive will be more economical.

Reversibility—Backing Power

Requires a backing turbine, which complicates design and enables only a portion of full power to be used for backing. Limited to about 50 per cent backing power, even with very large backing turbines.	Full backing power is secured without disturbing turbine. Reversing is made particularly easy, and the full utilization of the steam supply is possible for backing, since there is about the same engine efficiency backing as going ahead.

Care in Operation

Little or no special care required for the gear. Oil supply the essential matter. Some difficulty in lubrication has been experienced.	Considerable attention will have to be given to maintaining generator and motor in condition. This also requires a special knowledge of electrical features, for which personnel will have to be specially trained. Ventilation of motor and keeping it dry will require special attention.

Facility for Installation

Location of turbines and gear fixed by position of shaft.	Generators can be located anywhere without regard to shaft. Best location of condenser, steam piping, etc., can be secured. This enables a more more adaptable and simple arrangement to be made. Special advantage of this may be taken in making best provision for torpedo protection.

Certainty of Data on Which to Base Design

Gears suitable for very large power have not yet been built in this country. Each installation practically necessitates a new design of the gear. Existing installations have been generally successful, but some trouble with wear on gear and breaking of gears has been experienced.	All portions of the electric drive apparatus have been built and fully tested out: They have been applied to one marine installation and have been successful.

The Ljungström turbo-dynamos are a new feature in marine electric driving, but though there has been an installation actually built, the device is still experimental. If it stands up in service it will be a means of improving the now accepted type of electric drive in this country by about 10 per cent. Nothing definite has been done with this device in the U. S., though a great increase in economy is claimed for it and has been secured in numerous actual installations.

Boiler Efficiency

The campaign for economy also makes it necessary to inquire into possible ways of improving boiler economy. Boiler efficiency has remained approximately at a standstill for quite a number of years, but the advent of oil burning has given a new phase to the situation. By means of improved burners continual improvement in combustion has been effected. A great deal of experimental work has been done by the fuel-oil testing plant at the Navy Yard, Philadelphia, and marked improvement in burners has been secured.

It is believed, however, that we are about to secure a material improvement by arranging the heating surface of boilers so as to secure a proper relation between the flow of gases and the circulation of water. The actual course of circulation in water-tube boilers is a matter that bears study and investigation. A recent disclosure has shown that some generally accepted ideas are in error. It is believed that to obtain the best efficiency the gases must be so directed as to pass in the counter direction to the flow of water in the tubes, and that as the gases are cooled and the volume reduced the area of the gas passage should be decreased in order that the velocity of the gases may be maintained at a proper point for the requisite efficiency. Some experiments along these lines are under way.

The best boiler results that we have record of give from 77 to 81 per cent efficiency for well-baffled straight-tube boilers (with 0.1 to 0.3 lb. oil per sq. ft. of heating surface), and about 70 to 78 per cent for express boilers. With coal the boiler efficiency averages about 5 per cent less. It is believed that by special care based on proper experimental data a boiler efficiency of 85 per cent can be secured for continuous operation on board ship; this economy to be effected by means of proper baffling and proper relation of baffling to boiler circulation, and by supplying more efficient clothing and lagging. An oil furnace means a higher furnace temperature, and hence more boiler clothing is needed.

Special Conditions of Design

The demands upon the engineer to secure in the new designs the necessary power for a great increase in speed, as well as for special and unprecedented protection from torpedo attack, have made it necessary to get every bit of power out of every pound of weight and cubic foot of space allowed. Everything non-essential must be left off, and every part must be designed to be adequate but without excessive margin. The principal method of saving both weight and space is to install machinery that will secure the highest practical economy, and in searching for the means of accomplishing this the naval engineer is looking to the engineering talent of the country to come to his assistance.

New Developments in Naval Engineering

The present time is especially a period of development in naval engineering. The European war, and the developments caused by it, have emphasized and will tend to emphasize many new features and point out special lines of advancement in naval engineering. We are now almost at the stage of dis-

carding the reciprocating engine and the direct turbine drive for new fighting craft, and in their place are coming turbine reduction gear and the electric drive, with the oil engine for submarines and as a possibility for some auxiliary vessels. Coal burning is being superseded by oil burning on nearly all classes of vessels building for our Navy. There have been recently successfully tried three superdreadnoughts, the *Nevada*, *Oklahoma* and *Pennsylvania*, all of them equipped with oil-burning boilers exclusively. This marks a special step of progress in the evolution of naval engineering work, and the use of oil fuel has permitted many engineering and operating advantages to be secured. Special development is taking place in the field of aeronautical apparatus, and a great deal of this is being done by the coöperation between the Navy and the engineering industries of the country. Many new developments of condensing apparatus, pumps and other auxiliaries are coming on. New things are dawning all the time, and as fast as they give promise of practicability, reliability and proper adaptation to naval use they are tried out and adopted. There is continual progress toward greater efficiency, greater economy, compactness, and in reduction of weight, which enables the United States to take the lead in engineering development. Such developments are largely the result of coöperation between the industrial engineers and the naval engineers. Further to develop this, more experimental and laboratory work is necessary, and the country must be willing to spend some money for experimentation in order to save in actual service, and to secure greater efficiency.

The Navy has now in service one destroyer, one destroyer tender and one submarine tender equipped with Parsons turbine reduction gear, and one collier equipped with Westinghouse reduction gear. There are building four destroyers with machinery of this type, three with Parsons turbines and one with Curtis. Geared cruising turbines are being used on fifteen destroyers and five battleships built and building. The electric drive has been tested out on one auxiliary vessel and is being installed on three first-class battleships building. In the matter of electric drive for propulsion of ships our Navy is the pioneer. This is entirely an American development, and the men responsible for its initiative and its development to a successful point are all Americans. The Navy Department has materially assisted in this development. An experimental Diesel engine, the largest yet to be installed on a vessel, has been completed at the Navy Yard, New York, and is now being installed on the oil-fuel carrier *Maumee*, which has been towed there from San Francisco. This two-cycle Diesel engine, of 5200 h.p., was built by the Government. The tender *Fulton* has been equipped with a two-cycle Diesel engine and has been in service for over a year.

Among the new things in the auxiliary machinery of naval vessels, it may be mentioned that the small steam turbine has been developed as the accepted drive for forced-draft blowers on nearly all our naval vessels. In this also the United States has been the pioneer. The use of gearing for turbine-driven generators, pumps and blowers has also been initiated. Rotary pumps are now being used for oil-fuel service.

Condensers.—The principal improvement in condenser practice has been the adoption of expanded tubes in place of packed tubes. Expanded tubes can be kept absolutely tight, while there is always some doubt about a packed tube. For some years expanded tubes have been used on destroyers. For large vessels the tubes have been expanded at inlet end and packed at outlet end. This prevents crawling of tubes.

Augmenters, dual air pumps, or some kind of dry vacuum apparatus are installed. Tube spacing to allow of least possible resistance to flow of steam is being employed.

Steam ejectors in combination with a condensate pump have been experimented with and their use is being considered. These ejectors save a great deal of weight and space, but they will have to be thoroughly tried out before they can be generally applied.

The importance of high vacuum is fully appreciated and no effort is spared to obtain all possible advantage within the limitations of the design. On turbine vessels the design contemplates securing a vacuum of about 28 to 28½ in. of mercury at full power, with circulating water at 70 deg. fahr. At lower powers a better vacuum is obtained. On destroyers and scouts scoop injection condensers are being used, with a small auxiliary circulating pump to furnish circulating water for backing and while vessel is standing still or maneuvering.

Feed Pumps.—Turbine-driven multiple-stage centrifugal feed pumps are being installed on our latest vessels. It is expected that these pumps will be more reliable, furnish a more steady pressure, and be considerably more economical, especially in repairs, than the reciprocating plunger pumps that they supersede. It is also expected that the centrifugal pumps will require far less overhaul and will lessen the danger of rupturing feed piping.

Rotary Pumps are being adopted for fuel oil service. These pumps give a more steady pressure.

CO_2 *Refrigerating Machines* are being used in place of dense-air ice machines. Some of the later machines are electrically driven, but there is no very special advantage in the electric drive. Small electrically driven refrigerating machines of several types have been developed for use on destroyers and small craft, these being similar to machines used in yachts and private houses.

Distilling Plants of multiple-effect, low-pressure (operating under a vacuum), non-scaling type are being fitted, and auxiliary exhaust is being extensively used for operating evaporators. These steps have resulted in materially reducing the fuel consumption in port. The use of feed heating in connection with distilling plants is being extended and consequent gain in economy realized.

Clutches for connecting or disconnecting cruising units or motors while shafts are revolving, have been experimented with and installed in a number of vessels; some are hydraulic oil clutches, others magnetic. A thoroughly reliable clutch for this service is very desirable, and from the different kinds tried it is hoped that several will be developed beyond the experimental state in the near future. The clutches used are the Metten clutch, operated by oil pressure, the Turner mechanical clutch, and the magnetic clutch manufactured by the Cutler-Hammer Co.

Forced-Draft Blowers.—Tests and experiments have been carried on for several years in order to develop forced-draft fans for destroyers that will be both strong and durable, and which will operate as noiselessly as possible. This is an extremely important matter, as the noise of these fans is one of the things that will disclose the presence of a destroyer to an enemy; it also indicates lack of efficiency.

The Gyroscope, besides its entirely successful application in the gyroscopic compass, which is now installed on all naval vessels of fighting value and which has made submarine navigation practical and reliable, is also being used in numerous other fields, such as a stabilizer for air craft, submarines and for other naval craft.

Radio Apparatus.—In the field of radio development tre-

mendous strides are being made. The range of apparatus on naval vessels has been doubled. Trans-Pacific stations are being built to connect the radio chain across the Pacific from San Diego to Cavite *via* Pearl Harbor. The wireless telephone is also being developed in conjunction with the radio stations.

STANDARDIZATION OF ENGINEERING APPARATUS

Another vital matter involving naval engineering preparedness is the standardization of engineering methods, tools, gages, fittings, parts, etc. Comparatively little has been done in this matter, and the difficulty seems to be to get someone or somebody to start things. The American Society of Mechanical Engineers and other engineering societies have labored in this field, but definite progress is not satisfactory.

Standardization of mechanical apparatus is essential to the maximum efficiency of the naval engineer. Whenever standardized commercial articles can be used the Department is desirous of so doing, as a standard commercial article is (1) more quickly obtained; (2) allows increased competition; (3) will be cheaper; (4) will necessitate carrying a smaller stock of material; (5) and can be obtained readily when away from the source of supply.

Steps towards standardization have been made along the following lines: (1) Boiler-tube specifications of the American Society for Testing Materials, The American Society of Mechanical Engineers, and Railway Master Mechanics' Association are recognized by law in several of the states; (2) Spark plugs for gas engines are fast coming to a standard size with a standard screw thread.

The Navy Department has always been in favor of standardizing mechanical apparatus, and of late years we are trying hard to fix matters so that the best commercial practice in any field will be suitable for naval work. Standardization in many particulars is essential, and the manufacturers and mechanical engineers of the country should be making special effort to secure further standardization of methods, tools and parts. In the end the engineering industry of the country will benefit by this standardization, and engineering material and apparatus can be more economically supplied.

COÖPERATION OF ENGINEERING ACTIVITIES

The naval engineer, both in and out of the service, has many new and interesting problems before him, and it behooves him to be looking to the future to employ the best that science and mechanical ability can provide for fashioning the weapons of naval preparedness. The best development of naval engineering matters will be accelerated by the best possible coöperation between the naval and the industrial engineering talent of the country. Without this hearty coöperation and the support of the engineering facilities of the country, the Navy could not be properly placed or kept upon a war footing. In fact, without the utilization of the civilian engineering talent of the country we would not get very far with our material for the Navy. The Navy appreciates the need of this coöperation, and desires that our commercial engineering forces coöperate in every possible way to give it the best material that American engineering talent can devise and that its mechanical forces can fabricate.

But not only should there be coördination between the civilian engineer and the engineer in the Navy, but there must also be that coöperation and standardization of engineering means and efforts that this Society aims to foster and in which it has been so markedly successful.

A new type of Humphrey pump, built in small sizes, utilizes the oscillations of a heavy weight instead of a column of water.

On the initiative of the Royal Society a Board of Scientific Societies has been established in England to promote the coöperation of those interested in pure or applied science; to supply a means by which the scientific opinion of the country may, on matters relating to science, industry and education, find effective expression; to take such action as may be necessary to promote the application of science to the nation's industries and to its service; and to discuss scientific questions in which international coöperation seems advisable. The board at present consists of representatives of 27 scientific, including technical, societies.

The term "yield point" does not appear to have any fixed meaning, according to J. E. Howard, in a discussion of a paper read before the American Society for Testing Materials, and in his opinion there seems to be no feature in the behavior of steel which calls for this term, or to which it can properly apply. The term is essentially vague and uncertain, and well calculated to create confusion. It is an approximation to the elastic limit, but having been given a name it purports to have a definite meaning. The most that can be said about it is that a structural member loaded up to its yield point will suffer a certain amount of permanent strain.

In steel coal hoppers, filled as they are almost all the time with moist coal, the corrosion of the metal is quite rapid. To prevent this, according to the *Electrical World* (Aug. 19, 1916), it is the practice of the Commonwealth Edison Company (Chicago) to line the hoppers with cement, as follows: After removing any rust from the metal the steel is painted with rust-resisting paint and wire mesh fastened in place. Cement is then applied by spray or by a cement gun, under an air pressure between 40 and 60 lb. per sq. in., and is hydrated before emerging from the nozzle by water coming through a separate hose. The lining thus applied is about 3½ in. in thickness and offers a smooth surface not easily abraded and which protects the steel from the deteriorating influence of the moist fuel.

The lifting capacity of a lifting magnet depends entirely on the materials which it has to handle, particularly, however, on (*a*) the magnetic quality of the load; (*b*) the temperature of the material, which should not be above black heat; (*c*) the shape of the load and whether it consists of one solid piece or a number of small parts; and (*d*) the manner in which the material to be lifted is stacked. Although the lifting capacity cannot be calculated, it may be assumed that a well-designed magnet is capable of lifting a solid piece of steel, with machined surface, of not less diameter than the magnet itself, weighing approximately 15 times the weight of small magnets, 8 to 12 times the weight of magnets from 24 to 36 in. in diameter, and 5 to 6 times the weight of magnets from 36 to 60 in. in diameter.—*The Electrician*, Aug. 11, 1916.

STEAM-FLOW MEASUREMENT

A Statement of the Problem of Steam Metering to Determine Boiler Output or Prime Mover Capacity, and a Description of an Experimentally Developed Meter of the Orifice Type

By ERVIN G. BAILEY, BOSTON, MASS.

Member of the Society

THE accurate measurement of the flow of fluids is one of the most important problems facing the mechanical engineer today. The turbine, boiler and mechanical stoker have been materially improved in their design both as to size and efficiency, but much still depends upon the method of operating these large units. The operating engineer cannot get results when working in the dark: he particularly needs to know the steam output from the boilers, the condition of the fuel bed, the air supply to the furnaces and the steam consumption of the turbines. Methods of determining the kilowatt output of the latter have been in satisfactory use for a number of years. Electricity is comparatively easy to measure, and we find the switchboard supplied with all kinds of instruments for this purpose. There is just as much need for the corresponding measurements of the flow of steam and gases.

METHODS OF MEASURING PRESSURE DIFFERENCE

It is desirable to go a step further than merely to measure these rates of flow, and show in addition the relation between two or more interdependent quantities which enter into the operation of a steam boiler or prime mover. Seven years of experimenting, which involved the use of more than fifty steam-generating or steam-using units, have produced many interesting results along this line, but the present paper will be confined to the measurement of steam flow, as this is really the crux of the whole question. Few problems have been more baffling to the mechanical engineer than the accurate metering of steam in large quantities. It is necessary to use the "flow" principle; that is, to produce a pressure difference which varies in a definite and known relation to the rate of flow, and then to measure accurately this pressure difference in terms of weight of steam.

There are only two fundamental principles that have been used to obtain the pressure difference, *viz.*, "impact" and "change in velocity." The "impact" principle is used in the pitot tube with its various modifications, and the Vortex[1] and Metering Bend[2] also belong to this class. The "change in velocity" type covers the venturi tube and the orifice.

We do not usually think of the orifice as being of the same basic principle as the venturi tube, but the two are practically identical when the orifice is used in a pipe and the pressure connections are made at the proper place. The pressure difference produced in both cases is caused by the increased velocity and the corresponding change in the static pressure between two different positions along the pipe where the flowing stream has different areas. The exact area and location of the smallest section of the stream on the downstream side of an orifice may not be quite as tangible a thing to see and measure as is the throat of a venturi tube, to which it corresponds; but experiments have proven that it is none the less a perfectly dependable function of the opening in the orifice plate. With high initial velocities the pressure difference is largely restored in static pressure within four pipe diameters beyond the orifice, so that the net loss in head caused by the orifice may not be more than 25 per cent of the head available. This compares very favorably with the best design of venturi tube, where the net loss is about 15 per cent of the total venturi head.

Pitot-tube and multi-hole nozzles of various designs and

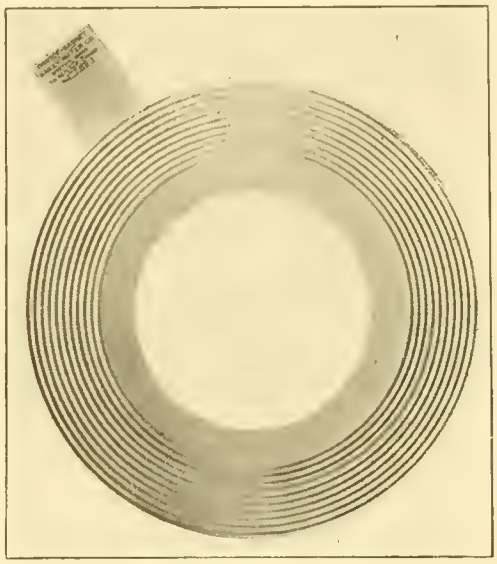

FIG. 1 INITIAL DESIGN OF ORIFICE PLATE

modifications were used exclusively during the first two years of experiment, but were entirely abandoned for reasons explained later. The venturi tube was at first considered to be the only available substitute, but the expense of changing large steam pipes, in addition to the cost of the tube itself, made this prohibitive for very general use. The orifice was taken up and the following important points were considered in working out a suitable design:

1 The orifice plate must go in between a pair of existing pipe flanges.

2 It should not thicken the joint so as to throw the flanges out of parallel.

3 The metal used should perfectly withstand all corrosion and abrasion.

4 It should be capable of easy installation.

TYPE OF ORIFICE ADOPTED

The initial design shown in Fig. 1 consisted of a $^1/_{32}$-in. Monel metal plate having corrugations on its outer edge to

[1] A Rate Flow Meter, H. C. Hayes, Trans. Am.Soc.M.E., vol. 36, 1914.

[2] A Flow Metering Apparatus, A. M. Levin, Trans. Am.Soc.M.E., vol. 36, 1914.

Presented at a meeting of the Boston Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, May 23, 1916.

make its own packing the same as a corrugated copper gasket, and having a round concentric hole smaller than the pipe diameter. But what coefficient to allow in calculating the size of the orifice for a given pipe diameter, steam density and rate of flow, was the big unknown. The importance of testing the orifice to see if it would maintain a constant factor over long periods of time was of more importance than to know the exact factors under all conditions, consequently some guesses as to the coefficient were made and several orifices were put into experimental use in places where the service was continuous and severe.

It may seem that the early experimenting could have been done with most anything and a satisfactory design worked out later, but too often some practical consideration necessitates a decided change in design which upsets all the previous results. It is much better to get a good working design and learn whether the device will keep on working and maintain its accuracy, before any extensive scientific tests are made to learn definitely what physical laws are involved in its use.

One of the first orifices of this type was put into a 15-in. pipe supplying steam at 200 lb. pressure and 150 deg. superheat to a 15,000-kw. turbine in the L St. Station of the Edison Electric Illuminating Company of Boston, where the rate of flow averages more than 150,000 lb. of steam per hour. The

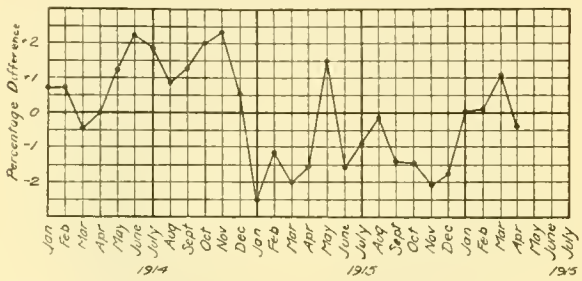

FIG. 2 COMPARISON OF STEAM METER READINGS AND ACTUAL WEIGHTS OF STEAM

Abscissas give percentage differences in meter readings from actual weights

only flange available was at the inlet to the turbine strainer, about 6 ft. (or five pipe diameters) beyond a 90-deg. bend of 6 ft. radius. The Testing Department of the Edison Company have made weighed water-rate tests of this turbine each month since this orifice was installed in December, 1913, and results from this orifice have been obtained at the same time.

DATA OF TESTS ON EXPERIMENTAL ORIFICE METER

The substance of these tests is given in Table 1, and the percentage differences between the weights and orifice-meter results are plotted in Fig. 2. It is noted that there are 28 tests extending over more than two years, and that approximately 1,000,000 tons of steam have passed through the orifice in this period. It is also noted that the greatest difference is 2.51 per cent, and that the majority of them are within 1 per cent. The device for measuring this pressure difference was not of the latest and best design.

It is shown conclusively that there is no appreciable change in the orifice factor over this period. This is also borne out by the measurement and appearance of orifice plates replaced by others of larger capacity after a year or more of service, none of which shows any corrosion or wear whatever.

The main object of the Edison tests is to determine the water rate of the turbine, the orifice data being secondary, and it is customary to make all tests at approximately the same load, but this does not detract from the value of these results in proving the continued accuracy of the orifice over long periods of time.

Other orifices were put in from time to time under various conditions where weighed-water calibration data could be obtained at capacities most frequently met in practice. The coefficient of discharge did not appear to be as constant for different ratios of orifice to pipe diameter as it had been hoped that it would. The indications were that the orifice was fundamentally correct, and the discrepancies encountered were only through lack of sufficient knowledge relating to details. The general trend of the data up to this point was that the coefficient of discharge increased with an increase in the ratio of orifice diameter to pipe diameter, with no obvious reason why it should. In cases where the area of the orifice is large compared with the area of the pipe, the velocity of approach is an important factor, but even taking this into consideration, the net coefficient of discharge increased with the orifice area. This same fact has since been brought out by Hickstein,[1] who practically followed the results obtained in Charlottenburg[2]

TABLE 1 STEAM MEASUREMENTS WITH AN ORIFICE-TYPE FLOW METER

Results from a meter measuring steam to a 15000-kw. turbine in the L Street Station of the Edison Electric Illuminating Company of Boston. This meter has a maximum capacity of over 200,000 lb. per hour, and is provided with a Monel metal orifice placed in the inlet flange of the turbine strainer about 6 ft. beyond a 90 deg. bend in a 15-in. pipe. Meter readings were taken in conjunction with the regular monthly turbine water-rate tests by the company's testing department.

Date	Duration of test	Steam pressure by gage, lb.	Superheat, deg. fahr.	Condensed steam per hour as weighed, lb.	Steam per hour by orifice meter, lb.	Difference between meter and weight, per cent
1/ 8/14	1 hr.	196.5	129.6	133,417	134,372	+0.72
2/ 6/14	1 hr.	191.3	152.2	137,739	138,756	+0.74
3/28/14	55 min.	200.1	128.4	136,763	138,163	−0.44
4/23/14	1 hr.	190.7	135.4	136,332	136,366	+0.02
5/14/14	1 hr.	193.1	149.0	132,610	134,299	+1.27
6/12/14	35 min.	196.5	134.1	135,421	138,495	+2.27
7/ 9/14	1 hr.	191.3	128.8	138,740	141,300	+1.85
8/15/14	1 hr.	194.2	130.8	142,065	143,235	+0.84
9/10/14	1 hr.	197.0	129.3	136,846	138,606	+1.29
10/20/14	1 hr.	197.5	138.2	137,003	139,723	+1.99
11/21/14	1 hr.	193.9	140.8	132,552	135,631	+2.32
12/19/14	1 hr.	196.0	146.2	129,759	130,454	+0.54
1/22/15	1 hr.	198.0	152.1	131,134	127,845	−2.51
2/19/15	1 hr.	195.2	163.7	129,165	127,641	−1.18
3/18/15	1 hr.	193.0	168.3	128,917	126,317	−2.02
4/24/15	40 min.	195.0	158.5	132,017	129,856	−1.56
5/20/15	1 hr.	197.4	158.6	132,107	134,120	+1.52
6/22/15	1 hr.	193.5	145.8	140,582	138,340	−1.59
7/20/15	1 hr.	192.8	141.2	138,457	137,110	−0.97
8/19/15	1 hr.	192.6	141.5	139,200	138,975	−0.16
9/23/15	1 hr.	196.8	143.0	139,385	137,399	−1.42
10/27/15	1 hr.	195.0	142.3	137,504	135,472	−1.48
11/19/15	1 hr.	193.8	152.1	137,397	134,528	−2.09
12/7/15	1 hr.	196.1	154.2	131,466	129,205	−1.72
1/18/16	1 hr.	196.0	152.2	130,526	130,610	+0.06
2/11/16	1 hr.	194.1	141.3	131,812	132,001	+0.14
3/14/16	1 hr.	195.2	171.4	129,030	130,391	+1.05
4/13/16	80 min.	189.4	144.2	137,472	136,945	−0.38

[1] The Flow of Air Through Thin-Plate Orifices, Trans. Am. Soc. M. E., vol. 37, p. 765.

[2] Zeit. d. Ver. deutsch. Ing., Feb. 22, 1908.

some years ago. These two experiments dealt with natural gas and air only, and unfortunately the pressure connections were located at such great distances from the orifice plate that they could not possibly be duplicated in but very few steam pipes, where there were long straight runs.

LOCATION OF PRESSURE CONNECTIONS

The question which came up in this problem, that had never been thoroughly investigated to our knowledge, was the location of the pressure connections on the upstream and downstream sides of the orifice. It was felt that this was a point which should be thorougly investigated, consequently, at the

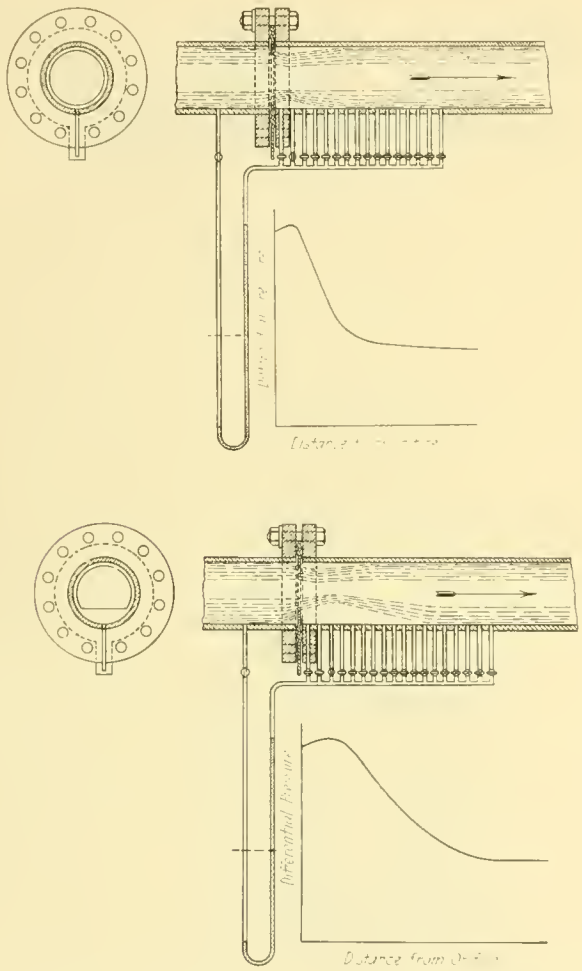

Fig. 3 Effect of Location of Pressure Connections

writer's suggestion, Professor Judd of Ohio State University started some experimental work along this line and some of his results were presented in a paper at the New Orleans Meeting of this year under the title of Experiments on Water Flow Through Pipe Orifices.

The important points brought out by Mr. Judd's data are:

1 The coefficients of the orifices tested are substantially constant at all rates of flow for any one set of pressure connections, regardless of their location with respect to the orifice plate.

2 The location of the pressure connections is of vital importance with the higher ratios of orifice to pipe diameter with round concentric orifices, due to the restoration of static pressure.

3 The use of specially designed orifices of other shapes than round and concentric permits the downstream connection to be far enough away to clear any flange, and also allows more latitude in the location of this connection without endangering the accuracy.

The last two points are clearly illustrated in Fig. 3, which shows a diagrammatic arrangement of the experiment and the plotted curve representing the pressure difference as measured between the upstream connections and the several downstream connections located at ½-in. intervals from the orifice plate. It is evident from the round concentric orifice of rela-

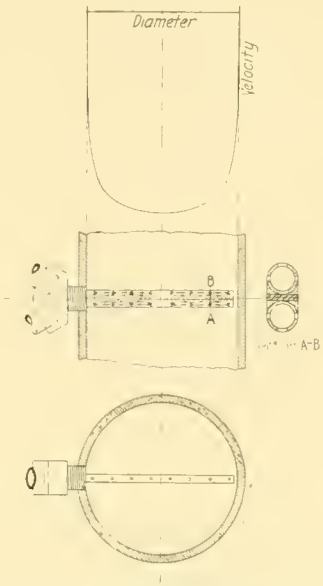

Fig. 4 Experimental Multi-Hole Nozzle with Side Outlets

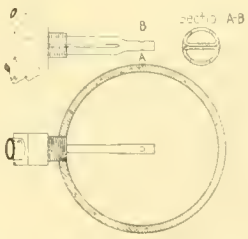

Fig. 5 Single-Hole Nozzle

tively large diameter in the upper view of Fig. 3 that the action of the fluid on the downstream side of the orifice is practically identical with that in the venturi tube. The point of highest velocity is at the "vena contracta" just beyond the orifice plate, and the static pressure is the least and the pressure difference the greatest at this point which corresponds to the throat of the venturi tube. The active stream expands beyond this point, and as its velocity is thereby reduced the static pressure is partially restored and the pressure difference correspondingly diminished. As high as 77 per cent of the pressure difference is restored in some cases.

It seems that the orifice acts merely as a forming tool to direct the active stream into a natural venturi shape, and at the same time gives just as dependable results. In fact, it appears to give more dependable readings than a venturi tube when placed close beyond or in front of bends or other disturbances. Similar orifices put in under the conditions given

below gave the same coefficient within 1 per cent when calibrated by actual weight tests.

CONDITIONS OF ORIFICE INSTALLATIONS GIVING SAME COEFFICIENT WITHIN 1 PER CENT

Size of Pipe, In.	Fluid Measured	Straight Run on Upstream Side, Pipe Diam.	Conditions on Upstream Side of Straight Run	Straight Run on Downstream Side, Pipe Diam.	Conditions on Downstream Side of Straight Run
15	Steam	5	90 deg. bend	none	Turbine strainer
8	Steam	1½	90 deg. bend	none	Turbine strainer
6	Steam	3	90 deg. bend	none	Gate valve
6	Steam	20	Gate and globe valve	20	Orifice
5	Water	59	Elbow	56	Orifice
4	Steam	6	Outlet of 4-in. tee	none	Gate valve

UNSUITABILITY OF PITOT TUBES AND NOZZLES FOR MEASURING THE FLOW OF SWIRLING FLUID

The writer believes that a helical or corkscrew motion of the fluid following a bend or similar disturbance is very common and prevents any satisfactory results being obtained from

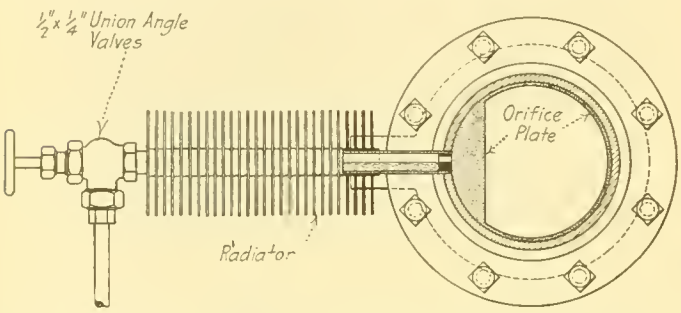

Fig. 6 Segmental Orifice and Radiator in Horizontal Pipe

the use of pitot tubes, multi-hole nozzles, or venturi tubes, while the orifice seems to give the same coefficient as if in a long straight run of pipe. To illustrate this the following interesting experience is given:

It was desired to measure the steam output from some 250-h.p. boilers having 8-in. steam outlets which gave a very low steam velocity. The boilers were standard two-drum Babcock and Wilcox with the 8-in. pipe rising from the manifold with a 90-deg. bend and then about 3 ft. of straight horizontal run into a gate valve adjacent to the header. At first a multi-hole nozzle similar to that shown in Fig. 4 was located about 1 ft. in front of the gate valve, and upon calibration it was found that the reading was about 15 per cent lower than would be expected. At first it was assumed that the highest velocity was not in the center of the pipe, but was shooting above the nozzle as a result of the 90-deg. bend. Traverse work in steam pipes from boilers was not attempted, owing to the fluctuating rate of steam flow and the difficulty of handling adjustable tubes in high-pressure steam lines. A single-hole nozzle like that shown in Fig. 5 was then tried, and a rather unexpected set of results obtained; for during the night time, when the load on the boiler was very light, it was found that this nozzle gave very nearly the same factor as applies to a long straight run of pipe, but as soon as the load came on in the morning, instead of the steam-flow pen starting up, it would drop. If the load was sufficiently increased it would come back to the same reading given on the night load, or a little higher, but never did it go anywhere near as high as it should. Some calibration work under the heavy-load conditions showed that this single-hole nozzle gave results as much as 85 per cent low.

In seeking an explanation all available literature on the subject was examined, and it was found that the paper of Gregory and Schoder[1] gave practically the only data pertaining to traverses of pipe lines in and near a bend. Some very peculiar flow curves were shown in this paper with practically no comment, but by plotting these flow curves on pieces of paper and pasting them at right angles to each other as the traverses were made and stringing them on a bent wire, it was very

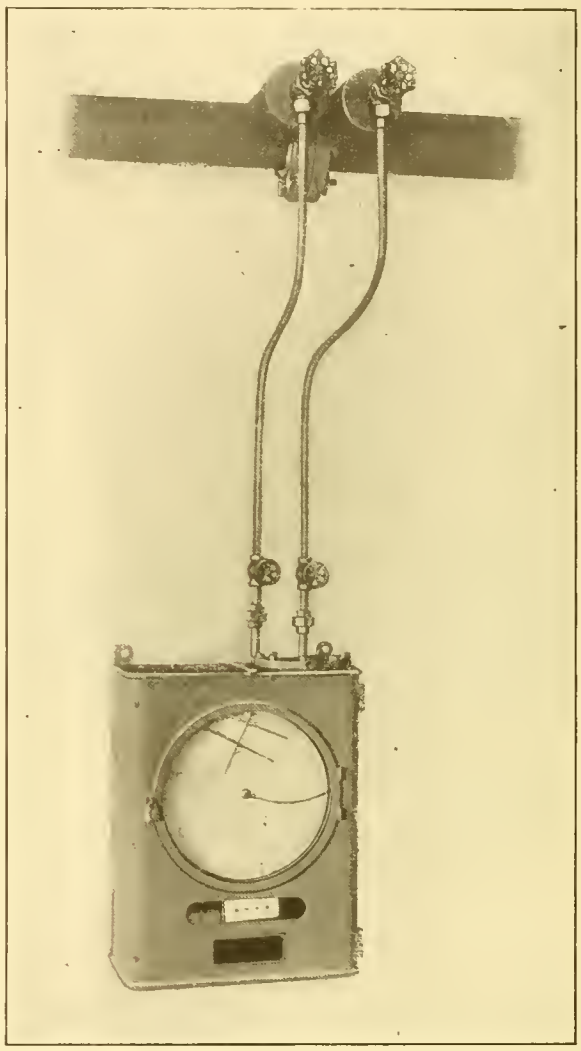

Fig. 7 Bailey Fluid Meter

evident that a swirling motion was taking place, which resulted in a higher velocity near the circumference of the pipe than existed in the center. This coincided with our experience, because the single-hole nozzle showed the velocity in the center of the pipe to be normal at low velocities, but very much below normal at velocities which might be expected to produce the helical motion.

To prove this beyond doubt, the next step was to put in a single-hole nozzle, or the equivalent to a pitot tube, with the openings near the circumference of the pipe. This was done, and it was found that a very high velocity existed within ½

[1] Some Pitot Tube Studies. Trans. Am.Soc.M.E., vol. 30, 1908.

in. of the circumference of the pipe when the boiler was steaming at 50 per cent or more of its rated capacity.

This experience killed all faith in the pitot tube and any other type of nozzle for use in steam pipes where there was any possibility of helical or swirling motion. Orifices were installed in these boiler connections at the inlet to the gate valves with very accurate and satisfactory results.

The gradual contraction at the inlet to a venturi tube would have no tendency to destroy the helical motion, and its angular velocity would be greatly accelerated in the throat, thereby producing a centrifugal force against the piezometer holes and giving an erroneous pressure difference. The more sudden contraction in the orifice and its downstream pressure connection being entirely away from the active stream, are undoubtedly responsible for the satisfactory results from its use.

In addition to the fact that the multi-hole nozzle did not give a true average in the instance referred to with the helical motion of steam, it also failed to maintain a constant factor even in long runs of straight pipe. The type of nozzle used in these experiments is shown in Fig. 4. This was made by driving two pieces of $^5/_{16}$-in. phosphor-bronze tubing into a plug having a ¾-in. pipe thread to be screwed into the side of the steam pipe. Regardless of the size of pipe, the upstream tube was drilled with eight $^3/_{32}$-in. holes, equally spaced across the diameter of the pipe. The downstream tube was drilled in the same manner, so that it got the reverse effect instead of being a true static. The side outlet holes shown were used only for high velocities. The theory of this multi-hole nozzle is not based upon very sound premises, for in the case of a normal flow in a long run of straight pipe with the higher velocity in the center, it is obvious that the dynamic force against the holes near the center of the pipe will be greater than that against the holes near the side, therefore steam will enter the center holes, divide, and run in both directions through the $^5/_{16}$-in. tube and be forced out against the flowing stream through the holes near the side of the pipe. The net result, insofar as pressure or pressure difference is concerned, will therefore be a function of the relative area of these holes as compared with the area and length of the tube in which they are drilled, together with the spacing of the holes along the tube with respect to the diameter of the pipe. Considerable experimenting was done with this type of nozzle in various sizes of pipes, and its coefficient was found to vary between 1.19 and 1.21.

Early in our experience some very high velocities were encountered in the case of 500-h.p. boilers provided with 5-in. steam pipes, as the boilers were frequently operated at 220 per cent or more of their rated capacity. The velocity head that would be produced by the multi-hole nozzle as shown in Fig. 4 with only the upstream and downstream holes would have exceeded 7 in. of mercury, which was beyond the capacity of the recording device being used, and it was therefore necessary to minimize this pressure difference in some way. It was first decided to drill by-pass holes between the upstream and downstream tubes of the nozzle, but this was never tried because the tubes were not always exactly the same distance apart, and in drilling through the spacer and brazing material which filled the space between the tubes, it would give the equivalent of a long tube of small diameter with variable and undetermined length. Therefore the holes were drilled in the sides of both the upstream and downstream tubes, which would be top and bottom in a horizontal pipe. Such a tube is shown in Fig. 4. The size of these outlet holes was varied according to the velocity to be contended with and the pressure difference desired.

A large number of calibrations was made with such multi-hole nozzles in 5-in., 6-in. and 8-in. pipes, with outlet holes varying from a No. 60 drill up to a No. 47 drill, in which case the coefficient was brought down as low as 0.68, as against 1.20 with no side outlet holes.

Continued experiments with these multi-hole nozzles showed their vital weakness to be in a change in coefficient resulting from the accumulation of sediment around the edges of some of the holes, thus reducing their area. In many cases some of the holes were entirely plugged. In some steam pipes this sediment accumulated very rapidly, so that no dependable results could be obtained over any reasonable length of time. Even the simpler types of nozzle, where there were no outlet holes, and only those pointing directly up and down stream, produced the same trouble, for sediment would accumulate around the holes at the radiator end of these tubes and a higher pressure difference was produced due to the relatively

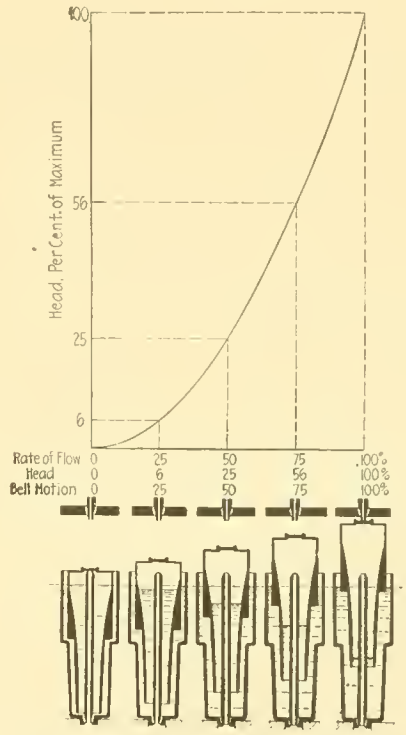

Fig. 8 Principle of Ledoux Liquid-Sealed Bell

greater effect of the holes near the center of the pipe. In time the center holes would become partially or completely plugged, in which case the coefficient would again approach normal, and then it would decrease when only the holes in the low-velocity zone at the farther side of the pipe were left open. In the latter case the meter would read low. Larger holes minimized or delayed the change in the factor, but they did not prevent it.

MAINTENANCE OF EQUAL WATER LEVELS IN CONNECTING PIPES

In measuring the comparatively small velocity heads or pressure differences available, it is necessary that the recording instrument casing and the connecting pipes be completely filled with water and its level be maintained equal in both pipes, otherwise a false differential due to the unequal water head will result. At first it was thought best to provide large reservoirs in each connection and on a level with the point where the steam line is tapped, so that any displacement caused

by a movement of the mercury in the U-tube or recorder mechanism, due to a change in the rate of flow, would not materially lower the water level in one reservoir. The equal volume of water that was forced into the other reservoir from the recorder drained back into the steam pipe. This arrangement required excessively large reservoirs to prevent serious lag with a variable rate of flow. It was realized that, regardless of the size of the reservoir, accuracy in following a variable rate of flow was dependent upon the rapidity with which steam could be condensed in the reservoir to replace that which had been drawn out. By providing sufficient radiating surface the size of the reservoir was of secondary importance, so the type of radiator shown in Fig. 6 was tried and found to be very satisfactory. The radiator consists of a piece

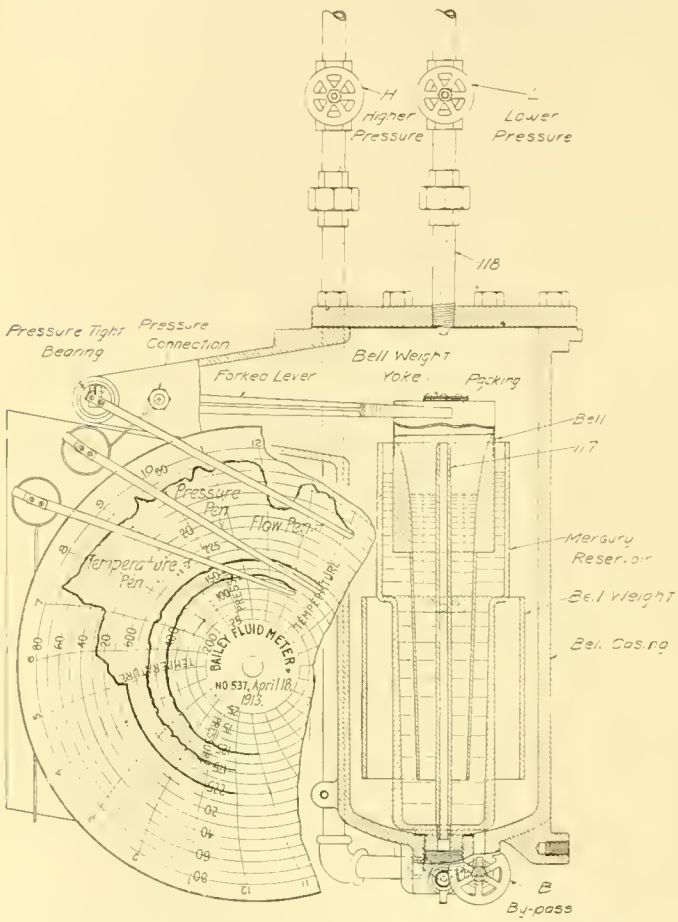

Fig. 9 Differential Pressure Recorder, Ledoux Bell Type

of ½-in. extra-heavy copper pipe, plugged on the end which is screwed into the steam pipe, with a ¼-in. hole drilled in the top half of the plug. A number of specially designed washers or fins, 4 in. in diameter and $^1/_{16}$ in. thick, are pressed onto the ½-in. pipe and give ample radiating surface to maintain substantially equal water levels in the connecting pipes, regardless of fluctuations in the rate of flow. Fig. 7 shows a pair of these radiators in place on opposite sides of a flange.

The relation between rate of flow and pressure difference substantially follows the $V^2 = 2gh$ law for the orifice as well as the pitot and venturi tubes. This means that for a rate of flow that is 10 per cent of the maximum allowable capacity, the pressure difference available to operate any U-tube indicator or other device is only 1 per cent of the maximum.

THE LEDOUX LIQUID-SEALED BELL FOR MEASURING SMALL PRESSURE DIFFERENCES

Of the three principal methods usually employed to measure small pressure differences, *viz.*, U-tube, diaphragm, and liquid-sealed bell, the latter has been found to be the most satisfactory. It is on the same basic principle as a piston which gives a force proportional to the area times the difference in pressure applied to its opposite sides, but by sealing the walls of the bell in a liquid, instead of confining the piston to a cylinder, it is made substantially frictionless in its operation. Furthermore, by varying the relative cross-sectional area of the bell and its walls, any complex relation between pressure difference and bell motion may be readily obtained.

A very ingenious and thoroughly practicable design for flow-meter work has been described by J. W. Ledoux,[1] member of this Society. This can be briefly explained by referring to Fig. 8, which shows a typical flow curve and a liquid-sealed bell of this type in five different positions corresponding to as many rates of flow equally spaced between zero and 100 per cent, inclusive. In the zero position the bell is held almost completely submerged so that the large effective area and the thin wall are at the surface of the mercury. The increment of pressure difference corresponding to the first appreciable rate of flow is very small, but this is effective over the entire area of the bell, forcing it upward, and as the bell rises its walls emerge from the mercury, changing the buoyant force, thereby exactly counteracting the upward force due to the pressure difference. A rate of flow of 25 per cent corresponds to a head of only 6 per cent, so that the relation between bell area and wall gives a very powerful and magnified motion which is directly proportional to the rate of flow, and therefore amounts to 25 per cent of the total bell motion allowed for in the design. And so on, each step may be followed, showing that the motion of the bell is directly proportional to the rate of flow, and that the device is not only one easy to read and which permits integrating mechanism to be used with a simple design, but one which also has greater power at the lower rates of flow and produces a very satisfactory degree of accuracy. An interesting feature of this bell is that the volume of mercury displaced on its interior side by the difference in level of mercury, exactly equals the volume of the walls in the bell which are forced out from the mercury, so that the mercury level in the containing reservoir is substantially constant. The higher and lower pressure connections terminating within and above the bell respectively are so positioned that a soft packing filler piece will engage and seal either of these when an extreme position is taken. This effectively seals either outlet, and as the entire mechanism is enclosed in a steam-pressure-tight casing and completely filled with water, no mercury can be blown out or the accuracy of the mechanism impaired through excessive pressure differences caused either by abnormal rates of flow, faulty manipulation of the valves, or even the breaking of one of the two pressure connecting pipes. Fig. 9 shows one application of the Ledoux bell to a recorder.

MEASUREMENT OF PULSATING FLOW

The question of measuring steam to reciprocating engines, pumps, etc., has been somewhat misunderstood. Many engineers have the impression that the pulsations cause an unduly fluctuating motion of the recording or integrating mechanism,

[1] A Mechanism for Metering and Recording the Flow of Fluids, etc. Trans. Am. Soc. C. E., vol. 76 (1913).

so that accurate results cannot be secured. But such is not the case except in very-slow-speed pumps. It is also wrong to say that a flow meter is inaccurate for measuring pulsating flow, for the present flow meters will produce accurate results when more knowledge is gained along this line. Steam flowing to a reciprocating engine follows some such variations as are shown in Fig. 10, the exact nature of the curve depending upon the cut-off, capacity of the steam line between the orifice and the engine, and some other factors. At any rate of flow there are very great and frequent variations in the rate of flow which occur periodically and yet so rapidly that no recording meter could possibly follow them individually. In fact, the inertia of the water columns in the connecting pipes to the recorder, together with the mercury in the U-tube, bell float, or other mechanism, is so great that no appreciable motion results from the individual pulsations, but rather the reading is an average of the head or pressure difference resulting from such flow. Regardless of the use of cams, special-shaped bells, displacing members, or any other mechanism whereby a motion is produced in direct proportion to the rate of flow, for continuous flow they cannot possibly produce an average reading that is directly proportional to the rate of flow in the case of pulsating flow.

In Fig. 10 the parabola shows the characteristic relation between rate of flow and pressure difference with 100 per cent flow at 100 per cent head. Assuming that the rate of flow varies from zero to 100 per cent, the nature of the cycle being no flow during 50 per cent of the time and 100 per cent flow during the other 50 per cent of time, then the average flow would be 50 per cent. At the same time the pressure difference varies in like manner from 0 to 50 in. water head, with an average of 25 in. The inertia of the meter mechanism produces a reading corresponding to this average pressure difference of 25 in. instead of an average reading of 50 per cent on the quantity scale. The reading on the quantity scale corresponding to the average head of 25 in. is 70.7 per cent. This 70.7 per cent divided by 50 per cent, which is the true average flow, gives 1.42, or a reading 42 per cent higher than would be the case if the same amount of steam were flowing at a continuous rate. This ratio has been termed the "pulsating factor," and while it might be calculated on a theoretical basis from the nature of the flow curve, if it were known, yet it is better to determine it by actual calibration; and if so determined the steam-flow meter can operate as satisfactorily on a reciprocating engine as on a continuous flow to turbines, heating systems, etc. It should be remembered that the pulsating factor may not be the same at all different loads of the engine. It is, however, a function of the load for any one engine so long as the valve adjustment, etc. remain reasonably uniform.

The problems in connection with pulsating flow that are most difficult are those in which there is a mixture of pulsating and continuous flow, with no definite ratio or relation existing between the two. An example of this would be a steam line supplying both an engine and a turbine. Another case where the pulsating effect has been encountered was in a steam line leading from a main header to a heating system where a reciprocating engine also drew steam from the same header. Even though the orifice of the flow meter was in the branch line leading to the heating system alone, yet the intermittent flow of steam to the engine caused a fluctuation in the steam pressure in the header. This fluctuation in static pressure caused a fluctuation in the rate of flow of steam to the heating system from this header, with the result that an erroneous reading might have been obtained if the meter had not been calibrated under such operating conditions. The pulsating factor may sometimes be eliminated by throttling between the orifice and the source of pulsation.

CALIBRATION OF STEAM-FLOW METERS

It is desirable to have a ready means for calibrating steam-flow meters in place, as it is for wattmeters, pressure gages, thermometers, etc. It has heretofore been considered necessary that steam-flow meters be calibrated by passing all the steam through a turbine to a surface condenser that is known to be tight and free from leaks. This latter point can be well taken care of where sea water is used for circulating, but is often difficult where fresh water is used. The other method is in weighing water to a boiler from which all the steam passes through the meter being calibrated. In this case it is necessary to guard against leaks from the feed line, blow-off, or branch steam lines. An additional difficulty arises in the boiler method, which is in having the same amount of water in the boiler at the end as at the beginning of the test. The fact that the water level is brought to the same mark on the gage glass is not positive evidence that the water in both drums or even different parts of the same drum is at the same level. But a still greater source of error along this line lies in the volume of steam beneath the water level, which is greatly affected by the rate of steaming. Some tests on a 500-h.p. Babcock and Wilcox boiler have shown that the volume of steam beneath the water level varies as much as 50 cu. ft. with a change in the rate of steaming of 14,000 lb. per hour. That is, the boiler was steaming at the rate of 24,000 lb. per hour at the beginning of the hour, and at 10,000 lb. per hour at the end of the hour; there were 11,500 lb. of steam generated during the

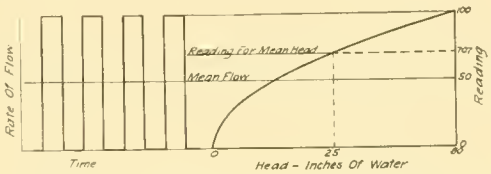

Fig. 10 Effect of Pulsating Flow

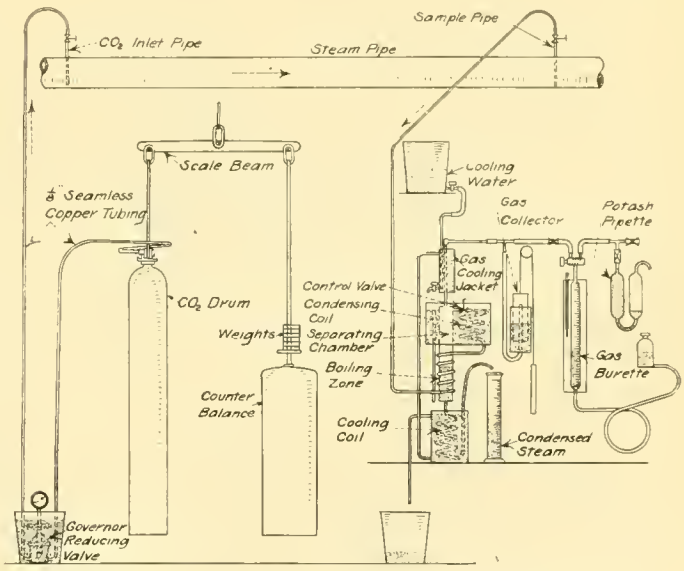

Fig. 11 "CO_2 Method" of Steam Measurement

hour, but it was necessary to feed 14,750 lb. of water to the boiler during this period to maintain the water level at the same point in the gage glass. This means that 3250 lb. of water, or over 50 cu. ft., were required to fill the additional space occupied by steam below the water level at the higher rate of steaming as compared with the lower rate. This is a source of error that cannot be overcome or corrected except by continuing a test over a long period of time and ending the test with the same rate of steaming as at the beginning.

CO_2 METHOD OF STEAM-METER CALIBRATION

In case of weighing water either to a boiler or from a surface condenser, it is necessary to put in large weighing tanks and scales and often make very costly changes in the feed line or steam piping, so that a diligent study of this problem was made to find a better method of steam-meter calibration. The method worked out by the writer consists in introducing CO_2 gas from a high-pressure drum into the steam line at a known and continuous rate, permitting it to mix with the steam, then drawing out a sample, condensing the steam and determining the ratio of condensed steam to CO_2 gas.

TABLE 2 SUMMARY OF DATA COMPARING STEAM MEASUREMENT BY CO_2 METHOD WITH ACTUAL WEIGHT AND STEAM-FLOW METER, ORIFICE TYPE

Made in connection with evaporation tests on a 512-h.p. B. & W. boiler.

Duration of test, hours	Water fed to boiler by actual weight, lb.	CO_2 fed per hr., lb.	Ratio water to CO_2	Steam by CO_2, lb.	Steam by meter, lb.	Difference between CO_2 method and	
						Actual weight, per cent	Steam meter, per cent
4	.....	8.64	2548	90,500	91,620	.....	−1.22
2.5	78,515	8.53	3645	77,650	78,040	−1.10	−0.50
6	133,474	8.68	2506	130,500	129,190	−2.26	+1.01
3	54,505	14.63	1276	56,000	55,830	+2.78	+0.29
9[1]	187,979	.....	....	186,500	185,020	−0.78	+0.80
5	132,667	8.85	2992	132,130	133,650	−0 40	−1.14

[1] This line gives the sums of the two runs directly above.

In the first experimental work along this line the attempt was made to determine this ratio by considering the CO_2 as carbonic acid in solution and titrating for the amount of it contained in the condensed steam by the use of chemical means. Some rather erratic and unexpected results were at first obtained from this titration method, and in an effort to check up this method another more valuable feature was worked out whereby the gas was thoroughly separated continuously from the condensed steam and the two measured separately. The general diagrammatic arrangement of the apparatus used in this method is shown in Fig. 11.

This method is based upon the addition of CO_2 gas from a high-pressure tank or drum to the steam line at a continuous and known rate. The gas becomes thoroughly mixed with the steam as it passes along, and a sample consisting of a mixture of steam and CO_2 gas is drawn off continuously from a point further down the line. The steam in the sample is then condensed, the gas and water are thoroughly separated and each measured so as to determine the ratio of water to gas. This ratio multiplied by the rate at which the gas was added will give the rate of flow of steam.

The drum containing CO_2 gas under high pressure is supported on a scale beam so that its weight can be determined at any time, from which the rate of adding the gas is accurately determined. The gas is continuously discharged through a flexible copper tube and a governor valve into the steam line through a ⅛-in. spray tube. A sample of the mixed steam and gas is taken from the steam pipe at a point further down the line. The sample is then passed through a condensing and separating apparatus and the condensed steam and gas are measured separately in a graduate and Hempel burette, respectively. The entire operation is continuous, except that these two measurements are taken simultaneously at regular intervals of four to five minutes.

An accuracy of 1 per cent to 1½ per cent can be secured when using only 1 lb. of gas to 2000 lb. of steam. Hence it is possible to use this method on large capacities up to several hundred thousand pounds of steam per hour. Some data are given in Table 2.

This method has also been tested out for measuring the flow of water, the gas being injected into the feed line, and with the small ratio of gas required the CO_2 is completely absorbed by the water so that a representative sample is readily obtained. The gas is then completely separated from the water and the ratio determined by the measurement of each.

It will be noted that this method is entirely independent of steam pressure, superheat or percentage of moisture, and it resolves back to an actual weight basis. It requires no change in piping except to drill and tap for ⅛-in. pipe at two places. It is particularly adapted for test work in calibrating meters, determining steam consumption of turbines, engines, pumps, auxiliaries, etc., but does not take the place of a permanently installed recording or integrating meter.

DISCUSSION

In the discussion which followed the paper, Walter S. Burke, Mem.Am.Soc.M.E., Superintendent of Buildings and Grounds at Harvard University, described the meters used by the University to measure steam flow and condensation in the purchase of steam from the Boston Elevated Company, amounting to some $40,000 per year. The net B.t.u. are computed and paid for on the basis of heat supply.

Mr. Burke considered the CO_2 method of calibrating steam meters very valuable, affording a convenient and close method of determining just what results the meter is giving. He regarded Mr. Bailey's method of showing steam flow, air flow and condition of fuel bed on one chart for use of the firemen in handling the fire very important. In his experience with the Bailey meter, results within a small fraction of 1 per cent had been effected by using steam meters to show the requirements of the various departments.

A. G. DUNCAN, Mem.Am.Soc.M.E., stated that in the mills with which he was connected he believed a saving of 25 per cent has been effected by using steam meters to show the requirements of the various departments.

EDWARD A. UEHLING, Mem.Am.Soc.M.E., considered the Bailey meter would serve a useful purpose, and, inasmuch as the majority of practical engineers prefer physical and mechanical means to chemical means for the control of combustion, no doubt many would prefer his apparatus to the CO_2 recorder.

JOHN A. STEVENS, Mem.Am.Soc.M.E., gave his experiences in regard to measuring steam from several sources with a single meter, with suitable valves to cut off the sources as required.

HEAVY-OIL ENGINES

A Discussion of the Question of Availability of Fuel, Followed by Some Observations on Oil Engines in General and the Diesel Type in Particular

By S. B. DAUGHERTY, BUFFALO, N. Y.

Member of the Society

IN a consideration of the oil engine, the questions at once arise: What kind of oil is suitable? Are supplies of fuel available in sufficient quantities in various parts of the country? Will the probable production of oil in years to come be equal to the demand?

To answer the first question requires a word of explanation as to the types of oil engines. Broadly there are two: the low-compression engine, wherein ignition is effected by the injection of the oil spray against a heated surface, or even by an electric igniter, as in gas engines; and the high-compression, or Diesel type, with ignition from the heat of compression of the air charge. The low-compression engines are the simpler and cheaper, but on the other hand suitable fuels for use in them are fewer and higher-priced, and the thermal efficiency is less. These limitations tend to restrict the use of low-compression engines to smaller installations. Suitable oils are kerosene, the lighter distillates and light crude oils.

The high-compression or Diesel-type engines can in general utilize any liquid fuel. It is to be remembered that there is no strict line of demarcation between the types, but that they tend to merge one into the other. The grades of suitable oils vary inversely as the grade of the engine,—the cheaper and simpler the engine, the higher the grade of oil required; the more elaborate and specialized the engine, the lower the grade of oil which may be successfully used.

AVAILABILITY OF FUEL IN THE UNITED STATES

The date of the beginning of the production of petroleum or mineral oil in this country is recorded in government publications as 1859, the production of that year being 2,000 bbl. of 42 gal. each. The United States production marketed in 1914, the last year for which statistics are available, was 265,762,535 barrels.

There are six major oil fields of the United States: the Appalachian, the Lima Indiana, the Mid-Continent, the Illinois, the Gulf and the California.

The quality of the oil produced in the Appalachian field is the best. It is light, yielding a large percentage of gasoline and kerosene, and paraffin is obtained from the residuum; the Lima Indiana oil is also light, but contains sulphur; the Illinois oil contains less sulphur than Lima Indiana oil, but contains some asphalt as well as paraffin; oils of the Mid-Continent field contain paraffin and asphalt and show considerable variation; those from the Gulf field contain considerable sulphur, while the California oils in general contain much asphalt and considerable sulphur. Some of the California oils are valueless to the refiner and find their market as fuel oil or as road oil.

In addition to the oil produced in the United States, there is an enormous potential production in Mexico. This oil is asphaltic and contains often as much as 3½ per cent sulphur. It finds a ready market as fuel oil and can be sold in the ports of New England at a price that allows of its being used as fuel under boilers in competition with coal. In Florida, Mexican crude is used extensively.

A general survey of the statistics shows that the total production of oil in the United States is increasing. This increase is in the lower-grade oils, as the production of the Appalachian field is decreasing, even though the price has recently been maintained at a fairly high level.

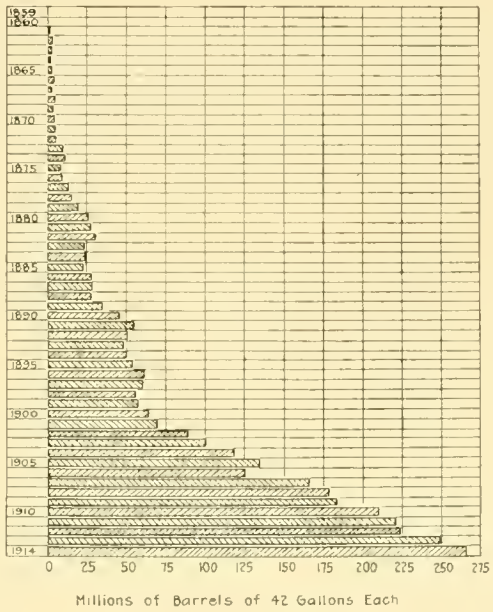

FIG. 1 ANNUAL PRODUCTION OF PETROLEUM IN THE UNITED STATES

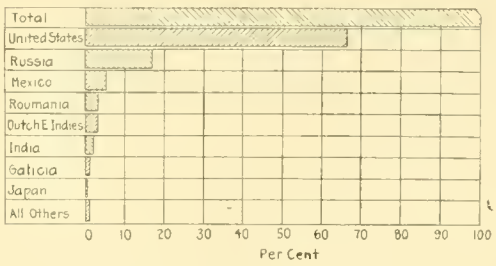

FIG. 2 WORLD'S PRODUCTION OF PETROLEUM IN 1914

New fields are being discovered and the limits of old fields are being extended. It is probable that for many years the total production will increase. In fact, it is the opinion of experts that the petroleum resources of the world are relatively undeveloped. Some fields are enormously productive, as for instance the Cushing pool, which a year ago was producing at the rate of about 30,000 bbl. per day; the production of this field has decreased so that now it is about 12,000 bbl. daily.

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Consumption of petroleum products is constantly on the increase. This applies particularly to gasoline. It is estimated that the automobiles of this country are consuming over 1,000,000,000 gal. annually. In addition to this amount the yearly consumption of gasoline for other purposes is about 500,000,000 gallons.

It is in this enormous demand for gasoline that there is an assurance of a reasonable supply of oil suitable for use in engines. Part of this supply is the residue from refining operations, and a great portion is in the lower grades of crude oil discovered in the search for new supplies. Fig. 1 shows the annual production of petroleum in the United States from 1859 to 1914. Fig. 2 shows the total production of the world for 1914, and the percentages produced in the different countries.

A first impression would be that any decided increase in the number of oil engines in use would create such a demand for fuel oil that prices would advance to a figure which would make the oil engine unprofitable. But this does not take into consideration the fact that in many cases the oil engine supplants an oil-fired boiler, and that but 1/5 to 1/10 of the oil burned under the boiler is required for the oil engine, the

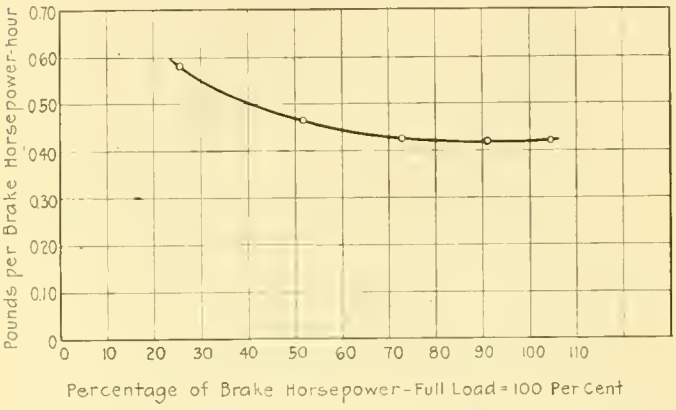

Fig. 3 Fuel Consumption, 4-cycle "Snow" Oil Engine, From Actual Brake Tests

remainder being available for other purposes. It must also be remembered that the price of fuel oils is largely determined by the price of other fuels. Heat units in oil must not be much higher priced than heat units in other fuels, or there is no market for the oil. For many years the price of low-grade oils will be determined by the demand for other purposes than use in oil engines.

OIL ENGINES, DIESEL AND SEMI-DIESEL

This paper will consider Diesel-type engines particularly. The Diesel engine is the most economical prime mover yet designed. It is now twenty-two years since the engine was patented in Germany. The engine was developed by the Augsburg-Nürnberg Co. The first commercial engine was put in service in 1897, and, according to the Augsburg-Nürnberg Company, was still in service and running satisfactorily in 1911.

The Diesel engine is unique, in that it was designed to fit a theory. Some of the paragraphs in Diesel's patent show clearly that his calculations were not entirely correct; for instance, his statement that there is "no increase in the temperature produced on the introduction of the fuel, or at most only a very slight one, and the highest or extreme temperature is produced by the compression of the air. It is, therefore, under control and will be kept within moderate limits, and moreover, in view of the cooling of the products of combustion by the subsequent expansion, no artificial cooling is required for the cylinder, the mean temperature of the gases being such that the parts of the engine can be kept tight and lubricated;" also that "the exhaust may be cooled by expansion below the temperature of the atmosphere and utilized for refrigerating purposes." Experiment has proven these statements incorrect, but in its essential features his theory was sound. The first claim in his patent covers the engine so completely that, so far as I am aware, no infringement was ever attempted. This is the claim: *"The herein-described process of converting the heat energy of fuel into work, consisting of first compressing air, or a mixture of air and neutral gas or vapor, to a degree producing a temperature above the igniting point of the fuel to be consumed, then gradually introducing the fuel for combustion into the compressed air, expanding against a resistance sufficiently to prevent an essential increase of temperature and pressure, then discontinuing the supply of fuel and further expanding without transfer of heat."*

The first Diesel engine was a vertical machine, and this design was followed in subsequent engines until it became so standardized in Europe that the opinion prevails to a great extent that there must be some vital reason for the adoption of the vertical type. The first commercial engine was a twin-cylinder vertical engine of 60 b.h.p. Both horizontal and vertical Diesel engines are now being built in the United States, and the expiration of Diesel's patent in July, 1912, was the occasion of many builders entering the field.

In addition to Diesel engines, the De La Vergne type FH engine should be mentioned. It is classed as semi-Diesel but its equipment includes all of the essentials of a Diesel engine, and the compression needs only to be raised from about 350 to 500 lb. in order to bring it into the Diesel class. The economy of this engine is practically the same as that of the true Diesel type.

ECONOMY OF THE DIESEL ENGINE

As stated, the main feature of the Diesel engine is its economy. The measure of efficiency of a prime mover is the percentage of potential power actually obtained for useful work. In the transformation of heat energy into useful power various losses occur. If steam be the medium, there will be a loss of heat in the boiler, due to radiation, to the escape of heat into the stack with the gases formed by combustion of the fuel, and to imperfect combustion of the fuel. Heat in the steam is lost by radiation, and a very considerable amount is rejected in the exhaust. Friction accounts for a further loss, and so, with steam as a prime mover, the percentage of actual heat in the fuel that is transformed into work ranges from 6 per cent to 16 per cent. For intermittent operation, where a considerable portion of the fuel burned is for stand-by service, the percentage may be even lower. In the internal-combustion engine the heat losses are due to radiation, to heat carried off in the jacket water and in the exhaust, and to friction. The principal saving is in the reduction of the amount of heat lost in the exhaust.

The effective thermal efficiencies of various prime movers are about as follows:

Non-condensing steam engine	8.4 to 6.6	per	cent
Condensing steam engine and turbine using superheated steam	15 to 10	"	"
Suction gas engine	23 to 18	"	"
Four-cycle Diesel engine	34 to 32	"	"

The significance of this Diesel-engine economy can best be appreciated by a familiar comparison: Assume that a touring car can be run twelve miles on a gallon of gasoline which costs 23 cents per gallon and weighs about 6 lb. Assume that the engine has a thermal efficiency of 18 per cent, and that the effective heating value of the gasoline is 114,000 B.t.u. per gallon.

Fuel oil weighing about 7.5 lb. per gallon would have an effective heating value of about 135,000 B.t.u. per gallon. On this basis of relative heat values and efficiencies a Diesel-type engine would drive a car 26 miles on a gallon of oil, as compared with 12 miles with gasoline. But 7.66 gal. of oil can be purchased for the price of one gallon of gasoline, so that the distance covered for 23 cents worth of fuel would be 200 miles with oil and 12 miles with gasoline, or 16.6 times.

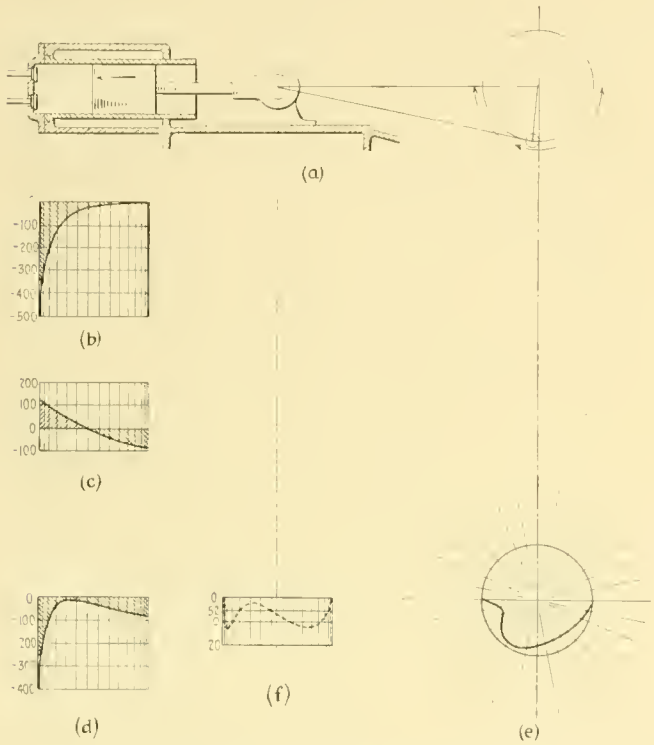

Fig. 4 Piston-Effort Diagrams for Horizontal Oil Engine, Compression Stroke

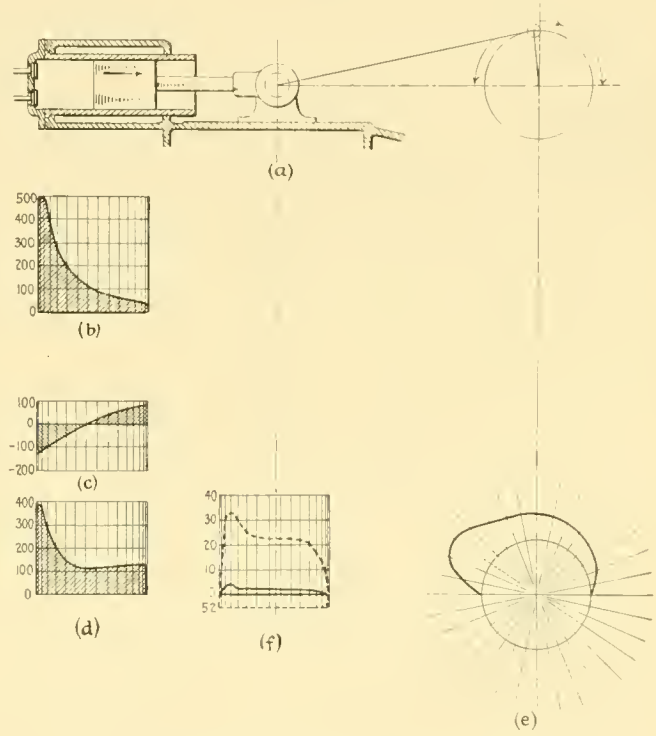

Fig. 5 Piston-Effort Diagrams for Horizontal Oil Engine, Working Stroke

(*a*), frame diagram; (*b*), compression diagram; (*c*), inertia diagram; (*d*), combined compression and inertia; (*e*), crank effort; (*f*), reaction on crosshead guide

Fig. 3 shows the fuel-consumption curve of a single-cylinder four-cycle engine. At loads from 80 per cent to full load the consumption is practically constant, and at the rate of 0.42 lb. per b.h.p-hr. At this rate one gallon of oil will furnish about 18 b.h.p-hr., and the cost for fuel per b.h.p-hr. with oil at 3 cents per gal. is one and two-thirds mills. To supply 100 h.p. for ten hours would require 55½ gal. of oil, costing $1.67.

The opponents of internal-combustion engines, both gas and oil, always state that these engines are economical only when operating near maximum load, and that the economy falls off rapidly as the loads decrease. Observe on this curve that the load is approximately 42 per cent where the consumption curve crosses the 0.5 lb. line, and that the consumption at half load is 0.47 lb. The fuel consumption for a ten-hour day, running a 100-h.p. engine at half load, would be about 31½ gal., costing, at 3 cents per gal., 95 cents. It is evident that the fuel expense for keeping an engine running on friction load is very slight. By actual test on a 65-h.p. engine, full speed without load was maintained on 1.1 gal. per hour.

VERTICAL VS. HORIZONTAL DIESEL ENGINES

One of the outstanding features of Diesel-engine manufacture in the United States is that, in general, those manufacturers who have done their own designing have brought out horizontal engines, while those who are building vertical engines have purchased the designs abroad.

The advantages of the horizontal engine, as enumerated by a concern with an established reputation as builders of vertical engines are: lower price; easy survey and convenient attendance; better distribution of stresses on the crankshaft and main bearings; better lubrication of bearings; better lubrication of piston; easier cleaning and repair work, especially to pistons, which can be taken out without removing the cylinder head and the valve gear; reduced height of engine room, as all pipes are laid in trenches under the floor and do not obstruct the room.

In a comparison of vertical and horizontal Diesel engines the detail most discussed is the piston. Vertical builders call attention to the weight of the piston, and the side pressure thereby produced on the cylinder bore, in the case of the horizontal engine. The fact that the first Diesel engines were built vertical, and that excessive height was undesirable, probably led to the use of trunk pistons. For the same reason a connecting rod of a length but slightly more than five cranks has been used in vertical engines. An analysis of the forces prevailing throughout the cycle of operations shows that the side pressure on the cylinder walls, due to the angularity of the connecting rod, is far greater than the pressure due to the weight of a piston, even though the piston lies horizontally. Any increase in connecting-rod length means a proportional decrease in the side thrust. Ordinarily an increase in the length of the connecting rod of one crank length decreases the side thrust an amount equal to the weight of a piston and

wrist pin, or, in other words, a vertical trunk-piston engine with a connecting rod five cranks long is subjected to about the same side pressure on the cylinder wall as a horizontal trunk-piston engine with a connecting rod six cranks long.

The magnitude of the forces involved in the engine is not generally realized. Weight is obvious, but loads due to fluid pressure inside of cylinders and the reactions resulting therefrom are not so readily appreciated. For example, with a connecting rod five cranks long, and the engine crank 45 deg. from dead center on the working stroke, the side thrust on the piston, not considering the modifying effect of inertia of the reciprocating parts, is about 41 lb. per sq. in. of piston area. For a 19-in. diameter piston, this is $284 \times 41 = 11640$ lb. The weight of a 19-in. piston with wrist pin and one-half of the connecting rod is approximately 1600 lb. The side thrust due to angularity of the connecting rod for this condition is about 7.3 times the weight of piston. In actual running, the force transmitted to the crank pin through the connecting rod is reduced by inertia effects, so that the side thrust due to angularity is from five to six times the piston weight instead of 7.3 times.

In order to present this feature more clearly, diagrams are given showing the pressures acting on the piston during the compression and working strokes; the inertia; the combined inertia and pressures, which is the measure of the effort transmitted to the crank pin; the turning effort on the crank pin, and the resulting thrusts due to the angularity of the connecting rod. The figures on the diagrams are in pounds per square inch of piston area.

In these piston-effort diagrams, the forces which tend to drive the crank in clockwise direction are shown above the horizontal base line, and those forces that would tend to drive the crank in the reverse direction are shown below the base line.

Beginning with the compression stroke, Fig. 4*a*, note that the crank is driving the piston against a constantly increasing pressure, which reaches 500 lb. per sq. in. at the end of the compression stroke, Fig. 4*b*. At the beginning of the compression stroke, when the inertia of the reciprocating weights must be overcome, the pressure in the cylinder is low. At the end of the compression stroke the inertia effect is tending to revolve the crank in clockwise direction, as shown in Fig. 4*c*. Note, in Fig. 4*d*, how closely the line approaches the base. An increase in the weight of the reciprocating parts or an increase in the rotative speed of the engine would cause the line to cross the base line, or, in other words, would result in the piston actually pulling the crank during a short portion of the compression stroke; such a condition tends to cause a knock. From this piston-effort curve the negative turning effort on the crank is obtained, Fig. 4*e*, and the reaction on the crosshead due to the angularity of the connecting rod, Fig. 4*f*. On the compression stroke, the tendency is to lift the crosshead throughout the stroke. The upward thrust is maximum near the end of the compression stroke, and equals 14.5 lb. per sq. in. of piston area. The weight is about 5.2 lb. per sq. in., so that the net upward thrust is 9.3 lb. per sq. in. of piston area, or about 2610 lb. for a 19-in. piston. This upward thrust is resisted by adjustable gibs bearing on the sides of the crosshead shoe, and no trouble is experienced in making these adjustments so that the engine runs quietly.

At the end of the compression stroke, fuel is injected and the working stroke follows, Fig. 5*a*. The pressures in the cylinder through out the stroke are indicated in Fig. 5*b*. The inertia diagram for this stroke is shown in Fig. 5*c*. Note particularly, in Figs. 4*d* and 5*d*, the beneficial effect of inertia in reducing the high pressures at the end of the compression stroke and the beginning of the working stroke, and in supplementing the low pressures in the cylinder at the end of the working stroke so that the effort is more evenly distributed. During this stroke the thrust due to the angularity of the connecting rod is all downward, Fig. 5*f*, and reaches a maximum of 32.6 lb. per sq. in. of piston area. Adding the weight to this, the maximum downward pressure is 37.8 lb. per sq. in. of piston area, or 10,700 lb. For a 19-in. diam. piston, note particularly that if the cylinder were vertical there would still be a maximum side thrust of 9250 lb.

From the foregoing it will be very apparent that it makes but little difference whether an engine is built vertical or horizontal in so far as side pressures are concerned. In the case above analyzed, weight adds but 16 per cent if the maximum pressure is considered. The advantage of the horizontal engine in general, and the crosshead type in particular, is in its superior accessibility. In the case of a vertical trunk-piston engine it is necessary to practically dismantle the engine in order to get at the piston, piston rings, or wrist-pin bearings. In most cases the valve gear and the cylinder heads must be removed, the connecting rod must be disconnected at the crank pin, and the piston and piston rod then lifted out through the cylinder.

Compare this procedure with that necessary in the horizontal engine: The sheet-steel crank splasher is removed; then the connecting rod is disconnected, at the crank pin in the case of a trunk-piston type, or more simply at the wrist pin if the engine has a crosshead, and the piston is then removed from the open end of the cylinder. The actual time required to remove a piston and cross head of a 19-in. by 33-in. engine was twenty minutes. The piston was wiped clean and replaced in thirty minutes, making the total shut-down fifty minutes, as compared with about one day of ten hours to accomplish the same thing in the case of a vertical engine.

TYPE OF DIESEL ENGINE AND LUBRICATION

The matter of cylinder lubrication is another feature of superiority in horizontal engines. In the vertical type it is absolutely essential, in order to secure a distribution of the lubricant around the cylinder bore, to supply the oil through a number of feeds, as many as four per cylinder on the smallest sizes and more on larger diameters. A horizontal cylinder, on the other hand, even of the largest size that is practicable to build, can be effectively lubricated over its whole surface from a single feed on the upper side. Gravity helps to distribute the oil.

In any internal-combustion engine some of the lubricating oil is carbonized. In a vertical engine this carbon tends to work down past the piston, fouling the rings and dropping into the crank pit, where it becomes mixed with the bearing oil. In the horizontal type, much of this carbon is pushed into the counterbore, whence it can be removed through a blow-off valve in the bottom of the cylinder. Such portion as works by the piston can be caught in the frame and prevented from mixing with the bearing lubricating oil. Even the main bearings in a horizontal engine are more effectually lubricated. During the working stroke, when the pressures are highest, the main shaft is partly lifted from the bottom shell, allowing the lubricant to fill the space. Then on the two idle strokes, the exhaust and inlet, inertia effects tend to bring the shaft first against one side of the bearing, then against the other, thus effecting a very thorough distribution of the oil.

SUCCESS IN DIESEL-ENGINE OPERATION

On the showing of economy of the Diesel engine, one might ask why the engines are not in more general use, since the United States is the great producer of oil and power is so universally used. One answer is that those who are in a position to reap the most benefit are not aware of the possibilities. Perhaps they have heard of an oil-engine installation that has not come up to expectations. Without investigation, they immediately condemn oil engines in general. Or it may be that even when an engine of a suitable type has been installed, satisfactory operation is not obtained on account of the failure of the men in charge to properly care for the engine.

It is evident that in a machine that requires uniformly high pressure to properly ignite the fuel charge, any appreciable leakage of valves or piston rings results in faulty ignition. This applies to the compressor which furnishes the spraying air as well as to the power cylinder. On the other hand, a little intelligent care will prevent trouble of this kind. I know of no case where the proverb, "a stitch in time saves nine," is more applicable.

Another cause of trouble that is avoidable is overloading. A moment's consideration will make plain the ill effects of overloading. In any internal-combustion engine the amount of fuel burned is limited by the oxygen in the charge of air at the end of the compression stroke. In the case of a Diesel-type engine the time available for burning the fuel charge at full load will not exceed 35 deg. of crank travel. In the case of an engine running 200 r.p.m. this is equivalent to $^1/_{34}$ of a second. During this time the oil must enter the cylinder, come in contact with the necessary oxygen, and be consumed. There must of necessity be some excess oxygen in order to effect complete combustion of the fuel. The effect of overloading is to increase the fuel charge so that the amount is greater than can be burned clean with the air that is available. The result is that combustion continues after expansion has begun, and if the overload is great it may even be that the charge will be still burning when the exhaust valve is opened. The temperature of the exhaust gases is then so far above normal that the valve becomes distorted with the heat, causing leaks which still further aggravate the trouble. If an engine be allowed to run with a leaking valve it is only a question of a few hours until both valve and seat will be cut out by hot gases blowing through at high velocities. The secret of success in operating a Diesel engine is in taking care of just such relatively small items. When you find an owner who condemns this type of engine, you will generally find that he is careless, and allows his engine to get out of order in some small particular, and then complains about unreliability, high cost of repairs, etc.

FIELD OF THE DIESEL ENGINE

The Diesel engine has a fairly well defined field in which it will have no competitor when its merits are known and appreciated. This is the relatively small plant which, when steam operated, is usually inefficient. In generating electric current for a small town, savings are effected that would justify the installation of the Diesel engine if the cost were two or three times what it actually is. For instance, a 300-h.p. engine is effecting a saving of $1000.00 per month in fuel. In another case a 60-h.p. is saving $2500.00 a year. In ice making the cost of fuel per ton of ice with oil at 3 cents per gal. is around 18 to 20 cents per ton of ice produced. This includes driving all the auxiliaries, lighting the plant, etc. For pumping, the combination of an oil engine with a geared power pump makes a pumping unit that has a higher thermal efficiency than the best crank-and-flywheel pumping engine ever built, and this efficiency can be obtained when the oil engine is only 65 h.p., compared with hundreds of horsepower in the steam-driven pump. This means that in parts of the country where oil is used under boilers, oil-engine-driven pumps in small units are pumping water cheaper than is done by the largest steam-driven pumps. Of course, where heat units in coal can be purchased cheaper than heat units in oil, this advantage of the higher efficiency of the oil engine is offset, but it is probable that there is no place in the United States where the power requirements for pumping are around 50 to 60 h.p. that an oil-engine-driven pump would not be the most economical, all things considered.

The ability to generate electric power cheaply by means of Diesel engines has led to the installation of engines of this type in the phosphate-mining industry in Florida. The load conditions are almost ideal for the realization of high economy. The plants are operated continuously except for a Sunday shutdown. It has been found that multi-stage centrifugal pumps motor-driven will deliver water at the high pressure required for hydraulic mining at an expense that compares most favorably with compound-condensing pumping engines. The advantage of this combination lies in the ability to shift the pump and motor with but little trouble as the mining progresses, thereby saving the expense and losses due to extending pipe lines from a permanently located pumping unit.

The pipe-line companies have come to appreciate the merits of the oil engine for driving pumps. A large number of units have been installed, mostly of relatively small sizes, the 100-h.p. De La Vergne engine having been very popular. But now that horizontal Diesel type engines are to be had, larger units are being used. The economies effected are such that it is only a question of time when steam engines for this service will be abandoned.

DISCUSSION

The discussion of the paper was active and interesting. The principal points discussed were the opportunities for the Diesel type of oil engine and the matter of lubrication. It was believed that the Diesel engine would find more extensive use as it became better known. Its possibilities are not fully appreciated at the present time and it offers a great field for economical power units. If more scientific consideration be given the lubrication of the oil-engine units it was believed that more economical operation and better service would result. Several instances of exceptional oil-engine performances were mentioned. In one case an oil engine operating a refrigerating plant in the South ran for over 11 months without a shutdown. The experience of those using oil, having an asphaltum base, showed that the difficulties expected were greatly overestimated and that it could be used very satisfactorily. Among those discussing the paper were A. W. Moseley, Mem.Am.Soc.M.E., H. S. Philbrick, Mem.Am.Soc.M.E., O. J. May, Mem.Am.Soc. M.E., L. F. Burger, O. B. Zimmerman, Mem.Am.Soc.M.E., W. A. Hartley, Mem.Am.Soc.M.E., and F. G. Hobart, Mem.Am. Soc.M.E.

The exchange of heat between superheated steam and pipe walls or condensers has been investigated by R. Poensgen (*Zeit. Ver. deutsch. Ing.*, Jan. 8 and 15, 1916). His experiments were carried out with a seamless tube 3.5 m. long and 95.7 and 39.4 mm. in internal diameter in a gas-fired superheater, an auxiliary electric superheater being also provided.

MOTOR TRUCKS IN SOUTHERN CALIFORNIA

Notes on the Development of the Motor Truck, the Economics of Truck Operation, in Southern California, and Costs in the Southwest

BY W. HOWARD CLAPP, PASADENA, CAL.

Member of the Society

Motor-truck service on American roads is the severest kind of service, and in discussing the economic possibilities of motor trucks many factors must be taken into account.

This paper first reviews the development of American motor trucks, describing types of chassis, engine, transmission system, final drive, and other elements.

It then discusses the economics of truck operation and costs of gasoline trucks in Southern California—an ideal field for motor-truck service on account of perfect operating conditions throughout the year.

The author concludes with a discussion of the methods of reducing trucking costs and a comparison of operating costs of horse-drawn and motor trucks for general application.

THE object of this paper is to outline the development of the motor truck and to tell something of its economic possibilities under the conditions in Southern California. No attempt will be made to go into the many differences in the details of design for the great variety of trucks. The broader differences in construction will be brought out and the advantages or objections which they embody will be mentioned.

Commercial motor vehicles were at first simple pleasure cars with improvised truck bodies. The first ones were steam- or electric-driven, but were not successful, chiefly because of the inadequate capacity of the boilers and batteries. The steam-driven truck or lorry was developed successfully in England, but on the poorer roads of this country it was a failure. On the other hand, the electric truck has been continually improved from the first, and has reached its highest development here in this country.

The first recorded sale of a truck was in 1896, and in 1904 a truck made an endurance run from New York to Chicago which attracted wide attention. The manufacture of trucks was at first only a side-issue with pleasure-car makers, and there were few users prior to 1910; since then the sale of trucks in the United States has just about equaled the sale of pleasure cars for the period six to seven years before. Last year's sales totaled 72,000, an increase of 43 per cent over the previous year. Europe took about 22,000 trucks, but sales in this country increased also.

MOTOR-TRUCK CHASSIS

The design of the truck at first was patterned very closely after the pleasure car. This was a natural sequence for a business growing up as a branch of pleasure-car manufacturing. The same type of engine was used for both and the same drive through a differential on a live rear axle, such as still in use for trucks of the light delivery type. For the heavier trucks the frame of the car was lengthened out, and the differential and rear axle gave way to a differential and jackshaft attached to the frame. The jackshaft carried sprockets, and the final drive was made by chain to the rear wheels, which were carried on a dead axle. This arrangement had three obvious advantages: first, it kept the engine drive as small and light as possible, since the final reduction in rotations was made right at the rear wheels; second, it was accessible, and the gear ratio could be changed at will by putting a different-size sprocket on the jackshaft; lastly, it segregated the power plant so that the truck from the design viewpoint might be considered as made up of two separate units. The first of these units, the wheels, axles and steering gear, was expected to take all of the jar and distortion of running, while the other unit, the truck frame and power plant, floated above the first one on the springs, the chain furnishing the power connection between the two units. Automobile engineers state that each pound of unsprung weight is as hard on the tires, and therefore on the truck, as four pounds would be if placed above the springs, where the effects of the weight are cushioned. The chain drive kept the weight of the parts a minimum, and also kept it above the springs.

It was soon discovered that it was not possible to absorb all of the vibration and twisting which hard service gives to a truck without transmitting a considerable part of it to the frame and power plant. To the jar from the road was also added the twistings set up in the frame because of eccentric loading, and these effects were all transmitted to the power plant, to the radiator and to all parts which were attached rigidly to the frame. There were two possible ways of dealing with this difficulty: first, a more rigid frame and a better cushioning through the tires and springs; or, second, a flexible frame to which the various power-plant units would be flexibly mounted, so that each unit, while in itself a compact, rigid, perfectly aligned machine, would not suffer distortion by twisting set up in the frame. These units would be connected by shafts having universal joints or some other flexible connection. The modern truck has been developed along both of these lines. For the lighter and faster-running delivery truck the pneumatic tire is largely used, and its use is being extended to heavier trucks. Double pneumatic tires for the rear wheels are being used somewhat, and single pneumatics are being made up to 12 in. tread diameter. Both pneumatic and solid tires have been made as elastic as possible without sacrificing too much the other desirable qualities. Truck springs have been greatly improved also. The older types of truck springs were made up of rather thick leaves. They were short and narrow and had considerable camber. With the ad-

Paper presented at a meeting of the Los Angeles Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, March 28, 1916.

vent of modern heat-treated steel there has been developed a much better design of spring, with thinner leaves, and which is longer and flatter and much better suited to the needs of the truck. They are made of high-grade carbon or alloy steel, with the leaves self-lubricated and the spring eyes provided with phosphor-bronze bushings. The pins are nickel steel and the clips of chrome-nickel or vanadium steel. The old-fashioned full elliptical type has given place to the semi-elliptical as the preferred type. This improvement in the design and quality of springs and tires has gone far to reduce the strains set up in the frame.

But truck service on American roads is the severest sort of service: the uneven roads, which alternately elevate or depress diagonally opposite wheels; the chuckholes, into which a driver will plunge the truck at full speed; and the load on the vehicle, which is frequently thrown on without any regard to the way it strains the frame—all these tend to twist the frame members, and through them the power-plant units themselves. It is not possible to absorb all of these jars and distortions below the frame members as is done in the lighter and more resilient pleasure car. The method of mounting the power-plant units in gasoline trucks so that they shall not be distorted and jarred is a very important part of truck design. In the smaller trucks, up to about two tons capacity, it is possible to combine the engine, the flywheel and its clutch, and the transmission all in one rigid assembly. This gives perfect alignment. This unit power plant is then flexibly mounted within the main frame, usually with three points of support, two rigidly attached to the main frame and the third swiveled from a bearing on a main-frame cross-member. Another method is to mount the power plant rigidly to a sub-frame, which, in turn, is flexibly mounted within the main frame. This mounting may be a three-point support or one of four points, with spring buffers to absorb the jar and twist. Where the transmission is separate from the engine it is also flexibly mounted to the frame. The differential and jackshaft unit is treated the same way.

MOTOR-TRUCK ENGINES

Motor-truck engines do not differ greatly from those on pleasure cars. Motor-truck service is more severe and the engines are kept at capacity for longer times. For this reason the engines are run at slower speeds, from 800 to 1200 r.p.m. for trucks of one ton capacity or heavier, and the engines are therefore larger for the same horsepower. In general, truck engines are usually built stockier, with heavier crankshafts and connecting rods and larger bearings throughout. The water-jacket space is somewhat larger and the cylinder walls thicker, which permits more reboring. The radiator is larger than for the same size of pleasure-car engine. The valves, carburetor and intake manifold are often made smaller than on a pleasure car. This is possible with the slower speed, and has the advantage of preventing the driver from overspeeding the engine when it is not under governor control. Governors are now coming into general use, however, on trucks of one ton capacity or heavier. The governor throttles the gas mixture between the carburetor and the intake manifold. It may be driven from any exposed rotating part of the engine, or from the transmission, or from the wheel of the truck itself. The use of the governor does not prevent the driver from throwing out the clutch and racing the truck downhill. The four-cylinder, four-stroke-cycle engine is now standard for truck construction. There are a few makes of two-cylinder engines with the cylinders opposed to each other. One of this type has been very successful here in California. Also one or two builders have recently brought out six-cylinder engines, but their use for most work would not seem to be warranted at the present price of motor fuel. Four-cylinder construction is being used on more than 95 per cent of all trucks; and this condition will probably continue. The four-stroke cycle is made necessary by the varying load which every truck engine must handle.

Cylinders are cast separate, in pairs or *en bloc*. The preference seems to be for cylinders in pairs with either three or five crankshaft bearings for trucks of moderate to large size, and cylinders *en bloc* with three bearings for the smaller sizes. Individual cylinders are used on many of the larger trucks. As to the placing of valves in the cylinder, the same types obtain as on pleasure cars. There is a preference for the L-head type for the smaller engines up to about four inches in diameter, as ample valves may be used and still provide for the necessary water-cooling space around them. Nearly 80 per cent of all engines are of this type. With increase of cylinder diameter cooling is more difficult, and many makers prefer the T-head construction with valves on opposite sides of the cylinder. There are a few motors with the valves in the head, and some with one set of valves in the head and the other in the side. The advantages of these types, however, would be such as would recommend them for fast-running pleasure cars or racing automobiles rather than for motor-truck service. Owing to better design and balancing, the stroke on motor engines has been gradually increased, while the bore has been reduced. The bore-stroke ratio varies from 1 : 1.1 up to 1 : 1.5. Average sizes vary from $3\frac{1}{2}$ by $4\frac{3}{4}$ in. for a 1-ton truck up to 5 by 6 in. for a $7\frac{1}{2}$-ton machine.

The clutch is usually housed with the flywheel. The cone clutch with leather against metal and the cone a part of the flywheel itself has been the favorite until very recently. The more complex multiple-disk clutches with steel against steel or against bronze plates running in an oil bath, or steel against a built-up fabric of brass wire and asbestos running either in oil or running dry are also largely used. The dry type has been gaining in favor. In design it is accessible, frequently separately housed and removable from the engine train, and there is abundant surface to take care of the friction of starting.

TRANSMISSION SYSTEM

The transmission system on trucks was patterned after that on pleasure cars. There are a few friction-type or planetary-type transmissions on some of the lighter trucks, but the selective type with sliding gears, three speeds forward and a reverse, is the one which has been quite generally used. It has not been entirely successful for heavy truck duty. The operation of a transmission requires a certain amount of skill and respect for machinery not always found in an unskilled employee. There has been a marked tendency to adopt some form of individual clutch system for the heavier trucks. Also a fourth speed forward on these trucks is coming into use to meet the requirements of tractor duty and of starting under heavy load.

No matter what part of the truck is studied, one is impressed with the fact that for each part there are two or more radically different types of design competing for favor. Many of these parts have been brought out by manufacturers who make a specialty of one particular product. It is said

that 85 per cent of all trucks sold are almost entirely assembled products. Thus a manufacturer can assemble whatever parts he thinks are best suited to his particular truck. Whether some of these parts are better or not nearly so good and only cheaper is a thing which time alone will determine. For example, there are two methods of water cooling used on light truck engines, one the thermo syphon, for which the claim is made that it is simpler and just as effective, while opposed to the cheaper and simpler method is that of pump circulation, which tends to keep the engine cylinder more nearly uniform in temperature under all running conditions. Other examples of different design for truck parts are the frame members, which may be built-up shapes of channels or I's, very rigid and formerly exclusively used; or pressed-steel frames, which are lighter and more flexible, made of a higher grade of heat-treated steel, more expensive, but coming into increased favor with truck manufacturers. Again, the truck wheels may be of the wooden artillery type, of cast steel, or of built-up pressed-steel construction. For bearings flexible rollers and balls compete with the truncated cone roller. Brakes are either shoe or band, each of which may be either internally expanding or externally contracting. They may be placed both on the rear wheels, or one set, usually the service brakes, on the jackshaft on chain-drive machines or on the main shaft back of the transmission on the other types of drives. Again, there are four types of radiator construction, twenty standard types of carburetor, and nearly as many ignition systems. Lubrication may be by splash, by forced feed or a combination of both, and so with nearly every feature of truck construction.

But the development which is creating the widest interest and no end of argument among truck manufacturers is the final drive. For light-running trucks the pleasure-car type of drive with the differential on the rear axle is customary. Its use is restricted to cars of 1500 lb. capacity or less, as a greater gear reduction than about five to one gives such a big differential assembly that there is not enough road clearance. An additional speed reduction of some kind must be made for the heavier trucks. The many advantages of the chain drive have not been sufficient to overcome the objectionable features of exposed grit-collecting parts and broken chains. Three separate types have been developed to meet these objections. All are alike objectionable because they place an increased weight below the springs and because they are heavier than the chain-drive parts.

TYPES OF FINAL DRIVE

The first of these types, the double-reduction axle, uses one pair of bevel gears and one pair of spur gears trained together and housed with the differential on the rear axle. There is the advantage of enclosure of all working parts, quiet operation and no thrust loads on the differential. The assembly is heavy and there are a good many parts. Its use is now restricted to a few makes of light trucks of 1½ tons capacity or less. This drive has been very successful in standing up under long service.

The internal-gear drive is also a double-reduction drive, as two sets of gears are used. It is also like the chain drive, in that a dead axle carries the load while the differential is on a jackshaft, but in this drive the jackshaft is carried alongside of and parallel to the rear axle, while the chain connection gives way to a spur pinion running inside an annular gear on the rear wheel. It is quiet in operation and the parts are all enclosed. It has the advantage of a dead axle to carry the load, an argument that appeals to many customers; also the differential is smaller than that on the double-reduction drive, as it runs faster. There is, however, a thrust on the differential from the driving shaft. The weight-carrying axle is usually of I-beam construction, and the jackshaft may lie either in front of or back of this axle. This drive was first developed on the continent of Europe, and has been used increasingly in this country principally for trucks of from 1½ to 3 tons capacity.

The worm-gear drive, while it has met with much opposition, seems to be winning its way as the simplest and very possibly the most satisfactory of the three types. It has fewer parts, since the differential is carried within the worm wheel and the entire reduction is made in one step. There is a live rear axle which transmits the power to the rear wheels. This is usually of the full floating type, with the truck weight carried on the outside of the axle casing. The live axle must be of goodly size, as must also be the differential, since there is no reduction in rotations at the wheel. There is a heavy pressure between the worm and wheel, as the wheel is of small diameter. It is necessary to maintain the most exact alignment between the worm and wheel, which necessitates a very heavy built-up housing to carry the assembly. This housing is of cast construction, and all of this weight comes on the tires with no spring intervening. In spite of these objections, the worm drive, which was first successfully developed in England, has been increasing in favor very rapidly in this country, especially in the last year, and it is now being used on all sizes of trucks from ½ up to 6 tons capacity.

The success of the worm drive depends upon exact proportions, perfect alignment at all times, and, most important of all, the maintenance of an oil film which will not be squeezed out by the thrust of the worm shaft. It is now known that the efficiency of the worm depends entirely upon the condition of the oil film, and that this efficiency will remain practically constant under all conditions of running so long as the oil film is intact. Under test the pressures have been increased to a force per unit area comparable with the elastic limit of the bronze of the wheel, and the oil film has still held. This pressure is many times higher than is considered possible for any other pair of sliding surfaces at high speed, yet the coefficient of friction is only 0.02. Some of the interesting results of these tests are that the efficiency varies widely for different lubricants; that in general mineral oils are inferior to vegetable and animal oils; and that the best film is maintained at a moderately high rate of speed and with the gear box not too full of lubricant.

The methods of drive outlined are not necessarily limited in their application to the rear wheels of the truck. There are a variety of four-wheel drives on the market in which various combinations of internal gears or live axles are used to propel the truck through all four wheels. As the front wheels must swivel, and in some cases the rear wheels also are used in steering, it is necessary to provide for this in the drive either by knuckle joints or through a bevel-gear train with one gear mounted on the swiveling axis. These trucks are much used where the road conditions are severe, as for ore-hauling work in mountainous country or out on the desert, and for army transport work.

What has been said of the methods of driving gasoline trucks applies also to battery-driven electric trucks. These trucks, because of their simplicity and durability, and because of a high starting torque compared with the gasoline truck, are much used for work within their special fields. For de-

livery service in congested districts and where the number of stops per mile is large, and for special service such as street-work hauling with heavy loads and many stops, drawing in conduit wires, raising telephone poles and wholesale delivery, they are especially suited. Their use within these fields would be increased if the first cost were not so high. It is considerably more for the lighter types of truck. Electric trucks are handicapped by a slower speed, about 60 per cent of that of a gasoline truck, and the mileage is limited to between 35 and 45 miles per day as compared with 75 miles or more for the latter. Also, the electric must be brought to some point where direct current is available for charging the batteries. This charging is usually done at night, though the batteries may be given a slight boost during the noon hour or other convenient interval. For work for which they are suited the electric trucks will usually show a lower daily cost than gasoline trucks, where the latter are held down to the same number of miles a day. It frequently happens that it is not possible to get a greater mileage with the gasoline truck because of frequent stops and congested streets. The electric truck, with fewer parts, and none of these reciprocating, gives a lower maintenance cost outside of batteries, and the depreciation has been less than on the older types of gasoline trucks. There are many examples of electric trucks which have been in service for ten years or more and are still giving good service.

There is another type of truck which combines both the gasoline-engine and the electric-motor drive. The engine runs at a constant speed at all times, and is direct-connected to a generator which drives motors placed within the four built-up steel wheels of the truck. Each motor is carried by a steering knuckle, and the armature has a pinion at one end which engages with a ring gear on one side of the wheel, while a pinion on the opposite end of the armature engages with another gear on the opposite face of the wheel. This arrangement, while undoubtedly less efficient than the direct-connected drive, has all of the simplicity of the electric truck, for it does away with all chains, sprockets, clutches, sliding gears and differential. The mileage is unlimited, and it promises to meet the requirements of heavy duty and long-drawn-out service.

For every truck it is necessary to provide some means of resisting the rear-axle torque, which reacts on the driving gear and axle casing. The reduction gear on the rear axle tends to rotate instead of turning the wheel, and carries the axle casing with it. This turning must be prevented by some member connecting the casing with the main frame of the truck. Again, the thrust of the wheels against the roadbed must be made to react on the frame of the truck instead of upon the axle bearings alone, for the frame is suspended on the springs above the axles. There are several ways of taking care of these two forces. The torque may be taken through the rear springs or through separate torque rods swiveled from the rear-axle housing to the frame. The thrust may be transmitted through the rear springs, or through radius rods, and these rods may take both thrust and torque, or there may be separate rods for each duty. Where the springs take the thrust they are shackled at the rear end only, and the front end is pin-connected direct to the frame. A combined torque and radius rod is frequently used for the internal-gear drive axle, and for many of the smaller worm-drive trucks. The larger worm-drive trucks use separate torque and thrust rods.

ECONOMICS OF TRUCK OPERATION

Many things contribute to make Southern California an ideal field for the motor truck: perfect operating conditions throughout the year, many miles of good roads—city streets out into the country, a population which has scattered out instead of congesting, cheaper fuel than can be had in any other truck country, and a labor market where intelligent, careful drivers may be had for a moderate wage. For many kinds of haulage, covering a wide range of operation, the motor truck is distinctly superior to any other method of transportation. Given an active service at full load, with a terminal not definitely fixed and a radius of operation up to thirty miles, it is an exceptional condition which will justify any other method of goods haulage.

Some of the especially active fields for the truck in Southern California are goods hauling to and from Los Angeles harbor, interurban delivery service, road building and wholesalers' delivery. There are, however, special considerations which may have considerable bearing upon the employment of a truck. A committee of the Boston Chamber of Commerce, in a detailed report on street traffic in Boston, covering eighteen months of study, reported that "development of motor trucks will tend to relieve congestion by moving all merchandise in larger units and more rapidly," and that "the average speed of motor vehicles in getting into and away

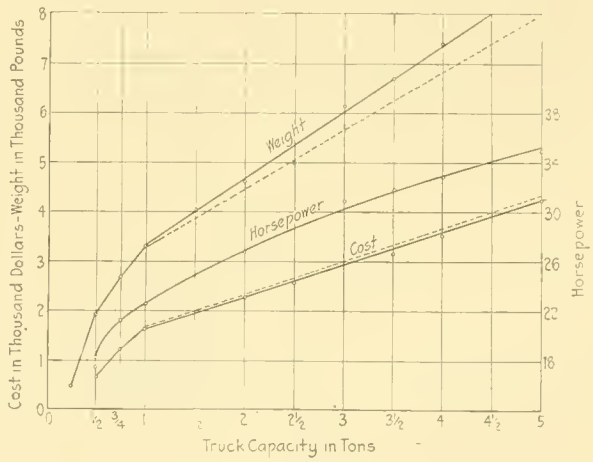

Fig. 1 Averages from All Classes of Gasoline Motor Trucks

from railway terminals is from two to three times that of the horse." This is especially applicable to Los Angeles, which has nearly two miles of as congested streets as are to be found in nearly any city.

Another great advantage of the motor truck to the retailer is that he cannot only supply his customers more quickly, but also because of the greater mileage range his territory is increased to about eight times what he could serve with a horse.

COSTS OF GASOLINE TRUCKS

Fig. 1 gives curves of cost, weight and horsepower (average values) for all classes of gasoline trucks as listed by publishers of motor-truck publications. The noticeable feature of these curves is the sudden break of each for the lighter trucks of less than 1 ton capacity. These show that the demand for a light truck has been met by making a vehicle which is much lighter for the rated load than the heavier trucks. This is possible because of the higher engine speed, a more simple final drive, torque and thrust taken through the vehicle springs, and by the generous use of special alloys and heat-treated

steels. The curves suggest that these trucks are too light for the load that they are rated to carry. That this is true is abundantly proved by the records of many light trucks, which show that the average life of a light delivery truck is about 35,000 miles, whereas the heavier trucks when properly driven and cared for can be depended upon to give 80,000 to 100,000 miles, or even more for the better grade of trucks, if they are carefully driven and ordinary maintenance is kept up. It would seem that there is a real field for a more serviceable light truck which will at a little greater cost give enough lower depreciation and maintenance to be a profitable investment.

That there is a real field for such a truck not only for city service but also for use throughout the country is shown by the report of the U. S. Government, which states that only 15 per cent of the entire traffic of the country is moved by railroads and steamships combined, the remainder of 85 per cent being carried for the most part in wagons and the greater part of it in lots of 1000 lb. or less. This field has only been touched by the motor truck as yet, and to fully occupy it would require not less than two million light trucks. This estimate makes no provision for hauling done on the farm.

Table 1 is an itemized cost statement for various sizes of gasoline trucks under average service conditions on the roads of Southern California. These costs are conservative. It is possible to find plenty of examples of lower costs and also of costs that are much higher, but these costs are easily realizable for ordinary truck work in this locality. With proper management an even lower cost per day should be realized. That these costs are somewhat lower than averages for other localities may be largely credited to good roads and an equable climate. In making this table three conditions of operation are assumed: the costs for each size of truck are computed for a daily run of 25, 50 and 75 miles, and for each condition the life of the truck is estimated, and depreciation is based on this life. Costs are given in dollars for the entire life of the truck. First costs are average chassis costs in Los Angeles.

In California distillate is being used to quite an extent as a substitute for gasoline. The cost per gallon is about half that of gasoline at the present time, and the B.t.u. content somewhat greater. A local truck manufacturer has been very successful in equipping trucks with gasifiers by which the heat of the exhaust gases from the engine is used to heat the inlet air as it goes to the carburetor, and also to heat the mixture as it goes from the carburetor to the cylinder. A supply of gasoline is carried and used in starting. The consumption of distillate is about the same as that of gasoline. The success which has attended this innovation would seem to justify the claims of the manufacturer that the use of distillate does not increase carbon trouble. The question of a lessened volumetric efficiency is a negligible consideration.

Tires will outwear the manufacturers' guarantee at least twenty-five per cent when used on the good roads of Southern California. Smooth roads, dry surfaces and an equable climate all contribute to this result. Overloading and overspeeding are the things that shorten tire life. However, the important consideration is not tire economy, but economy of truck operation per ton of material carried; therefore, durability is only one factor that must be taken into account. Resilience, which prevents the wasting of truck power; cushion-

TABLE 1 TOTAL COST OF OPERATING GASOLINE MOTOR TRUCKS AT VARIOUS DAILY MILEAGES

Capacity of Truck	Cost in Dollars	Horsepower	Miles per Hour	Miles per Gallon of Gasoline	Daily Mileage	Estimated Life, Years	Total Mileage	Costs for Entire Life of Truck, in Dollars: Insurance, Fire and Liability	License and Taxes	Interest at 6 per cent	Depreciation	Administration	Garaging	Gasoline at 16 Cents per Gal.	Oil, Grease and Waste	Tires (less first cost)	Driver's Salary	Inspection and Maintenance	Total	Cost per Day, Dollars	Cost per Mile, Dollars	Cost per Ton-Mile, Dollars
Light					25	5	37,500	200	40	180	600	35	180	400	190	225	2,400	750	5,200	3.47	0.139	0.417
delivery	600	18	25	15	50	2½	37,500	100	25	90	500	20	90	400	190	225	1,200	655	3,495	4.66	0.096	0.288
wagon					75	1½	33,750	60	20	55	450	10	55	360	170	200	900	505	2,785	6.19	0.082	0.246
					25	6	45,000	300	65	400	1100	110	215	600	340	270	3,600	1010	8,010	4.45	0.178	0.237
1500 lb.	1100	22	20	12	50	3	45,000	150	50	230	950	55	110	600	340	270	1,800	900	5,455	6.06	0.121	0.161
					75	2	45,000	100	30	130	850	35	70	600	340	270	1,440	790	4,655	7.76	0.103	0.137
					25	10	75,000	850	220	1125	1875	225	480	1500	560	1340	7,200	1900	17,275	5.76	0.230	0.230
1 ton	1875	24	19	8	50	6½	97,500	550	140	730	1690	140	310	1950	730	1800	4,680	1900	14,620	7.50	0.150	0.150
					75	4	90,000	300	85	395	1500	90	170	1800	675	1640	3,468	1800	11,815	9.85	0.131	0.131
					25	10	75,000	1000	235	1290	2150	255	600	1710	560	1505	7,200	2000	18,505	6.17	0.247	0.165
1½ tons	2150	25	18	7	50	6½	97,500	650	150	840	1935	170	390	2230	730	2025	4,680	2000	15,800	8.10	0.162	0.109
					75	4	90,000	350	95	450	1725	100	210	2055	675	1850	3,360	1900	12,770	10.64	0.142	0.095
					25	10	75,000	1150	265	1575	2625	315	720	2000	750	1840	7,200	2250	19,440	6.90	0.276	0.138
2 tons	2625	26	17	6	50	6½	97,500	750	195	1025	2360	205	470	2600	975	2475	4,680	2250	17,985	9.22	0.184	0.092
					75	4	90,000	400	110	550	2100	125	250	2400	900	2255	3,360	2100	14,550	12.12	0.162	0.081
					25	10	75,000	1350	380	2100	3500	415	960	2400	750	2345	9,600	3250	25,700	9.02	0.361	0.103
3½ tons	3500	32	14	5	50	6½	97,500	875	245	1365	3150	270	625	3120	975	3150	6,240	3250	23,265	11.93	0.239	0.068
					75	4	90,000	460	150	735	2800	165	335	2880	900	2870	3,840	3000	18,135	15.11	0.201	0.057
					25	10	75,000	1760	440	2760	4600	550	1200	3430	750	2680	10,800	4000	32,970	10.99	0.439	0.088
5 tons	4600	35	12	3½	50	6½	97,500	1145	285	1845	4140	360	780	4460	975	3600	7,020	4000	28,610	14.67	0.297	0.059
					75	4	90,000	600	180	965	3680	220	480	4115	900	3280	4,320	3600	22,340	18.62	0.223	0.044
					25	10	75,000	1875	525	3000	5000	599	1320	4000	940	3015	10,800	5000	36,065	12.02	0.481	0.074
6½ tons	5000	40	10	3	50	6½	97,500	1220	350	1950	4500	380	860	5200	1220	4050	7,020	5000	31,750	16.35	0.326	0.050

ing effect, which keeps the maintenance charges low on the whole truck; a good tractive grip, and a reasonable cost are all properties which are required in a truck tire.

OPERATING COSTS

Fig. 2 gives a graphical view of percentage costs for a light-, a medium- and a heavy-weight truck, each averaging 50 miles a day. The higher proportion which the light truck has in the items of labor, depreciation and maintenance is noticeable. Against this increase is the lower percentage of the entire cost charged to fuel and tires.

In discussing motor-truck costs it is not possible to neglect the human factor, which here more than in most cases of machinery handling is one of the principal items. It is hardly too much to say that maintenance costs are chiefly driver. An expensive and intricate machine is put in charge of a low-paid employee who is not the owner and who ordinarily has but a limited knowledge of machinery. This is one reason why the life of a light truck is usually about two or three years.

Many of the larger department stores will not allow their drivers to make any repairs or even to carry a wrench or a pair of pliers. A repair force looks after each truck and keeps it cleaned, oiled and set up. Ownership of eight or ten

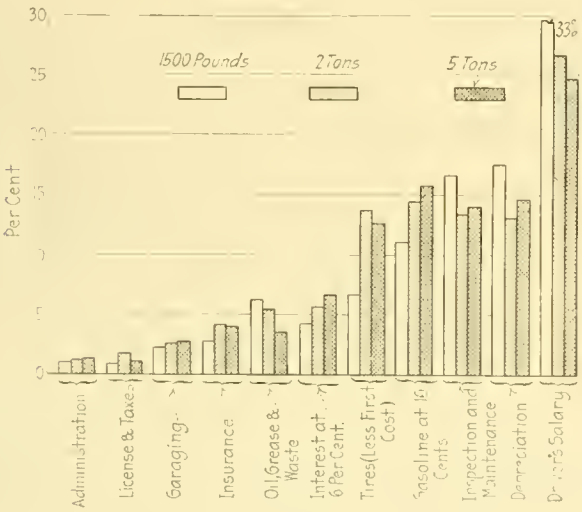

Fig. 2 Division of Truck Costs

trucks will justify an owner in employing a mechanic who, with a small outfit of tools and a helper, can keep the trucks clean and in adjustment and make many of the smaller repairs. Reliable service garages are now to be found which will do the same work for a reasonable charge, and this is more satisfactory than to leave it to the driver.

It is impossible for the manufacturer to devise a shop test that will equal the brutality of actual service. The modern motor truck has had to meet the demand for a vehicle that will stand abuse. The careless or indifferent driver is quick to find this out. Operating costs for the same make and capacity of truck engaged in exactly the same kind of work for one firm will frequently show a variation of 40 per cent in the items of gasoline, oil, tires, and maintenance. It is easy to see how a poor driver will shorten the life of a truck.

Manufacturers have tried to meet this condition by making truck parts as few and simple as possible; by standardization of parts; by making wrong assemblies impossible; by printing detailed information about oiling and caring for the truck; and by instituting a follow-up service to get the truck owner started right. The truck governor has helped to solve the speeding problem. Another aid is a recording speedometer, which gives a graphical log of each day's run—velocity plotted against time: thus every minute of the day is accounted for; the number of stops and time of each, maximum speed, etc. The chart will show, for example, whether it will pay to put on a second man to hasten deliveries or whether a rerouting of existing lines will give a better all-around service. A driver's record sheet, if it is brief and informing and filled out each day, is frequently helpful. It must be drawn off at the office and kept up to date. Records are of little use unless changed conditions can be recognized at once.

Lubrication is probably the most important item in truck maintenance. Manufacturers have tried to make oiling simple and easy to do by making oiling places few and accessible, and

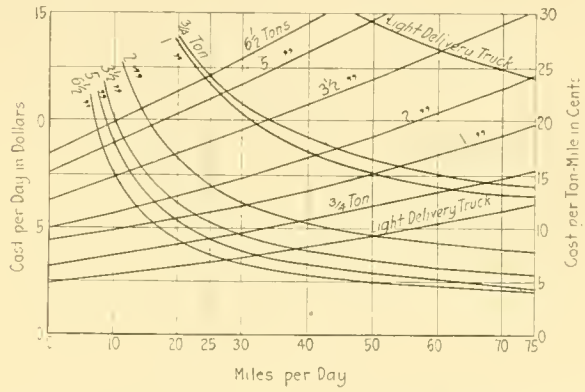

Fig. 3 Cost of Operating Gasoline Motor Trucks

by providing charts and printed instructions for this work: some parts every day, some parts twice a week, etc. Still, there are about seventy places in the average truck that must be lubricated, and if there is no intelligent head to look after this work, local wear soon starts and then things go fast. Motor oil should be changed frequently, at least once for every 1000 to 1500 miles' run. It is not enough to build up the supply, as the oil is fast charged with carbon and with grit from the intake air and soon loses its lubricating qualities.

Fig. 3 gives curves for gasoline trucks plotted from the data of Table 1. These curves, if continued out to the line of zero miles per day, show the daily fixed charges for each truck. The cost per day increases quite uniformly with the increase in size of the truck, whether the daily run be a large or a small one. The cost per ton-mile is less for the larger trucks, and decreases quite rapidly as the daily mileage increases up to thirty or forty miles per day. The cost per ton-mile is based on a full load each way. This chart shows that under such favorable conditions of haulage a heavy truck may reach a ton-mile cost of as low as five cents, provided that the nature of the work is such that the truck can run daily at the rate of 50 or 60 miles a day. This is a heavy mileage for a big truck, and such an ideal service as would be represented by a full haul each way on level roads, with loading and unloading time minimized so that the truck could be under way for six or seven hours each day and with no extra helper required, is not often found.

In deciding upon a truck, one of the most important questions to settle is that of size. On the good roads of this section it is more disastrous to buy a truck too large for the work than to buy one that is too small. A 5-ton truck costs

some 25 per cent more to operate than a 3-ton machine, nor is this cost reduced very much by taking a lighter load on the heavier truck. Interest, depreciation, maintenance, taxes, insurance and fuel—all are higher. Until very recently the tendency has been for owners to buy trucks too large for their needs. Now the buyers have commenced to realize that it costs too much to "deliver the vehicle."

Another point that must not be overlooked is that the capacity of a truck is figured for average conditions, and that the average road condition throughout the country is very much harder on the truck than it is here. A half load on a truck carried over a road full of ruts and chuckholes is much worse for the truck than a 20 per cent overload on a good concrete or asphalt road. A 6½-ton truck recently carried an 11-ton casting up the Mount Wilson toll road, a distance of 9 miles. This is a tremendous overload, but it can not be said that the truck was injured by it. In fact, it is probable that the truck parts were not weakened in any way by this test, for the road, while steep, is firm and smooth.

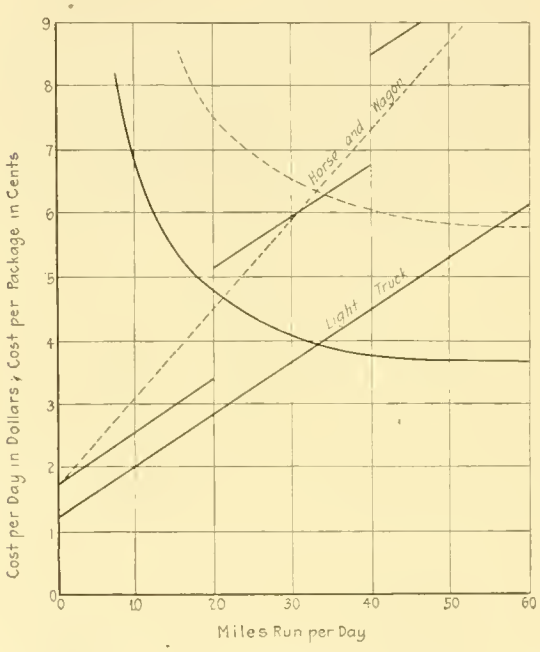

Fig. 4 Comparison of Single Horse and Wagon and Light Delivery Truck Costs

The writer does not wish to encourage overloading, which has been responsible for many truck failures and against which much has been written, but he does wish to point out that an occasional overload of 25 per cent or even 50 per cent when handled carefully on a good road is not a serious matter, while to haul a heavy truck day after day, loaded at half capacity, is a very serious matter if one would haul cheaply.

It is possible to buy a truck that is suited for work on good roads or one that is especially designed for rough roads, mud, steep hills and severe service generally. The problem is to know what is suited and to weigh properly the arguments of the salesman who offers a 2-ton truck with a 15-h.p. motor and a 25-h.p. rear axle, and the counter arguments of his rival whose truck has a 25-h.p. motor and a 20-h.p. rear axle. This is one of the surprising results of the modern method of building up assembled parts into a truck, and while there may be advantages of such variations in the relative strength of truck parts for some particular service, it is a fact that both extremes are being sold for exactly the same work. The Society of Automobile Engineers has done a wonderful work in standardizing the parts for auto trucks. This will be carried much further in the future, for the economies that will result from standardized parts and also from standardized assemblies have been strongly emphasized by the experience of European countries with the use of trucks in the present war.

At present the truck owner or prospective purchaser is sadly in need of disinterested advice, and there is a good engineering field for the man who thoroughly knows trucks and can plan service. There is little doubt but that the average truck owner could save 20 per cent of his operating costs by properly analyzing his problem.

TABLE 2 COMPARISON OF OPERATING COSTS OF A SINGLE-HORSE WAGON AND A LIGHT GASOLINE DELIVERY TRUCK

Cost of wagon equipment (horse, $250; wagon, $140; harness, $40), $430.
Cost of 700-lb. capacity gasoline truck, $600.

	Wagon Costs		Truck Costs	
	Idle	20 miles per day	Idle	60 miles per day
Estimated life, years	10	10	10	2.5
Depreciation	0.108	0.156	0.200	0.760
Interest at 6 per cent	0.086	0.086	0.120	0.120
Taxes	0.009	0.009	0.012	0.012
Stable or garage rent	0.200	0.200	0.166	0.166
Insurance (fire and theft)	0.030	0.030	0.045	0.045
Driver (⅓ time when idle)	0.666	2.000	0.666	2.000
Feed: Hay, 10 lb. and 15 lb.	0.102	0.153	.....	.....
Feed: Oats, 10 qt. and 15 qt.	0.200	0.300	.....	.....
Gasoline, at 16 cents per gal.	.....	.....	.....	0.640
Lubricating oil, at 40 cents	.....	.....	.....	0.130
Hostler (1 man to 12 horses)	0.200	0.300	.....	.....
Cleaning and oiling	.....	.....	.....	0.400
Shoes and veterinary	0.095	0.135	.....	.....
Tires and tubes	.....	.....	.....	0.625
Repairs to wagon	.....	0.090	.....	.....
Maintenance	.....	.....	.....	1.200
Water, bedding, etc.	0.045	0.045	.....	0.005
Total cost per day	$1.741	$3.404	$1.209	$6.103

METHODS OF REDUCING TRUCKING COSTS

To get a low cost per ton it is necessary to keep the truck moving. Devices which cut down the time of loading and unloading are very important. Among these are self-dumping bodies of various kinds for stone, hot asphalt or lumber; loading chutes on bins which are filled by elevator or conveyor; there is also a movable steel tipple which can be run alongside a train of flat cars and be filled by shovelers while the truck is out on the road, so that the actual time required to fill the truck is very little. Another device is the use of extra truck bodies, which are loaded while the truck is on the road and swung onto the truck by an air lift or other hoist. A firm of wholesale grocers in Los Angeles is using this method very satisfactorily. In interurban delivery service loading nests or cartridges are being used. These are filled in the store and run out onto the truck. There is some promise in the extension of this device for relieving the congestion around freight stations and also for interurban service where a heavy truck can bring over all of the orders for an entire community and local deliveries be taken care of by light trucks each with its especial cartridge. A scheme somewhat similar to this is now being tried out by the City of Los Angeles. The incombustible rubbish is gathered by a house-to-house collection, using wagons. The material is put in large cans which are carried to a central point and a heavy truck is used to haul all of the cans to the city dump.

COMPARISONS OF OPERATING COSTS OF HORSE-DRAWN AND MOTOR TRUCKS

The use of an extra man to facilitate deliveries will often save enough time to make a good investment. One of the large department stores in Los Angeles found that on a certain route where one man had averaged 110 stops a day two men were able to make 190 deliveries. The use of self-starters on trucks of this type is also becoming common. These save a little time on each stop and also keep the driver out of the dirt, and particular customers appreciate this feature. At the plant of the Southern California Gas Company the night man unloads the trucks and stores the pipe and old meters that have been collected during the day, and then puts onto the truck the new supplies that have been requisitioned for the coming day.

Fig. 4 and Table 2 show a comparison between the cost of running a light gasoline delivery truck such as is used for close-in delivery work by grocers, and the cost of running a one-horse delivery wagon. The costs are from actual costs gathered in Los Angeles and vicinity and averaged. For each vehicle the cost is figured for the vehicle idle and again when running at a fair maximum daily average. The figures show that there is no excuse for using a horse for this kind of work, whether the number of deliveries be large or small. Twenty miles a day is a maximum for any delivery horse if used 300 days a year. If more than 20 miles a day are to be covered, it is necessary to duplicate equipment.

TABLE 3 COMPARISON OF OPERATING COSTS OF A 5-TON GASOLINE TRUCK AND A HEAVY TWO-HORSE WAGON

Cost of wagon equipment (2 draft horses, $600; wagon, $300; harness, $100), $1000
Cost of 5-ton gasoline truck, $4800

	Wagon Costs		Truck Costs	
	Idle	16 miles per day	Idle	50 miles per day
Depreciation	60	120	240	480
Interest	60	60	288	288
Taxes	6	6	30	30
Stable or garage	120	120	120	120
Insurance (liability)	...	26	...	140
Driver	250	750	360	1080
Helper	...	600	...	600
Feed or gasoline	90	135	...	686
Oil, grease, waste, etc	...	5	...	150
Shoes and veterinary, or tires	25	40	...	550
Repairs, maintenance	..	25	...	600
Water, bedding, etc	25	25	...	20
Hostler	100	100	...	...
Total cost per year	$736	$2012	$1038	$4744
Total cost per day	$2.45	$6.70	$3.46	$15.81

Fig. 5 and Table 3 give a similar comparison between the cost of operating a 5-ton gasoline truck and heavy teams used for such work as rock and dirt haulage and heavy transfer work generally. As in Fig. 5, the costs are figured from actual costs based on a maximum of service per day and an assumption as to what the costs would be if the vehicle did no work. The curves show that the truck should have enough work to do to occupy the time of more than one team, if it is to be the cheaper vehicle. The Pacific Electric Railway Company uses heavy trucks for patching the paving along the line. They find that for work outside the business district the truck will do the work of two to three teams, depending upon the length of haul and the size of the job; for long-distance hauling the truck will do the work of four or five teams.

In paving Vernon Avenue the rock and crushed stone were delivered by teams, the average haul being about two miles. Each team delivered a 3-ton load and averaged 5½ trips per day. When work on other contracts took the teams away, the work was sublet to another contractor who took the job at the same price per ton as the teams were figured to have cost. Three 5-ton trucks averaged 12 trips per day each, and carried an average of 54.7 tons per day apiece. This makes each truck equivalent to 3.3 teams, which would represent a considerable saving by the use of trucks, provided they could be kept steadily employed.

The use of electric trucks for delivery service is not so general in Los Angeles as in most large cities. Two of the largest department stores in Los Angeles use no electrics, and other stores which do use them have usually a smaller percentage of the entire fleet of this type. There are two reasons for this: first, a smaller congested area than cities like Boston or Chicago, and second, a smaller number of stops per mile. For light delivery service where the vehicles carry 1000 lb. or less the higher first cost of the electrics is a serious objection; for vehicles in the 1500-lb. class the difference in first cost is not so great, and the electric vehicle will show a lower cost per delivery than the gasoline truck where the latter is held down to the same number of miles per day. Table 4 gives the average work and costs for one month for both classes of vehicles for one of the large department stores in Los Angeles. From this it will be seen that where the electric truck gives a cheaper delivery, it has the advantage of more stops per mile. It is probable that in spite of the close-in traffic conditions the gasoline truck would cover the same route in less time or give a larger number of deliveries per day in the same territory. These costs are based on the use of two men with the gasoline truck and one man on the electric. The comparison shows that the advantage in favor of the electric truck is a very small one, and may vanish altogether under comparative tests. On the other hand, there is an advantage for the electric in its quieter operation and greater cleanliness that is worth something in delivery service.

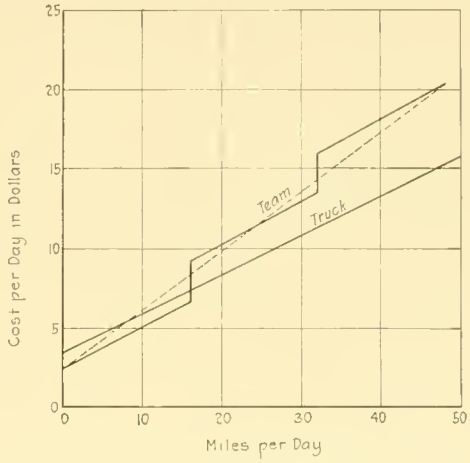

Fig. 5 Comparison of Costs for 5-Ton Gasoline Truck and Heavy Teams

TABLE 4 COMPARISON OF GASOLINE AND ELECTRIC DELIVERY TRUCKS
(Averages for 1 month)

Type of Truck	Gasoline	Electric
Miles traveled per day	75	36
Stops per mile	1.96	2.74
Stops per day	147	104
Cost per mile, cents	12	15.3
Cost per stop, cents	6.12	5.29

THE USE OF POWDERED COAL AS A FUEL

A Description of the Methods Employed in the Production, Handling and Firing of Powdered Coal, with a Discussion of Its Advantages when Used with Certain Types of Furnaces

By JOSEPH HARRINGTON, CHICAGO, ILL.

Member of the Society

POWDERED coal was under consideration as a fuel over twenty years ago, and its apparent advantages have attracted the attention of engineers ever since. The early experiments were naturally crude, and failed largely because of the lack of proper machinery for reducing the coal to the required state of fineness. It was not fully appreciated that the coal had to burn while floating in the air in the form of dust.

Sufficient experimentation was carried on, however, to prove that powdered coal would burn under these general conditions and would develop a particularly intense flame. In fact, one of the chief difficulties encountered was the melting down of the furnace due to the blast-like effect of the jet of coal and air.

After the early failures there was very little done for a number of years, but about five years ago the matter was revived, and with the development of adequate pulverizing machinery, extensive and practical applications have been made.

The first general field of usefulness to which it was applied was the burning or clinkering of cement. The coal was not required to be pulverized particularly fine. The velocity of the let of coal and air entering the kiln could be high, and little or no difficulty was encountered from deposits of slag or ash. The next general application of this fuel was in the simpler metallurgical processes in the heating furnaces, where excessive temperatures were not required and where the ash deposits were either continuously removed with the material to be heated or could readily settle on the hearth and be later withdrawn.

In 1912 the American Iron & Steel Manufacturing Company had carried their experimentations to a point where they were ready to publish statements of the successful use of the fuel. At the Lebanon plant they have used it in puddling and heating furnaces and small reheating furnaces for nut, bolt, and spike bars, and in larger furnaces for continuous billet heating and open-hearth melting.

REQUIREMENTS OF PULVERIZATION

The condition in which this fuel must be furnished to produce satisfactory results has been developed to a point where it can be considered as definitely standardized. Not only for the sake of combustion efficiency but for the sake of more perfect pulverization the coal should be practically dry, 1 per cent of moisture being the maximum amount at which pulverizing can properly be effected. One-half of 1 per cent moisture is the figure which is ordinarily required. Under these conditions the coal when pulverized remains quite fluid, and will break down under the influence of the crushing rolls with much less expenditure of power than when damp.

In order that the fuel may remain suspended in the carrying air and in the furnace chamber during combustion, it is necessary to reduce it to a certain degree of fineness. After a great deal of experimenting this standard has been established as follows: 85 per cent must pass through a 200-mesh screen and 95 per cent must pass through a 100-mesh screen. When these requirements are fulfilled there is an indeterminate amount of impalpable product, the absolute size of which it is beyond our ability to measure.

Much has been printed regarding the quality of coal most suitable for pulverization, but no arbitrary limits can be established as to the proximate analysis most suitable. Broadly speaking, the greater the volatile combustible content the more readily will the coal ignite and burn, and the less dependent will be this process upon the size and proportions of the combustion chamber. As the volatile content decreases, however, more dependence must be placed upon the proportions and location of the surrounding brickwork, in order to maintain the temperature until ignition is complete. Anthracite coal has been burned in a pulverized form, but it must be very finely ground and must be burned in a rather confined space, so that the ignition may be prompt and aid be rendered by nearby brickwork during the early stages of combustion.

PULVERIZING MACHINERY

Several types of machinery which are commercially marketed will satisfactorily pulverize coal. They are divided broadly into air-separation machines and screen machines. In the former class there is an upward current of air produced by a fan which has a carrying capacity sufficient to take with it the finest particles, but which will not lift the coarser ones. As soon, therefore, as the coal is reduced to the required degree of fineness this air current will lift the particles and take them away and will then deposit them in a receiving tank by means of a cyclone separator, which is usually vented in some manner to prevent the loss of dust.

In the screen mill the coal is continually thrown against a screen which permits the fine particles to pass through but causes the coarser particles to fall back under the rolls. Pulverization can be effected in a tube mill or ball mill with an expenditure of power and cost not greatly different from that of the other types.

THE BURNER

The pulverized fuel being collected in a hopper is conveyed either by screws or pneumatic means to the burner, which is situated at the furnace to be served. As to this particular appliance there is great divergence of opinion and a greater variety than at any other point of the entire system. It is now generally conceded that the most efficient results are obtained when the coal dust is carried into the furnace in a stream of air, the volume of which is just sufficient to supply the oxygen necessary for its complete combustion; the velocity

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of the entering jet must be greater than the rate of flame propagation to prevent burning back into the pipe.

This mixture of coal and air must be made in fairly close proximity to the furnace. The reasons therefor are that when this mixing is done there is produced an explosive compound, which it is desired should not be of any greater extent than necessary. The other reason for making the explosive mixture close to the furnace is that there is a tendency for the coal to separate and lose its uniformity of mixture, under which condition it is obvious that part of the jet would be oversupplied with coal, and the other part oversupplied with air. The production of this uniformity is the more important and difficult, and is the rock on which have been wrecked the hopes of more than one enthusiastic experimenter. Various devices have been provided for producing and maintaining the required uniformity of mixture.

In the existing commercial installations the fuel is removed from the storage hopper by means of a screw of special design. This screw is placed at the bottom of the hopper and is usually driven by some form of variable-speed device, thereby securing control over the amount of coal extracted per unit of time. It is a well-known fact that the delivery from such a screw is not uniform, the coal being delivered in little heaps and producing distinct pulsations in the furnace. To reduce this effect these screws have been made with a double or a triple helix, in which case two or three discharges per revolution are produced in place of one. This is a distinct improvement, of course, but even under these conditions a very noticeable pulsating effect is observed. Devices have been developed for passing this discharged material over a screen, or over a moving disk operated at a considerable speed, the idea being to smooth out the inequalities and produce a continuous delivery of dust. Some of these devices have proved their ability to secure this effect, which is all-important on account of its direct influence on the character of the flame in the furnace. Once established this uniformity must be maintained, and if it be necessary to have the mixer at any considerable distance from the furnace, means must be provided for uninterrupted agitation of the air current in order that the fuel cloud may remain of constant density. This is not a very difficult matter, but is one which must not be overlooked.

OBJECTIONS AND DIFFICULTIES

As is the case with all new things, the early history of the use of powdered coal is replete with accounts of failures, and this has left an impression on the minds of the engineering public which it will take years of successful application to eradicate. The early experimenters did not understand the necessity of fine grinding, and it would seem that they did not appreciate the influence of furnace design upon the temperature of the resulting gases. The coal was powdered sufficiently fine, however, to develop intense temperatures, even though part of the coal was lost by falling to the bottom of the furnace and being thus removed with the slag and ash.

Insufficient combustion space and the ease with which this fuel can be mixed with the minimum amount of air, combined to produce abnormal temperatures and a direct contact of flame and brickwork. The blowpipe effect of the high-velocity jet acted to melt out the brickwork upon which it impinged. A layer of melted lava, formed by the fusing of both ash and brickwork, accumulated in the bottom of the combustion chamber, and naturally discouraged those who depended upon this fuel for continuous service.

Later on, difficulty was encountered due to the minute particles of liquid slag being carried on in suspension and deposited upon the tube sheet or water tubes of the boiler, thereby closing up the flame space and putting the boiler out of action. These effects are particularly observable with certain grades of coal, but noticeably absent with others; and only until recently has research work been carried to a point where any knowledge has been obtained of what causes this trouble and what coals are most suitable for firing in powdered form.

ADVANTAGES

Having stated the objections, it is interesting to pay equal attention to the advantages of this fuel. Inasmuch as these advantageous features form the foundation of all discussions of this subject, as well as the impelling cause of all experimental work, I will but merely restate them, depending upon later paragraphs to develop the subject more fully.

From the viewpoint of the theorist, the use of powdered coal forms one of the best methods ever proposed for the promotion of combustion efficiency and commercial economies. In all transformations of energy there is unavoidable loss, and we are not possessed of apparatus which will gasify coal with 100 per cent efficiency. In the producer there is a succession of losses which reduce the available heat in the gas to a considerable extent, and in the mechanical stoker there are unavoidable losses due to various forms of incomplete combustion. Only in the case of powdered coal is the actual solid fuel both gasified and completely consumed directly within the chamber desired to be heated. With perfect pulverization the entire mass is burned in suspension, and in actual practice but a small fraction of one per cent is actually lost in the flue dust or slag pan.

On account of the fuel being conveyed into the furnace by the very air which is afterwards to be used in its combustion, and on account of the diffusing of the coal throughout the air in a cloudlike formation, there is a possibility of a mixture which can be secured by no other means. Each particle of coal is surrounded by a particle of air, and on account of the extreme fineness of the particles practically instantaneous oxidation occurs. The result is efficient combustion, and we have to deal only with the effects of the high temperature thereby obtained. That it is now possible to control this temperature while not sacrificing any material gain due to it, is definitely established. Moreover, the definite control of the amount of air per unit of coal permits of the most perfect variation in the results obtained. It would be impossible herein to enumerate in detail all of the means employed to take advantage of the inherent efficiency of this form of firing.

POWDERED COAL FUEL IN STATIONARY PRACTICE

It must be confessed, I think, that steam generation by the use of powdered coal as a fuel is still in the experimental stage, and here if anywhere will it meet severe competition. With the exception of the M. K. & T. installation at Parsons, Kansas, which is now being put in by the Fuller Engineering Company, all of the steam-making installations are in the plants of the manufacturers of powdered coal equipment, or in plants very directly connected therewith. That steam can be efficiently produced in this way is unquestioned if merely combustion and evaporation are considered. Whether it can be generated more economically than it is at present by plants with the best mechanical stokers, still remains to be commercially proved, and even with powdered coal, gas analyses better

than 16 per cent of CO_2 are not developed. With the mechanical stoker the CO_2 can be maintained around 14 per cent.

With powdered coal the loss in the ash pit and in the flue does not exceed 1 per cent, and with the best mechanical stokers this loss will not exceed 2 per cent of the coal fired. A possible advantage of 2 or 3 per cent in combustion efficiency in favor of powdered coal is offset by the cost of fuel preparation. It is not reasonably to be anticipated that we can get better than 96 per cent efficiency, and this is a figure which can be obtained by the mechanical stoker. I foresee, therefore, a hard fight for powdered coal in stationary steam-boiler practice.

POWDERED COAL FUEL IN LOCOMOTIVE PRACTICE

On account of the very comprehensive and detailed report on this subject which has today been presented at the Railway Fuel Association meeting, and its availability in printed form, I will not attempt to enlarge upon it here. It is in cases such as the locomotive that powdered coal shows most favorably. Here we have not only the single problem of combustion efficiency, but a long list of related conditions that are affected thereby. I can do no better than to quote the summary of the report of the standing committee of the Railway Fuel Association.

Summing the results that are being obtained in locomotive service these may be stated as:

1 Smokeless, sparkless and cinderless operation.
2 Maintenance of maximum boiler pressure within a uniform average variation of 3 lb. without popping.
3 An increase of from 7½ to 15 per cent in boiler efficiency as compared with burning lump coal on grates.
4 Saving from 15 to 30 per cent in fuel of equivalent heat value fired.
5 Enlarged exhaust nozzle area, resulting in greater drawbar pull and smoother working of the locomotive.
6 Elimination of ash-pit delays, facilities and expenses, and reduction in time required for, and ease in, firing up.
7 Maintenance of a relatively high degree of superheated steam.
8 No accumulation of cinders, soot or ashes in the superheater or in the boiler flues, smokebox, or on the superheater elements.
9 No punishment or overheating of the firebox, new or old sheets, seams, rivets, patches, bolts, stays or flue beads.
10 Elimination of arduous manual labor for building, cleaning and dumping fires, and for firing. This feature would appear to be quite advantageous, due to difficulty experienced in holding satisfactory labor on this class of work at the rates usually paid.
11 Avoidance of expense and annoyance in providing various sizes and kinds of fuels.
12 Elimination of front end and ashpan inspection and special fuels, firing tools and appliances for building fires and for stoking and cleaning them.

Your committee is of the opinion that the effectiveness and utility of the use of fuel in pulverized form has been demonstrated from the past year's development, and that the progress in the use of this method of stoking and burning bituminous and anthracite coals and lignites for generating power, heat and light on railways will be quite marked from now on.

The constantly increasing cost of railway fuel at the mine; the scarcity of fuel oil; the domestic and export demand for the larger sizes of coal; the prohibitive cost for briquetting the smaller sizes of coal and of lignite for railway use; the payment of labor on the run-of-mine basis for mining bituminous coals; and the necessity for eliminating smoke, sparks, and cinders, will all tend towards the inauguration of this practical means and method for increasing the efficiency of steam-boiler operation, which today affords the greatest opportunity for improving locomotive and power-plant costs and performance, and for changing public sentiment by smoke abatement.

ASH FUSIBILITY

A phase of the combustion problem both in connection with powdered coal and mechanical stokers, which is but now receiving adequate attention, is the study of the temperatures and conditions under which ash will melt. Engineers have always recognized the fact that certain coals were greater clinker producers than others, and this was laid at the door of the sulphur content. Recent experimental work, however, has shown that the sulphur is not the controlling element, although the exact causes are not yet sufficiently well known to be definitely stated.

Coal ash will melt at temperatures between 2200 and 2700 deg. fahr. Furnace temperatures in commercial practice run between 1800 and 2800 deg., so that it is possible to secure coals the ash from which will pass through the furnace without fusing. Under these conditions absolutely no clinker for-

TABLE 1 COST OF COAL-PULVERIZING PLANTS AND COST OF PULVERIZATION

This table is based on the following data:
Labor rates per hour: Millers, $0.20; drier firemen, $0.175; common labor, $0.15.
Cost of drier fuel, $0.03 per net ton. (Based on coal with 7 per cent moisture at $2.60 per ton, delivered, and 6 lb. evaporation per lb. of coal burned.)
Repairs, $0.05 per net ton. (This includes whole pulverizing plant, covering all machinery.)
Power, $0.102 per net ton pulverized. (Based on consumption of 17 hp-hr. per ton pulverized and cost per h.p. per annum of $45.00.)
Interest and Depreciation based on 10 per cent of cost of plant and 300 days' operation per year.

Daily Capacity, Net Tons	Total Cost of Pulverizing, Cents per Ton		Cost of Plants, Including Buildings, Dollars	Number of Men Required	Number and Size of Fuller Mills Required	Labor Cost, Cents per Net Ton
	Interest and Depreciation not Included	Including Interest and Depreciation				
5	70.0	....	4,000 [1]	1	1—24-in.	45.00
10	48.2	96.3	14,500	1	1—33-in.	30.00
20	37.4	61.9	14,500	2	1—33-in.	20.00
30	35.8	51.8	14,500	2	1—33-in.	17.40
40	33.6	47.0	14,500	2	1—33-in.	15.30
50	32.0	44.1	18,150	3	1—42-in.	13.80
60	31.0	41.4	18,150	3	1—42-in.	12.75
70	30.2	37.8	18,150	4	1—42-in.	11.85
80	29.3	36.7	18,150	4	1—42-in.	11.10
90	28.4	36.4	18,150	5	1—42-in.	10.25
100	27.7	36.2	25,620	5	3—33-in.	9.50
110	27.0	34.7	25,620	6	3—33-in.[2]	8.80
120	26.4	33.5	25,620	6	3—33-in.[2]	8.30
130	25.8	32.9	25,620	7	3—33-in.[2]	7.69
140	25.4	31.5	26,150	7	2—42-in.	7.14
150	25.0	30.6	26,150	7	2—42-in.	6.80
160	24.7	30.0	26,150	7	2—42-in.	6 50
170	24.5	29.6	26,150	8	2—42-in.	6.20
180	24.3	29.1	26,150	8	2—42-in.	6 00
190	24.0	28.5	40,130	8	3—42-in.	5 92
200	23.9	31.0	40,130	9	3—42-in.	5.75
210	23.8	30.5	40,130	9	3—42-in.	5.47
220	23.7	30.4	40,130	9	3—42-in.	5.22
230	23.6	30.2	40,130	9	3—42-in.	5.00
240	23.5	30.1	40,130	10	3—42-in.	5.00
250	23.4	30.0	40,130	10	3—42-in.	5.00

[1] Cost of building not included.
[2] Two 42-in. mills have the same daily capacity.

mation is encountered, and the coal is rated as satisfactory from this standpoint. In exactly the same furnace another coal will clinker badly and give trouble. There is no hard and fast rule, therefore, which can be stated for the selection of a coal.

The temperature obtained in service, which is a function of the rate of combustion, the amount of excess air, and the proportions of the furnace chamber, must be determined, and analyses of the fuel made to determine whether or not it will be suitable under the given conditions. Like many other scientific investigations, the value of a few dollars spent in this manner is not always appreciated, and the user will tolerate the formation of clinkers for months before he turns to another source of coal supply. When he does so, he may or may not solve his problem, and it becomes necessary to purchase and consume a variety of coals before one is found which is suitable to his needs.

TABLE 2 COST OF PULVERIZING COAL AT THE ALLENTOWN (PA.) PORTLAND CEMENT COMPANY FOR THE YEAR 1914

(Gross tons ground in year, 37,523)

		Cost per Annum	Cost per Gross Ton
Operating	Labor	$3786.72	$0.1008
	Material	161.04	0.0042
Driers and Elevators	Repair Labor	584.24	0.0155
	Material	512.40	0.0136
Pulverizing Mill Repairs	Labor	84.84	0.0022
	Material	428.88	0.0114
Electricity: Labor and Material		37.16	0.0009
Belts: Labor and Material		79.73	0.0021
Power		4096.73	0.1091
Total Cost		$9771.74	$0.2598

(Cost per net ton, $0 2324)

In powdered-coal work, with the more precise and scientific manner of the combustion process, the necessity for proper knowledge of the point of ash fusibility is greatly increased. The day is rapidly approaching when the burning of coal will be considered a precise scientific chemical reaction, in which the elements are supplied with exactness and understanding, and the result obtained, corresponding in definiteness to the precision of the mixing process, will be made to conform exactly to the requirements of the service.

The Commercial Testing & Engineering Company has determined that washing a dirty coal has no effect on the fusing point of the ash, so that mere ash content is not the determining factor of desirability when considering a coal for pulverization. The importance of this preliminary investigation can scarcely be overstated. Assuming a malleableizing oven, wherein the temperature does not exceed 1800 deg., it is quite obvious that this is below the melting point of ordinary ash, and aside from the objection to a large volume of ash, any coal can be used.

Considering a furnace of higher temperature requirements, such as a billet-heating furnace where, say, a temperature of 2300 deg. is desired, it is obvious that a coal fusing at 2500 deg. would be entirely satisfactory, whereas one fusing at less than 2300 deg. might cause clinker formation. In the case of still higher temperature work only those coals which have the highest fusing point could be used, unless ample provision were made for the accumulation of fluid ash.

CONCLUSION

My general conclusion as to the future of powdered coal as a fuel is briefly this: Powdered coal is radically different in its physical structure and method of handling from any other form of coal heretofore commercially used. Having marked characteristics it will fit into certain cases with extreme acceptability, and will probably prove just as undesirable in certain other cases. Probably the most important difference is the burning of the actual solid fuel directly within the chamber and in direct physical contact with the metal to be heated. There is, of course, an appreciable amount of incandescent carbon in the furnace at all times, and this solid fuel is emitting radiant heat in close proximity to the furnace contents. A large amount of the radiant energy is therefore directly utilized, which is not the case when coal is gasified in a detached chamber. I cannot but conclude, therefore, that the success of powdered coal lies in its adaptability to the special furnaces of the metallurgical field, and in those cases similar to the locomotives, where there are other and weighty considerations in addition to the actual relative increase in combustion efficiency.

PULVERIZED-FUEL INSTALLATION SERVING TEN 250-H.P. O'BRIEN BOILERS

By H. G. BARNHURST, ALLENTOWN, PA.

Member of the Society

At the Parsons (Kan.) shops of the Missouri, Kansas and Texas Railway Company an installation for preparing and burning pulverized low-grade coals, including lignite, under boilers is now being completed, which is the first and largest commercial installation of its kind in existence.

The boilers in the plant (O'Brien, 250-h.p.) are arranged in one continuous row of three and one batteries, respectively, there being a space between the settings of each pair of two boilers of 4 ft. 8 in., and a space between the two batteries of 28 ft. 4 in. for feed pumps, auxiliaries, etc. At the far end of the battery of two boilers space is allowed for four more boilers, which will then make twelve in all. Eight boilers are now installed, and equipment is supplied for ten.

The boilers are to carry 150 lb. steam pressure, the feed water being delivered to the boilers at 208 deg. fahr. Based on a boiler efficiency of 70 per cent, operating full capacity for 10 hours and half capacity for 14 hours, about 158,000 lb. of coal will be consumed in 24 hours, or 79 net tons for the ten boilers. When the two additional boilers are added, a total of 94 tons per day of 24 hours will be required. Two 42-in. Fuller mills operating 12 hours per day will readily produce 96 to 100 tons of pulverized coal, which will be more than ample for this plant.

Written discussion of paper entitled "The Use of Powdered Coal as a Fuel," presented at a meeting of the Chicago Section of The American Society of Mechanical Engineers, May 15, 1916.

THE PULVERIZING PLANT

The coal which is used in this plant is dumped directly from the cars into a concrete and steel hopper beneath the track which runs parallel and adjacent to the power house and coal plant. As a large percentage of it will be mine run, a 20 by 24-in. spike-toothed roll crusher is placed directly beneath the hopper discharge to break down the large lumps it contains. This crusher is driven by a belt-connected motor, 15 in. centers, placed in the inclined tunnel leading from the track hopper to the coal plant, a building 43 by 54 ft.

A 20-in. belt conveyer, with its receiving end directly beneath the discharge from the toothed roll crusher, conveys the coal through an inclined tunnel to the coal plant, the near wall of which is 25 ft. from the center of the track hopper, this distance being determined by the difference in height of the receiving and delivery ends of the belt conveyor. At the delivery end of the belt conveyor a 24 by 22-in. magnetic separator pulley is placed to hold and remove any tramp iron that will be brought along with the coal, and the coal is then discharged into a pair of 24 by 18-in. corrugated rolls driven along with the belt conveyor by a motor of the belted type.

From the corrugated rolls the crushed coal is carried up in an elevator, discharged into a screw conveyor and carried along to a bin over the back end of the drier. This bin has a capacity of 40 tons, which allows a storage ahead of the drier and mills of five hours. The elevator and screw conveyor are both run by one motor.

THE CONVEYING MACHINERY

From the bottom of the bin a screw conveyor feeds the coal to the back end of a 4½ by 30-ft. indirect-fired rotary drier, both being run by one motor.

The coal passes through the drier and is discharged to an elevator at the front end. A screw conveyor located in the floor also carries the tailings from the settling chamber beneath the drier stack to the elevator. The dried coal and tailings are elevated, discharged into a screw conveyor, and carried to the bin over the pulverizer. This bin is placed in front of and high enough above the mills to enable all the coal to be fed to them by gravity, and has a capacity of 45 tons. The elevators and conveyors over the bins are operated by one motor. There are two pulverizers.

The pulverized coal is delivered by spouts from the pulverizer mills directly to an elevator and raised to a screw conveyor which carries the coal to the boiler house. The conveyor and elevator are both operated by one motor. This conveyor is carried over a bridge 30 ft. long between the coal plant and boiler house, and continues on through the entire length of the power house over the bins in front of the boilers, thus making a single straight-delivery unit from coal plant to bins about 216 ft. in length.

One bin is placed in front of each pair of boilers. These bins are rectangular in shape but have divided hopper bottoms, thus enabling the coal to be fed by separate feeders to each boiler. Each half of the bin with its hopper bottom will hold 10 tons of pulverized coal, which will provide storage in front of each boiler for a run of 20 hours at full capacity. This allows ample capacity, so that any delay in the coal mill proper will not interfere with the continuous operation of the boilers for a period of over 24 hours if the boilers are run under ordinary operating conditions. Each bin is filled through three separate gates with spouts in the bottom of the conveyor, so that the supply to any bin can be controlled as desired.

AIR BLAST FOR FEEDING THE COAL

Underneath and between the sides of the inverted "V" formed by the two hoppers of the bin is placed a direct-connected motor-driven fan with a down-blast discharge which is divided into two 7-in. blast pipes. These two pipes diverging at an angle of 60 deg. with each other coming down in a plane parallel to the front of the boilers, about 8 ft. from the front wall of the firebox or combustion chamber, make an easy sweeping bend and discharge into the burner nozzle located in front of each boiler 3 ft. from the floor. The fan supplies the air needed in feeding the coal (4200 cu. ft. per min.) at 3 oz. static pressure to a burner nozzle in front of each boiler.

At the bottom of each of the two hoppers of each bin is a 4-in. screw feeder enclosed in a circular cast-iron casing. Above each feeder, between the hopper and the screw proper, is a slide, so that if for any reason the feeder should become jammed or broken it could be readily removed without first drawing the coal from the bin. Each feeder is chain-and-sprocket-driven by a 2-h.p. variable-speed back-geared motor, the controlling rheostat of which is located in a convenient position in front of the boilers.

THE BURNERS

Each feeder discharges into a 3-in. pipe, 8 ft. long, which drops the coal straight down and into a funnel-shaped opening in the top of the burner nozzle. This burner is ideal for the purpose, as it is both simple and highly efficient. It consists of an outside 14-in. cylindrical pipe, one end of which projects into the furnace; into the other end the 7-in. blast pipe is inserted and extends inwardly from 12 to 18 in. A metal cone is fitted over the blast pipe so that it can be moved back and forth any desired distance, thus forming a valve to regulate the amount of air that is induced in the burner or to close the opening entirely if desired. Directly over the inserted end of the blast pipe a small funnel-shaped cone is placed in the outside pipe, into which the coal is fed and drawn in by the suction formed by the blast. The funnel opening into which the coal is fed is directly over the discharge end or nozzle of the blast pipe, so that the coal will be drawn in and thoroughly mixed with the blast and induced air before reaching the combustion chamber of the furnace.

A large quantity of air can be induced in this burner, which, together with that blown in by the fan, will supply all the air required for combustion. The blast pipe is provided with a 2-in. screw-capped opening just back of the sliding cone, so that the pressure and velocity of the air can be determined when desired. The outside burner pipe is also provided with two similar openings, one between the coal opening and the open end, and the other about 1 ft. from the furnace wall.

At normal rating on a basis of 70 per cent efficiency and with feed water at 208 deg. fahr., these boilers will each consume 958 lb. of coal per hour or 16 lb. per min., and will therefore require about 3200 cu. ft. of air per min. for combustion. Half of the capacity of the fan (or 2100 cu. ft.) will be supplied through the 7-in. blast pipe to each boiler, the remainder being induced by the action of the blast in the intake end of the burner.

THE FURNACES OR COMBUSTION CHAMBERS

The furnace or combustion chamber of these boilers is well adapted for firing with pulverized coal, in that it has 583 cu. ft. of volume or, at normal rating, 36.4 cu. ft. per lb. of coal fired per min. The bridge wall is located 7 ft. from the front wall of the setting and from the end of the burner. The baffle wall, which in the standard O'Brien boiler is carried on the bottom row of tubes, has in this case been replaced over the combustion chamber with bricks, with a U-shaped opening in one side to fit the tube so that when inserted the two together will completely surround the bottom of any tube, and thus serve to protect the tubes from the direct action of the flame and likewise offer a combustion chamber whose top, bottom and sides present to the entering coal dust a surface entirely lined with highly refractory firebrick, the top or roof being protected by the tubes. From the base of the arch wall, on a level with the floor of the boiler room, the bottom of the combustion chamber slopes downward toward the front at an angle of 45 deg. till it reaches a point directly under the front setting, where a shelf 2 ft. wide projects straight out to a door in the ash tunnel through which steel cars are operated and into which the ash and slag which is precipitated on this shelf is raked. The bottoms of these ash doors are located 7 ft. below the floor of the boiler room, and the tops of the cars just come to within 3 in. of this level, so that all that is necessary is to move the car in front of the ash door. The sides of this sub-combustion chamber extend vertically downward from the floor level for a distance of 3 ft. 6 in. and then converge toward the center at an angle of 53 deg. with the vertical until they meet the above-mentioned bottom shelf 2 ft. apart, so that the bottom of the furnace or combustion chamber forms a firebrick-lined hopper with a bottom 2 ft. square. The remaining front wall of the furnace is, of course, extended straight down to 3 ft. 6 in. below the floor level and cut under in a sloping arch parallel to the rear side so that it will form a sloping roof to the top of the ash door.

The area between the top of the bridge wall and the bottom row of brick-protected tubes is 19 sq. ft., and with a temperature in the furnace of 2800 deg. the velocity of the gases over the bridge wall at normal rating will be about 16 ft. per sec. With such a low velocity it can be readily seen that the greater part of the process of combustion should be completed before the gases pass over the wall, and also that a large percentage of the ash or slag will be deposited in the hopper bottom. There is also a settling chamber back of the bridge wall, and any ash that settles in this chamber can be raked out of a door at the side.

APPENDIX

Since this discussion was submitted, the plant has been put into successful operation, and developments have made it advisable to alter the furnace design somewhat.

With Kansas coal containing approximately 22 per cent ash, the horizontal baffles allowed too much ash accumulation, so a Dutch oven approximating a 6-ft. cube was built in front of each of two boilers and vertical baffles were inserted, replacing the former horizontal ones. With these changes highly gratifying results are being obtained. No slag is formed, and the ash is readily blown off the floor of the rear chamber with an air hose once a week.

No part of the refractory lining is subjected to an excessive temperature even at considerable overload.

The Missouri, Kansas and Texas R. R. officials are very enthusiastic concerning the operation and economies being obtained both with the aforementioned 22 per cent ash coal and also with lignite, and the Dutch ovens and vertical baffles are being installed as promptly as possible for the other boilers.

The operation is quite flexible and by the most simple adjustments almost any furnace conditions can be realized, the capacity being varied at will.

The density of liquid hydrogen, according to the most recent determination—that of Dr. H. Augustin (*Annal. Physik.*, vol. 46, p. 415), is 0.07105 at—252.83 deg. cent. and 745.52 mm. pressure.

At a recent meeting of the American Drop Forgings Association the Holbeck system of burning pulverized coal in forging furnaces was described. It was stated that 10 lb. of pulverized coal are equivalent to 1 gal. of fuel oil, and with the former at $3 per ton the equivalent in fuel oil would mean oil at 1½ cents per gal. Also, that 75 lb. of coal dust are equivalent to 1000 cu. ft. of natural gas, or that $3 coal is on a parity with 12-cent gas.

The best composition for condenser tubes operating with fresh, unpolluted water is believed to be 70 per cent copper and 30 per cent zinc, as it has the maximum ductility of all brass compositions, gives a greater promise of adequate cold working and annealing, and, having but one metallagraphic constituent, the possibility of electrolytic action is precluded. The heat treatment of condenser tubes should consist in annealing each tube between each pair or set of cold drawings, at a temperature high enough to remove the grain distortion caused by the cold drawing, but not at such a temperature as will permit crystalline growth to take place that will result in coarse crystallization. After the final drawing each tube should be annealed just enough to break down the distorted structure produced by that drawing.—A. E. White, in a paper read before the American Society for Testing Materials, June 30, 1916.

An air-lift well-pumping installation of the Talbot type at the Camden (N. J.) Waterworks has, it is stated in the *Engineering Record* of June 3, 1916, developed on test an overall efficiency of 59 per cent, measured between the steam end of the compressor and the point of delivery of the water. The well was 120 ft. deep and 8 in. in diameter, the water reduction pipe 5 in. in diameter and fitted with an umbrella deflector at the top, and the air pipe 1¼ in. in diameter. The depth to the foot piece was 106 ft., and from the umbrella to the foot piece 115.5 ft. Certain of the test results are as follows:

Gallons pumped per minute.....	300	322	392
Cubic feet of free air per minute...	50	60	100
Efficiency, per cent.....	59.6	54.2	40.2

These show a steady falling off in efficiency as the air supply is increased and more water is pumped, which is to be expected (1) because of the lower submergence when pumping the larger volume and (2) because of the greatly increased friction of water and consequent slippage of air at the higher velocities of discharge. This friction and slippage, it is held, may be considered as the chief causes of inefficiency in most air-lifts.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

STRENGTH OF BOILER FURNACES

To the Editor:

The conventional engineer's theory on the strength of a lap joint assumes the stress uniformly distributed over the cross-section, either in the solid plate or between rivets, and ignores eccentricity of loading due to plates being out of line. Probably none will dispute the fact that a lap joint is considerably weaker than it is supposed to be, due to this neglected eccentricity of loading, but just how much weaker is considered debatable.

A comparison, by means of a concrete case, of the A.S.M.E. Boiler Code formula for the strength of boiler furnaces with other formulae shows that the former gives working pressures far too high.

Consider a flue of 29 in. external diameter made of ½-in.

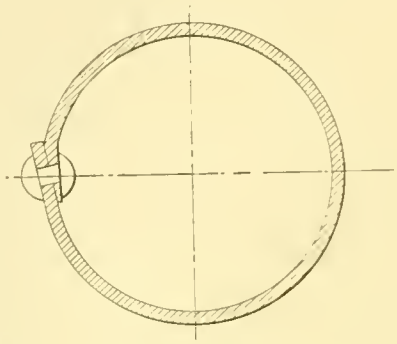

Fig. 1 Form of Lap Joint to Maintain True Circularity

steel plate with a single-riveted longitudinal lap joint; the length is 94 in.

In the following the permissible working pressure for this flue is computed by various formulae and arranged in order of decreasing magnitude. If a particular formula does not apply to *jointed* flues, then the value obtained as working pressure is multiplied by the efficiency of a single-riveted lap joint for purposes of comparison with the A.S.M.E. formula. If the formula permits a double-riveted lap joint, say, then the working pressure obtained is reduced in the proportion of the efficiency of a double-riveted lap joint to that of a single-riveted lap joint. These efficiencies are taken as 77.6 per cent and 63.3 per cent, respectively.[1] These figures represent the maximum possible efficiency, considering a perfect joint and accepting the A.S.M.E. Boiler Code values for unit stresses. This causes the Boiler Code formula to show up as favorably as possible.

A.S.M.E. Boiler Code Rule. This permits any kind of joint, hence the weakest possibility, viz.: a single-riveted lap joint is taken in the other cases for purpose of comparison. The efficiency of the joint is, however, always taken as the maximum possible, as stated above.

In the case considered, as the length exceeds 120 times the thickness, the second formula given in the Boiler Code must be used, viz.:

$$P = \frac{4{,}250T^2}{LD}$$

where P = maximum allowable working pressure, lb. per sq. in.
D = outside diameter of furnace in in.
L = length of furnace in in.
T = thickness of furnace wall in sixteenths of an inch.

whence

$$P = \frac{4{,}250 \times 8^2}{94 \times 29} = 99.8 \text{ lb. per sq. in.}$$

Fairbairn's Rule. This formula does not allow for joint. Fairbairn's rule, although the parent formula, is recognized as giving working pressures far too high if the present-day factor of safety of 5 be employed.

$$p = \frac{806{,}300 \times t^{2.19}}{LD}$$

where t = thickness of tube in in.
L = length of tube in ft.
D = external diameter in in.
p = collapsing pressure in lb. per sq. in.

whence

$$p = \frac{806{,}300 \times 0.5^{2.19}}{\frac{94}{12} \times 29} = 777 \text{ lb. per sq. in.}$$

Allowing a factor of safety of 5 (see Progress Report of Boiler Code Committee, A.S.M.E.) gives 155.4 lb. per sq. in.

Taking 63.3 per cent of this to allow for a single-riveted lap joint makes the value of working pressure for purpose of comparison with the A.S.M.E. result to be 98.5 lb. per sq. in., or practically the same as the value given by the A.S.M.E. formula.

Modified Fairbairn Rule. The working pressure of a tube subjected to external pressure will obviously not be inversely proportional to the length indefinitely, as Fairbairn's rule would indicate. This has been partially counteracted by using a variable factor of safety, $\sqrt{(300 \div L)}$, where L is length in feet.

For the concrete case under discussion this gives a working pressure equal to

$$\sqrt{\frac{777}{\frac{300 \times 12}{94}}} = 125.8 \text{ lb. per sq. in.}$$

Making allowance for the lap joint gives

$125.8 \times 0.633 = 79.8$ lb. per sq. in., or 80.0 per cent of the value given by the A.S.M.E. formula.

Bureau Veritas Rule. This formula makes a distinction between the case where the flue is truly circular (i.e., butt joints or lapped and bevelled), and where the flue is not circular.

$$P = \frac{Ct^2}{DL}$$

where t = thickness of plate in in.

[1] For derivation, see Jour. Am. Soc. Nav. Engrs., August, 1916, p. 729 *et eq.*

D = outside diameter in in.
P = working pressure in lb. per sq. in. above atmosphere
L = length of furnace in ft., or length between rings
C = 70,000 when furnace is truly circular and the longitudinal seams are welded, butted, or lapped and bevelled, and double-riveted in last-named case
C = 60,000 when the furnace is not truly circular, or when the longitudinal seams are simply lapped

The above constants are for iron of fair quality. Multiply constants by 1.2 for mild steel.

For the concrete case under discussion this gives

$$P = \frac{60{,}000 \times 1.2 \times 0.5^2}{\frac{29 \times 94}{12}} = 79.3 \text{ lb. per sq. in.,}$$

or 79.47 per cent of the value given by the A.S.M.E. formula.

The above formula gives a much stronger design for the truly circular case than it does for the not truly circular case.

Hutton's Rule. This does not allow for a joint.

$$p = \frac{Ct^2}{dL}$$

where L = length in in.
d = outside diameter in in.
t = thickness in thirty-seconds of an inch
C = 660 for steel
p = collapsing pressure in lb. per sq. in.

For the concrete case under discussion this gives

$$p = \frac{660 \times 16^2}{29 \times 94} = 602 \text{ lb. per sq. in.}$$

Allowing a factor of safety of 5 and reducing to allow for single-riveted lap joint gives

$$\frac{0.633 \times 602}{5} = 76.1 \text{ lb. per sq. in., or 76.4 per cent of}$$

the value given by the A.S.M.E. formula.

German Government Rule. Thickness $= K \times P \times L \times D + 0.2$ cm.

where P = working pressure in kg. per sq. cm.
L = length between stiffeners in cm.
D = external diameter of furnace in cm.
K = 0.0035 when the longitudinal joints are lapped only.

For the concrete case under discussion this gives

$$2.54 \times 0.5 = 0.0035 \frac{P \times 0.4536}{2.54^2} \times 94 \times 2.54 \times 29 \times 2.54 + 0.2$$

$$P = \frac{(1.27 - 0.2)^2}{0.0035^2} \times \frac{1}{0.4536 \times 94 \times 29}$$

$$= 75.6 \text{ lb. per sq. in., or 75.7 per cent of the value}$$

given by the A.S.M.E. formula.

Lloyd's Rule. This does not allow for joint.

$$P = \frac{89{,}600t^2}{LD}$$

where P = working pressure in lb. per sq. in.
t = thickness of plate in in.
L = length of furnace in ft.
D = outside diameter of furnace in in.

For the concrete case under discussion this gives

$$P = \frac{89{,}600 \times 0.5^2}{\frac{94}{12} \times 29} = 98.7 \text{ lb. per sq. in.}$$

Reducing this to the corresponding value for single-riveted lap joint gives $98.7 \times 0.633 = 62.4$ lb. per sq. in., or 62.5 per cent of the value given by the A.S.M.E. formula.

U. S. Statute Rule. This is the same as the Lloyd's rule.

Michael Longridge's Rule. Michael Longridge takes C in Hutton's formula as 540 instead of 660; this gives 540/660 of the value obtained by Hutton's formula, or $540/660 \times 76.2 =$ 62.4 lb. per sq. in., or 62.5 per cent of the value given by the A.S.M.E. formula.

British Board of Trade Rule. This permits a double-riveted lap joint.

$$p = \frac{75{,}000t^2}{(L+1)D}$$

where p = working pressure in lb. per sq. in.
t = thickness in in.
L = length in ft.
D = external diameter in in.

For the concrete case under discussion this gives

$$p = \frac{75{,}000 \times 0.5^2}{\left(\frac{94}{12} + 1\right) 29} = 73 \text{ lb. per sq. in.}$$

Reducing this to the corresponding value for a single-riveted lap joint gives

$$73 \times \frac{0.633}{0.776} = 59.6 \text{ lb. per sq. in.}$$

or 59.7 per cent of the value given by the A.S.M.E. formula.

The previous results are collected below to facilitate comparison:

	Working Pressure	Percentage
A.S.M.E. Boiler Code	99.8 lb. per sq. in.	100.0
Fairbairn	98.5 lb. per sq. in.	98.7
Fairbairn (modified)	79.8 lb. per sq. in.	80.0
Bureau Veritas	79.3 lb. per sq. in.	79.4
Hutton	76.1 lb. per sq. in.	76.4
German Government	75.6 lb. per sq. in.	75.7
Lloyd's	62.4 lb. per sq. in.	62.5
U. S. Statute	62.4 lb. per sq. in.	62.5
Michael Longridge	62.4 lb. per sq. in.	62.5
British Board of Trade	59.6 lb. per sq. in.	59.7

Besides showing that the A.S.M.E. Boiler Code formula gives working pressures far too high, these results reveal the danger of the A.S.M.E. rule by no means fully because customary efficiencies have been taken for lap joints, and it can be shown that these are far too high due to neglected eccentricity. In the light of a new analysis which the author has made[1] of the weakening factor of a longitudinal lap joint in a cylinder subjected to external pressure, these results are modified as below:

	Working Pressure	Percentage
A.S.M.E. Boiler Code	99.8 lb. per sq. in.	100.0
Fairbairn	42.8 lb. per sq. in.	42.9
Fairbairn (modified)	34.7 lb. per sq. in.	34.8
Bureau Veritas	79.3 lb. per sq. in.	79.5
Hutton	33.1 lb. per sq. in.	33.2
German Government	75.6 lb. per sq. in.	75.8
Lloyd's	27.2 lb. per sq. in.	27.3
U. S. Statute	27.2 lb. per sq. in.	27.3
Michael Longridge	27.2 lb. per sq. in.	27.3
British Board of Trade	61.6 lb. per sq. in.	61.7

[1] Strength of Boiler Furnaces, Jour. Am. Soc. Nav. Engrs., August, 1916, p. 729.

These results, though arranged in the same sequence as before, are no longer in the order of descending magnitude. The reason is simply that those rules which permitted lap joints suffered no reduction, but those rules which did not permit a lap joint had to have their results diminished according to the new lower efficiency of a lap joint.

The writer is of the opinion that all existing rules permitting the use of lap joints do not make the necessary allowance for its weakness in comparison with solid plate or butt joints.

If the joint be formed as in Fig. 1, then it is possible to maintain true circularity, which eliminates all eccentricity of action. The strength will now be determined by the efficiency of the joint proper.

The value of the joint efficiency is a much more complex problem—in fact, a rigorous solution is not possible; it would, however, be much higher than the efficiency of the plate is under eccentric loading.

The most significant feature in the use of longitudinal lap joints for cylinders subjected to external pressure, is that, should the stress reach the elastic limit and deformation ensue, the *eccentricity of action is increased* and collapse is inevitable. In cylinders subjected to internal pressure, on the other hand, deformation decreases eccentricity and restores satisfactory conditions.

Considering that the use of longitudinal lap joints is rapidly diminishing in good practice for internal pressure, is it not desirable to prohibit absolutely their use for external pressure; or, what would serve equally well, cut down the acknowledged efficiency to its true value? If this were done, the use of a lap joint would entail such an abnormally thick plate to withstand a given pressure that considerations of economy would probably prohibit it.

John Airey.

Ann Arbor, Mich.

RELATION OF ENGINEERING SOCIETIES TO LEGISLATION AND PUBLIC AFFAIRS

To the Editor:

In the August issue of The Journal, page 642, Mr. Henry Hess stated in a very convincing manner his views regarding the proper attitude of engineers and their societies with reference to enactment of laws upon subjects concerning which engineers are practically the only well-informed persons. He stated that "in so restricting themselves they have actually broadened and deepened their influence on actual legislation. They have not sought nor do they seek to influence legislation, and in so refraining they have actually gained a deep and beneficial influence in and for the community."

This is a very important conclusion, and one to which engineers should give careful thought—the more so as it has a curiously familiar sound to those who have been listening to the arguments for and against universal suffrage. It is urged that certain classes of people will have a broader and deeper influence if they are not permitted to exercise suffrage. A similar argument appears to be advanced in the assertion that the national engineering societies, and presumably other engineering bodies, should not participate in public affairs.

Further on Mr. Hess stated that in one particular case many engineers "are now agreed that what they hoped for in the interest of the public and community actually came about much sooner and more readily as a result of their confining themselves to their special domain." The question thus arises as to "*whose* is the domain?" To whom belong the right and duty to draft new laws and to see that these are enacted? It is apparently assumed that the engineering organizations are not the proper persons to enter into legislative activity; but obviously some one must do this, and, however distasteful the duty to the highly trained scientific and professional man, he cannot safely neglect this duty, nor properly delegate it to some other class of citizens.

Possibly the answer may be that the duties of citizenship, so far as they pertain to drafting and enacting suitable laws, should be left to the lawyers. This is too often done, as shown by a study of law-making bodies—the great body is composed of lawyers, while engineers are notable by their absence. Is this the best condition, and are engineers to be commended because they and their organizations have abstained from public affairs? The training of a lawyer, while excellent in construing laws as they now exist, is not always conducive to a constructive attitude of mind. The lawyer is more impressed with the importance of existing precedents than of existing needs. However this may be, engineers should consider carefully whether they even tacitly admit that as a body they should refrain from the duties of citizenship and delegate to others the direct interest in making proper laws on subjects in which they are best informed.

As a matter of fact, those who have had much experience in state and national legislation appreciate that a good law, no matter how well drawn or greatly needed, has little hope of passage unless somewhere behind it is an effective man or body of men working intelligently in season and out of season for it. This activity may not be apparent from the surface, but it can always be found. Moreover, a matter which affects the entire community will rarely be enacted in a law suitable for the entire community unless there is a well-worked-out effort of this kind. The fact that the laws referred to have been enacted is undoubtedly due to conditions which may not be obvious and to the fruition of plans not made evident to the public.

The question is whether the engineer, and especially his organization, shall come out definitely and clearly for certain laws regarded as important, or whether he shall assume a more dignified attitude of agreeing upon certain principles and then decline to participate in the enactment of these principles into law. Shall his organization be indifferent to the means by which the desired end is to be accomplished, refraining from an outward or definite interest in the matter, knowing full well that some other class of citizens must exert themselves actively and continuously in order to secure the passage of these laws?

Or, to put it in another way, is there not really an attitude of complacent self-deception in the assumption that the engineering societies, by restricting their activities, are actually broadening and deepening their influence? Can any class of citizens in this country properly abstain from legislative activities and retain the respect of the community? These are points on which, as stated by Mr. Hess, representative opinions should be obtained for the guidance of engineering organizations in any future question concerning legislative and public affairs. My own feeling is that any association of independent citizens, especially those educated largely at public expense, as are most engineers, will inevitably be ignored, or even treated with contempt, by the great body of the public if it takes the position of refraining from actively performing its duties in legislation, particularly in those matters in which its members are best informed.

F. H. Newell.

Urbana, Ill.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES

OFFICERS AND COUNCIL, 1916

President

D. S. Jacobus

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Vice-Presidents

Terms expire December 1916

Henry Hess
George W. Dickie
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

COMMITTEES, ETC.

STANDING COMMITTEES

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library, John W. Lieb
House, William N. Dickinson
Research, R. J. S. Pigott
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee to Determine Cost of Electric Power
Conservation
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R. Hutton
Boiler Code Committee, John A. Stevens
Engineering Education
Filter Standardization, George W. Fuller
Increase of Membership, Irving E. Moultrop
Metric System, L. D. Burlingame
National Museum
Nominating Committee, Walter B. Snow
Patent Laws, Edward Weston
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee, R. J. S. Pigott
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Machine Tools, Leon P. Alford
- Sub-Committee on Safety Valves
- Sub-Committee on Steam-Flow Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A. Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, (Secretary not appointed)
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit (not appointed)
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

SECRETARY'S CHAT WITH THE MEMBERS

THIS month opens the season of Society activities under conditions which have never before been paralleled in our history. Events which will make the year 1916 a memorable one to engineers, thereby place each individual member of the Society under obligations, and make it encumbent upon him to help maintain the new position which the engineer, in distinction from other citizens, now occupies.

On a letter ballot from practically half its entire membership, the American Society of Civil Engineers has voted seven to one to make their headquarters in the Engineering Societies Building, and join the Founder Societies in the ownership and administration of the property of the United Engineering Society and the joint administration of the Library. This association, long hoped-for by all who have the interests of the engineering profession at heart, will be of great advantage to the profession in general, will widen greatly its influence and enhance its standing. At the same time, and reciprocally, this association of the principal national engineering societies sets the example for similar coöperation of their sections and individual members, and puts upon the latter the obligation of contributing their share to the team work being done by the officers of the national societies. Each individual member of our Society should do his best this winter to foster and actively develop the broad-minded spirit behind the relations of the Society with all the national engineering societies, so that the coöperation for which we have all been striving will reach its highest degree.

National recognition was accorded the engineering profession and the chemists in the invitation extended to them by the President of the United States to conduct the industrial census. The census was made with the coöperation of the industries, to the extent that from 75 to 80 per cent of firms doing business annually in excess of one hundred thousand dollars have responded to the census request of the engineers' representatives, and the work will be completed this month. In their dealings with manufacturers, engineers must in future recognize this spirit of coöperation.

In the passage by Congress of two bills directly and permanently establishing the engineering profession as an arm of the Government, public recognition of the engineer is an accomplished fact. The features concerning engineers in these bills were initiated by engineers in their capacity as citizens confident of ability to render greater service. We asked for recognition and we received it; it remains for us to show that this recognition was justified. The two movements represented in these bills are:

Through the initiative of a joint committee, of which in our Society Major W. H. Wiley, Treasurer Am.Soc.M.E., is chairman, in coöperation with similar committees of the Civil, Mining, Electrical and Consulting Engineers, a Reserve Corps of Civilian Engineers, comparable to the reserve corps of physicians and surgeons, has been established, and General Order No. 32, providing for the enrolment of all civilian engineers of the United States in an auxiliary corps to the Army in case of war, has just been issued by the Chief of Engineers of the Army. This action opens up to engineers another opportunity for service on an honor roll subject to the call of the President of the United States, and the theory is that in time of stress each engineer will be assigned to that duty which he can best perform, supposedly a continuation of the work he performs in civil life.

The second accomplishment of the year is the establishment of the National Council of Safety. This is to consist of five Cabinet officers, with an advisory council of seven civilians, the latter to be chosen, one each, to represent labor, industry, finance, transportation, physics and chemistry, and commerce. It behooves our members to see that engineers are represented on this important council. The qualifications of those who are to compose the advisory council are stated as "special knowledge of some industry, public utility or the development of some natural resource. The members of the advisory commission shall serve without compensation, but shall be allowed actual expenses of travel and subsistence."

It is proposed that the existing associate members of the Naval Consulting Board, now our directors of state canvasses of the industrial census, together with the examiners chosen from our nominees appointed by the War Department for the Engineers' Reserve Corps, will form the nucleus of the permanent State Councils of Safety.

Speaking of the recognition of the engineer by the Government, it might be mentioned that the Secretary recently had the honor of a call from the Secretary of the Navy. This is apparently the first time in the history of the engineering societies that an executive officer of the Government has visited us. In wishing Mr. Daniels good-by, the Secretary expressed the hope that we might have a call from the President of the United States, in the same manner as in France, to discuss important public engineering works.

A meeting of the Joint Conference Committee of the National Academy of Sciences and the National Engineering Societies took place on September 19, and organized with Mr. J. J. Carty, Past President of the A. I. E. E., as permanent chairman and Calvin W. Rice as permanent secretary. The discussion was along broad lines to develop ways in which the Academy and the engineering societies may develop closer relations. The Academy has already created a division of engineering, and this year will commence the election of engineers to its membership.

A Nitrate Committee of the National Academy is just now reporting on a Government Nitrate Plant, for which Congress has appropriated $20,000,000, and in this work the engineers are coöperating.

The National Research Council, appointed at the request of the President of the United States by Dr. W. H. Welch, president of the National Academy, is composed of members of the National Academy and of the national engineering societies. Their

immediate function is to coördinate the research facilities of the Government, the educational institutions and commercial and private laboratories.

At the meeting, on September 14, of the Engineering Foundation, Dr. F. R. Hutton, the acting secretary, resigned, and Dr. Cary T. Hutchinson was chosen secretary. One of the pieces of work to be done by the Foundation is that of the Research Council.

The above instances are signs of the growing appreciation of the strength of coöperation, to the spirit of which, we reiterate in closing, it is part of the duty of every member of the Society to contribute.

During the present month either the President or the Secretary expects to be with the members at their meetings in Meriden, Conn.; Buffalo, Erie, Indianapolis, and other places, bringing the greetings of our Council and receiving the views of the members as to the ways in which the Society may advance.

Calvin W. Rice,
Secretary.

PLAN OF ACTIVITIES FOR THE SEASON 1916-17

An important function of The Journal is to inform members of the Society regularly what its Officers and Committees, its Sections and Student Branches, are engaged in and planning to do, and what relations the Society is maintaining with other organizations and with the mechanical engineering profession generally. The aim is to maintain the personal interest of each member in the Society's government and actions.

The Council is about to resume activities, and its next regular meeting will be held on October 13. At this meeting important matters will be brought up for consideration, including the budget for the fiscal year upon which we enter on the first of this month.

Annual Reports have been requested from all Standing and Special Committees, and are now coming in. These will be presented to the Council and embodied in its Annual Report to be made at the Annual Meeting in December. The reports of the Standing Committees will be published in The Journal in due course, and will indicate what work has been accomplished by the committees this year, as well as what work is contemplated.

An outline of the proposed activities for the season of the several Sections and Student Branches as reported by their officers is given below.

ATLANTA SECTION

Mr. Earl F. Scott, Chairman, reports that the Affiliated Technical Societies of Atlanta will hold four meetings during the year. Each of the national societies represented in this affiliation, including our Society, will be allotted one meeting. At each meeting the particular organization in charge will contribute the paper of the evening, and the other societies will participate as guests. Our Section will have charge of the meeting in July, 1917.

If the Section is fortunate in securing a visit from any prominent member of the Society, it will call a special meeting to entertain him and will invite other engineers to participate.

BIRMINGHAM SECTION

The Birmingham Section expects to have no less than ten meetings during this, its second season. At least seven of these meetings will be devoted to papers or illustrated lectures. The other meetings will be inspection trips and possibly one joint meeting with engineers from the membership of the other national engineering societies.

The chairman, R. E. Brakeman, has taken the initial steps towards interesting the engineering faculties of the state colleges, and expects to have very interesting and valuable coöperation from them. He has in fact already received assurances of their willingness to coöperate.

The Section held a meeting on September 16, which consisted of an inspection trip through the plants of The Continental Gin Company, The Payne and Joubert Company and the Hardis-Tynes Manufacturing Company.

BUFFALO SECTION

The Buffalo Section coöperates with the Engineering Society of Buffalo. John Younger, Chairman of the Section and president of the local society, furnishes the following program of meetings of the society:

October 18, 1916. Dr. D. S. Jacobus, President of the Society, on Relationships of the National Societies to the Local Societies.

November 1, 1916. Frank B. Gilbreth, Mem. Am. Soc. M. E., on Motion Study.

November 15, 1916. Mr. Russell, of the Burgess Aeroplane Company, on an aeroplane topic.

November 29, 1916. C. H. Bierbaum, Mem.Am.Soc. M.E., on Recent Research Work on Graphite.

December 13, 1916. An automobile topic.

January 3, 1917. Social meeting.

January 17, 1917. Professor Spofford, of the Massachusetts Institute of Technology, on Highway Bridge Floors.

January 31, 1917. W. M. Corse, on Non-Ferrous Alloys.

February 14, 1917. An electrical engineering subject.

February 28, 1917. C. F. Kettering, Mem. Am. Soc. M. E., on Pure Science Applied to Engineering.

March 14, 1917. Mr. Zimmerschied, on Standardization.

April, 1917. Meeting will be devoted to discussion of Educational Systems and Apprenticeship Systems.

May 1, 1917. Business meeting.

CHICAGO SECTION

The Chicago Section has made plans for four meetings, with papers tentatively as below. The Section is making it its endeavor to secure the very highest class of speakers. It has the possibility of bringing out three or four hundred engineers of standing, and according to Joseph Harrington, chairman, the Section is fully alive to this fact.

November 17, 1916. Paper on either Industrial or Naval Preparedness. President Jacobus has been invited to attend this meeting.

January 19, 1917. Garbage Disposal in the City of Chicago.

March 16, 1917. Internal Combustion Engines under 50 H. P.

May 18, 1917. The Proper Preparation of the Young Engineer for Engineering Work.

CINCINNATI SECTION

The fact that the Spring Meeting, 1917, is to be held in Cincinnati is influencing the Section's activities there. The following recent communication from Prof. John T. Faig, Secretary of the Section demonstrates this:

"Dominating all of the activities of this Section for the season of 1916-1917 is the fact that the Spring Meeting for 1917 will be held in Cincinnati next May. Already tentative plans have been made regarding the visits to some of the most interesting plants and factories in this vicinity.

"Naturally there are to be found in this vicinity a number of large plants for the building of power machinery, which are the successors of those established by the river traffic. Strangely enough, however, the greatest expansion in the building of machinery has been along an entirely different line, that of machine tools. This is a comparatively recent development, extending over the last thirty-five years, and is the result of the foresight, perseverance and business ability of a group of men who are still living. During that short space of time they have built up factories whose products are known all over the world. Fifteen thousand men are employed in this field, and the annual output of the factories in which they work runs into many millions of dollars.

"It will be a great pleasure to members of this Section to show to fellow-members from elsewhere the results of Cincinnati's effort to do her share in the general industrial progress of the country.

"The tentative schedule of papers for the coming year includes several on steam and gas power, several on machine tool development and design and several on administration. It is hoped that the high standard set during the past year will be maintained. As stated before, however, the main business of this Section for the coming season is the organization of a record-breaking Spring Meeting for next May."

LOS ANGELES SECTION

Four technical sessions will be held in October, January, March and June respectively. The exact dates of these meetings are not yet determined.

The weekly luncheon meeting will be held every Thursday as last year. The members have responded ably and willingly at these luncheon meetings and the subjects discussed have been principally in the lines of local work in which the members are engaged.

This year the Section hopes to see further progress in its work in connection with bringing together into closer relationship the several engineering organizations of the city.

MINNESOTA SECTION

Professor Martenis, Chairman, writes that the Section has made elaborate plans for the forthcoming winter. Here, too, the activities proposed are best expressed in the Professor's own words:

"The Minnesota Section of the Am.Soc.M.E. will inaugurate a season of great activity at its first meeting to be held at the Main Engineering Building of the University of Minnesota on Thursday evening, September 14.

"Past experience seems to demonstrate the advisability of restricting the presentation of more than one good technical paper at each meeting. When more than one paper is presented, there is very little time left for discussion, and it is this part of the work that should be encouraged.

"It is proposed to widen the scope of papers to be presented, so that we may arouse a greater interest from those who are engaged in lines not heretofore discussed. For instance, we will have a paper on modern locomotive practice to attract our members and also prospective members who are interested and engaged in this line of work and who would not otherwise attend. We hope to develop the 'come to meetings' habit.

"A live social affair will come in January or February, and possibly a spring excursion in May.

"Realizing the importance of building up our membership, a large committee has been appointed to interest the many engineers in Minnesota who are qualified to join the Society and who would add materially to the effectiveness of the work of the Section.

"A plan must be worked out which will bring the members scattered about the State into closer working contact with the Section.

"The Minnesota Section will continue to coöperate with other engineers in holding occasional joint meetings.

"The existence and activities of the Section will become better known through the medium of the press, and it is proposed to appoint a committee for this purpose.

"The opportunities available for employment through the columns of The Journal of the Society will receive more consideration.

"The coming year is a most promising one, and we wish to make the greatest use of it for our Society and its members."

NEW ORLEANS SECTION

This newly organized Section has plans for the coming year which, it is hoped, will prove of interest and benefit to the local membership.

The dates for the meetings, with the topics for discussion, have been decided as follows:

October 2, 1916. Discussion of paper on The Design and Test of a Large Reclamation Pumping Plant, published in The Journal.

January 15, 1917. Oil Burning.

April 2, 1917. Preparedness.

July 2, 1917. The A.S.M.E. Boiler Code.

The meetings will be held in the rooms of the Louisiana Engineering Society. The first meeting will be a joint meeting with the Louisiana Association of Members of the American Society of Civil Engineers. The paper to be discussed is of much interest to both mechanical and civil engineers in this section of the country.

It is hoped that the President or Secretary of the Society will be able to attend one of the meetings during the year.

NEW YORK SECTION

The active season will be opened with an informal smoker on September 29, at which time tentative plans for the coming year, also for the Annual Meeting of the Society in December, will be discussed.

The October meeting of the Section will be held on the 10th. Dr. Charles L. Reese, of the E. I. du Pont de Nemours Powder Company, will speak on Explosives, giving special attention to the use of explosives for industrial purposes.

Monthly meetings are planned, as last year. These will again be preceded by the "get-together" informal dinners.

With the exception of the President's reception, all excursions and entertainment features of the Annual Meeting are placed in charge of the New York Section Committee.

The Section has decided to provide a mid-day luncheon in the Engineering Societies Building on Wednesday and Thursday of the week of the Annual Meeting; the charge will be nominal. Details of the excursions and entertainments are now being worked out by committees.

PHILADELPHIA SECTION

The Philadelphia Section is particularly fortunate in its affiliation with the Engineer's Club of Philadelphia, which is furnishing the Section with headquarters and keeping it in touch with all the engineering activities in the district. The Engineer's Club has been exceptionally liberal in its treatment of the affiliated societies, and has developed a feeling of good fellowship among the members of those societies.

It is proposed to hold eight meetings of the Section during the season. The dates as yet determined are:

October 24, 1916. The Development of Our Fleet and Naval Stations, by Prof. William L. Cathcart.

November 28, 1916. Aeroplane Engines, by Mr. Huntington of the Aero Club.

January 23, 1917. Coke Ovens and their By-Products, by Mr. Ramsberg, Vice-President of the Koppers Company.

February 27, 1917. A meeting on the textile industry.

March 27, 1917. District Heating, by Walter J. Kline, of the American District Steam Company.

April 24, 1917. Entertainment for the President of the Am.Soc.M.E. by the Philadelphia Section.

May 22, 1917. Engineering of Men, by Willard Behan.

Three of the meetings will be in charge of Emmett B. Carter, Chairman of the Section, one in charge of J. A. Steinmetz, one in charge of C. L. Bruff and one in charge of Prof. R. H. Fernald.

PROVIDENCE ENGINEERING SOCIETY

The Providence Engineering Society, affiliated with our Society, has this year leased the second floor of one of the Rhode Island School of Design buildings, and Henry D. Sharpe, Mem.Am.Soc.M.E., has made a generous gift to the society of $1,500 for furniture. A "house warming" will be held on October 11.

The Society plans one general engineering meeting a month and perhaps three Section meetings a month.

This summer the Society has increased its membership by 300.

ST. LOUIS SECTION

The St. Louis Section will endeavor to cultivate more than ever the spirit of sociability, as well as to awaken a more pronounced feeling of solidarity. The Section considers the latter particularly desirable today in view of the important changes which are taking place in the structure of our social and industrial institutions.

H. R. Setz, Chairman, reports that the tentative program for the season's activities has been drawn up and is now being confirmed.

WORCESTER SECTION

The Worcester Section enters upon its second year with the assurance of a successful season. Paul B. Morgan, Chairman, announces that the Section will this year take full advantage

of the circumstance that it is located in the center of an inventive field. Mr. Morgan writes:

"That portion of Central Massachusetts, known as Worcester County, has in the past been famous for men who have made inventions which have fairly revolutionized methods in the branches of industry affected. At the present time there is no cessation of the exercise of this same inventive faculty here. It has been planned by the Local Section Committee to center its activities for the present season about this fact.

"The first meeting will be held about the middle of November, when it is hoped that as one feature a paper will be presented outlining what has been accomplished here in the past. This meeting will be followed by two others, one in February and another in April, at which will be considered important mechanical developments of the present day which are being worked out here by men, most of whom are members of our Society. Many of us have but a fragmentary conception of the magnitude of these developments and it is hoped that we shall be able to bring this matter before our Section members. An exposition of this sort will doubtless stimulate all and particularly our younger members, and increase the interest in the Society among outsiders.

"We look forward confidently to a considerable increase in membership during the coming season."

At the time of going to press, the final programmes of activities of the Sections at Boston, Detroit, San Francisco and New Haven had not been received. It is planned to publish these next month, however.

STUDENT BRANCHES

The *Kansas State Agricultural College Student Branch* will hold a weekly meeting throughout the college year in order to enable the mechanical engineering students to become familiar with the various phases of the profession and with the ideals and ethics of master engineers. Two of the meetings each month will be devoted to the discussion of papers appearing in The Journal and to the presentations of new papers by student members of the Society. The other two meetings will be devoted to talks by members of the engineering faculty and outside engineers.

At the *Syracuse University Student Branch*, the following will be undertaken: (1) Presentation of technical papers by members of the branch and discussion; (2) lectures by engineers, possibly men sent by the Society; (3) discussion of the broader engineering subjects dealing with the engineer and the public; (4) coöperation with either the college or city Y. M. C. A. in educational work among the foreign industrial class, with a spirit of friendly interest in the men.

Throop College of Technology Student Branch will hold monthly meetings, some of them joint meetings with the student branch of the A. I. E. E. In addition excursions will be made to manufacturing plants in the vicinity of the college.

The general plan at the *University of Kansas Student Branch* this year will be to have meetings every Thursday evening. Three meetings each month will be in charge of the students and be given up to discussions of particular subjects; at the fourth meeting the discussions will be more general. The branch expects to hold an annual meeting in February or March, and needs a speaker with a message to the students to complete the program.

Stevens Institute of Technology Student Branch is going to devote all its energies to arranging for an interesting series of inspection trips and, if possible, a few lectures on engineering topics. It has also determined to interest more of the seniors in membership in the Society.

University of California Student Branch. It is proposed that at each of four meetings during the semester two students shall present papers upon such topics as they themselves shall select, there shall be a short talk or lecture by some member of the faculty, and discussion of the papers presented. For each of the other three meetings of the half year, it is proposed to invite some prominent member of the profession to deliver a lecture upon a practical subject of general interest, with the opportunity for discussion or questions.

The Student Branch at the *University of Nebraska* is looking forward to the coming year with pleasure. Even at this early date a spirit of fellowship exists, which promises to bring success to all society activities. Meetings will be held the first Tuesday of each month, at which time talks will be given by men with practical engineering experience. It is the aim of the branch to get every mechanical engineer, including freshmen, into the spirit of the work and to have them attend the meetings regularly. The first meeting, to be held on September 19, will be a get-together meeting and short talks will be given by the members concerning their summer's work; later the faculty will be introduced and short talks from them will be in order. It is intended to hold a smoker the second week of school and get every M. E. student interested in the Society and its affairs.

Although the schedule of the *University of Cincinnati Student Branch* has not yet been completed, it is planned to start work on September 25 with a membership campaign. During the year, papers on motor car engines, production work, the development of the machine tool industry in Cincinnati, and various other topics will be read before the branch. The discussion of the subjects will be general enough to interest all the members. A series of trips to new factories is being arranged. The Spring Meeting of the Am.Soc.M.E. will be held in Cincinnati in May and the local student members are planning to attend many of the sessions; invitations will be extended to the student branches in the vicinity to fraternize with the Society's branch during the meeting, and a smoker in honor of visiting members will be held at the University.

Leland Stanford Junior Student Branch will hold meetings of a professional or technical character every two weeks. At one-half of these meetings the students will assume full responsibility for the material to be presented, together with the discussion of it. For the remaining one-half it is expected that the material presented will be in the form of addresses or papers by engineers of San Francisco and vicinity.

There are at Stanford University five engineering societies composed of students specializing respectively in civil, mining, mechanical, electrical and chemical engineering; and it is the purpose during the year to foster and stimulate coöperative action among these societies with a view to holding a number of engineering assemblies. At least one joint social meeting with A. I. E. E. Student Branch is contemplated.

Virginia Polytechnic Institute Student Branch proposes to have a number of addresses by prominent men and to continue the practice of having papers by students themselves, which has been found very valuable. The administration of the institute has shown its appreciation of the work of the branch by offering a prize of a subscription to The Journal to the three best men in the year.

A meeting or excursion every two weeks is planned by the *Massachusetts Institute of Technology Student Branch.* The plan of having the students conduct the entire programme themselves, so successful last year, will be continued. Prominent engineers will be invited to address the meetings, and the excursions will be made to power houses or manufacturing establishments near Boston.

The *University of Illinois Student Branch* began the year with a business meeting on September 28, when plans for the coming season were discussed.

Seven or eight meetings are to be held during the first semester, and approximately the same number in the second. It is hoped at every one of these meetings to have presented, in the main by the student members themselves, at least one paper on a subject of an engineering nature.

The *Ohio State University Student Branch* will duplicate the practice of last year by having meetings every two or four weeks. At these meetings student members will either describe their observations or experiences in engineering work, read a paper giving the result of their inquiry and reading in the library, or read the text of a lecture furnished by the society, or addresses will be made to the branch by local or visiting engineers.

Copies of The Journal and other periodicals will be kept on file in the laboratory so that students may be encouraged to study their contents.

The above gives the plans of thirteen out of the forty Student Branches. The remaining branches are expecting to resume work during the present month, and we hope to be able to give reports of their prospects in the next issue of The Journal.

J. Sellers Bancroft and Henry Hess were guests of the Tenth Annual Convention of the Illuminating Engineering Society, held in Philadelphia, September 18 to 20.

THE THIRTY-SEVENTH ANNUAL MEETING

NEW YORK CITY, DECEMBER 5 TO 8

MEMBERS will soon be making their plans to attend the Annual Meeting, and to help them we give a few of the features of the meeting, in the hope that all will be persuaded that the convention will be well worth while.

To provide the mental stimulus, the Committee on Meetings, with its ten sub-committees, has been working for several months, and a glance at the papers they have secured will convince anyone that considerable benefit will be derived from attendance at the meeting.

Parallel with the professional sessions, the Entertainment Committee has been working assiduously to provide an ideal social programme, and will assure that all visitors will be made at home and have a good time.

A synopsis of the programme of the meeting is given below. In this synopsis titles and days on which events are to occur are given, for the benefit of members who may have to make special arrangements.

OPENING FEATURES

On Tuesday, December 5, headquarters will open at the Engineering Societies Building, and registration will be commenced. There will be a Council Meeting and a Conference of Sections.

In the evening the President of the Society, Dr. D. S. Jacobus, will deliver his presidential address on the subject of the Relation of Education to Engineering. Following the address there will be a reception by the Society to the President, President-Elect, ladies, members and guests.

On the morning of Wednesday, December 6, a business meeting will be held. At this the reports of the Council and Committees for the year will be presented, new officers elected, etc. Following the business meeting there will be a brief memorial meeting as a mark of respect to the memory of the late Dr. John Edson Sweet, Past-President and Honorary Member of the Society.

PROFESSIONAL FEATURES

An all-day Valuation Session will be held on Thursday, December 7. The Committee on Meetings has taken special pains to secure authoritative papers for this session, and a number of representative engineers will contribute valuable discussion. The titles of papers to be presented include Accurate Appraisals by Short Methods; Industrial Valuation Differs from Public Utility Valuation; Perpetual Inventory Value vs. Appraisal Value; Engineering Economics of Partial Construction; Amortization and Depreciation; Production Capacity as a Measure of Value of Industrial Property.

A Gas Power Session will be held on Thursday afternoon. The Sub-Committee on Gas Power has worked diligently to secure the success of this session and deserves special credit for its accomplishments. The titles of papers expected include Tar Forming Temperatures of Coals; Marine Diesel Engines; Results with Heavy Oil Engines; Experiences with the Humphrey Pump; Theory of Ignition in Internal Combustion Engines; Gas Tractors; Commercial Methods of Sampling and Analyzing Producer Gas, etc.

Two Machine Shop Sessions will be held, one on Wednesday afternoon and one on Thursday afternoon. The Sub-Committee on Machine Shop Practice has been fortunate in securing two leading authorities to present the subject of Standardization of Machine Tools; the chairman himself will discuss the Classification of Machine Shop Practice, and there will be miscellaneous papers.

A Textile Session will be held on Wednesday afternoon. This session is in charge of the Sub-Committee on Textiles, which announces three papers, including Relations of Importance between Moisture in the Air and Moisture in Materials, and Experiments to Determine the Relative Heat Transmission through Various Types of Sash.

A Railroad Session, the papers for which have been secured by the Sub-Committee on Railroads, will be held on Friday morning. The topics of papers include Pulverized Fuel for Locomotives, Clasp Brakes, and Electric Locomotives.

Papers not contributed by Sub-Committees, including this year a number of titles of sufficient diversity to insure interest for every one, and yet each one constituting an authoritative opinion on its special subject, will be presented at three Miscellaneous Sessions, planned for Wednesday morning, Wednesday afternoon and Friday morning. It is always a matter of difficulty to group such papers into sessions, but unfortunately the limitations imposed upon the Committee by the large number of papers offered, and the impossibility of devoting an entire session to the discussion of one paper only, render it necessary to group the papers as may seem best. Titles of these papers include The Proportioning of Surface Condensers; Small Steam Turbines; Graphic Methods of Power Plant Design; Ratio of Specific Heats and Coefficient of Viscosity of Natural Gas; Internal Combustion Engines, and The Impact Tube.

A session in charge of the Sub-Committee on Protection of Industrial Workers will be held on Wednesday morning.

On Friday morning there will be a session for the presentation of papers relating to steam boiler subjects; this session will be in charge of the Boiler Code Committee. On Friday afternoon there will be a public hearing on the revision of the Boiler Code.

Manuscripts of papers are being sent to the printer as soon as released by the Committee on Meetings, and it is anticipated that all the papers will be available in pamphlet form in advance of the meeting for distribution to members desiring to contribute discussion. Further, comprehensive abstracts will be published in The Journal before the meeting.

ENTERTAINMENT FEATURES

The reception on Tuesday evening will be followed by dancing and a collation. On account of the difficulty of handling this affair in the Society's rooms, due to the congestion from the increasingly greater number attending, the reception and dance will this year be held on the fifth floor of the Engineering Societies Building, as will also the Wednesday and Thursday evening functions. Luncheons are also to be served on the fifth floor between the forenoon and afternoon professional sessions on Wednesday and Thursday.

The success of last year's smoker has decided the repeating of this form of entertainment for Wednesday evening. A feature of the program will be a short talk by Frank B. Gilbreth, Mem.Am.Soc.M.E., who will recount his experiences in Germany during the European War.

On Thursday evening there will be an illustrated lecture by Dr. John A. Brashear on "The Science of the Beautiful in the Familiar Things of Everyday Life." Those who have listened to "Uncle John" before will look forward with the keenest anticipation to this address, in which it will be the Doctor's purpose to show by experimental physical demonstrations how much we miss in the path of everyday life in that which is beautiful all around us, and to induce, if possible, every engineer to have a hobby outside of his everyday calling.

Following this lecture, which will be given in the Auditorium of the Engineering Societies Building, there will be a reunion and informal dance, with light refreshments, on the fifth floor.

Other entertainment features include the usual conducted excursions to points of interest, the college reunions, which, by the way, are increasing in number each year, and a smoker as last year.

ELECTION OF OFFICERS

Before the end of this month, a ballot stating the names of candidates for the several offices falling vacant will be sent to each member entitled to vote. This ballot will be prepared from the report of the Nominating Committee, charged by President Jacobus with the duty of nominating candidates for the vacancies.

It will be recalled that the Nominating Committee was this year appointed by the President, and its members were chosen by the five groups of the different geographic sections of the Society, with the object of securing the greatest possible democracy. The committee consisted of Walter B. Snow, Chairman, representing the Boston, New Haven and Worcester Sections; H. M. Montgomery, representing the Chicago, Milwaukee and Minnesota Sections; E. H. Ohle, representing the Atlanta, Birmingham, St. Louis and Cincinnati Sections; J. T. Whittlesey, representing the San Francisco and Los Angeles Sections, and D. Robert Yarnall, representing the New York, Philadelphia and Buffalo Sections. The report from the Chairman follows:

To the Secretary:

Dear Sir: Acting for the Nominating Committee, which you advised upon February 24, 1916, of their appointment by the President, I have the honor to submit the following report.

As the result of several meetings at New Orleans in April, and subsequent personal interviews on the part of individual members, the following names of nominees for the various elective offices next falling vacant under the Constitution, together with the written consent of each nominee, are herewith presented:

For President, for one year:

Ira N. Hollis, Worcester, Mass.

For Vice-Presidents, for two years:

Charles H. Benjamin, Lafayette, Ind.
Arthur M. Greene, Jr., Troy, N. Y.
Charles T. Plunkett, Adams, Mass.

For Managers, for three years:

Robert H. Fernald, Philadelphia, Pa.
William B. Gregory, New Orleans, La.
C. R. Weymouth, Berkeley, Cal.

For Treasurer:

William H. Wiley, New York, N. Y.

Respectfully submitted,
For the Committee,
(*Signed*) Walter B. Snow, *Chairman.*

A brief account of the professional careers of each of the nominees is given below. Members are asked to read these accounts carefully, especially of candidates not known to them personally, so that when they receive their ballots they may vote intelligently.

IRA NELSON HOLLIS

Ira Nelson Hollis, president of Worcester Polytechnic Institute, was born in Mooresville, Md., in 1856. He received his early education in the public schools of Louisville, Ky., and in 1874 was appointed cadet engineer at the U. S. Naval Academy, from which he was graduated in 1878. Two years later he was commissioned assistant engineer in the United States Navy, and in 1888 passed assistant engineer. He resigned from the navy in 1893 to accept an appointment as professor of engineering at Harvard University, and in 1913 was called to his present position.

During the fifteen years after graduation from the Naval Academy, he served in various positions connected with the design, inspection and operation of marine machinery, and was chief engineer of two ships.

Dr. Hollis received the honorary degree of Master of Arts from Harvard University in 1899, the degree of L.H.D. from Union College in the same year, and the degree of Doctor of Science from the University of Pittsburgh in 1912.

He was elected to membership in The American Society of Mechanical Engineers in 1884, and was Vice-President of the Society from 1911 to 1913. He is at present serving on the Committee on Constitution and By-Laws.

He is a Fellow of the American Academy of Arts and Sciences, and a member of the Society of United States Naval Engineers, the American Society of Naval Architects and Marine Engineers, the Boston Society of Civil Engineers, and the Society for the Promotion of Engineering Education.

Dr. Hollis is the author of History of the Frigate *Constitution* (1900), and War College Lectures on Naval Ships (1912), as well as of a paper read before the Society in 1909, entitled Cast-Iron Fittings for Superheated Steam, and others dealing with naval, educational and engineering subjects.

CHARLES HENRY BENJAMIN

Charles Henry Benjamin, dean of the schools of engineering and director of engineering laboratories, Purdue University, was born at Patten, Me., in 1856. After serving an apprenticeship of three years with Benjamin & Allen, of Oakland, Cal., he matriculated at the University of Maine, from which he was graduated in 1881 with the degree of Mechanical Engineer. He was retained by this institution in the successive capacities of instructor and professor of mechanical engineering until 1886, when he resigned to become mechanical engineer for the McKay Machine Co., of Boston, Mass.

In 1889 Dr. Benjamin was appointed professor of mechanical engineering at Case School of Applied Science, where he remained until 1907, the year in which he became connected

with Purdue. The degree of Doctor of Engineering was conferred on him by Case School of Applied Science.

He was elected to membership in The American Society of Mechanical Engineers in 1892. He is also a member of the Engineers' Society of Cleveland, the Western Railway Club, the Master Car Builders' Association, and the Master Mechanics' Association.

He is the author of Modern American Machine Tools (1906), Machine Design (1906), The Steam Engine (1909), and of the following papers read before the Society: Electricity vs. Shafting in the Machine Shop (1897); Friction Horsepower in Factories (1897); Experiments on Cast Iron Cylinders (1898); Bursting of Small Cast Iron Flywheels (1899); Friction of Steam Packings (1900); Some Experiments on Ball Step-Bearings (1901); The Bursting of Small Cast Iron Flywheels (1902); Experiments on Spiral Springs (1902); The Bursting of Emery Wheels (1903); Smoke and Its Abatement (1905).

He has been a frequent contributor to technical journals, and his researches have dealt with lubrication, locomotive headlights, and other topics not indicated in the foregoing list of publications.

ARTHUR MAURICE GREENE, JR.

Arthur Maurice Greene, Jr., professor of mechanical engineering at Rensselaer Polytechnic Institute, was born in Philadelphia, Pa., in 1872. He was educated at the University of Pennsylvania, receiving the degree of Bachelor of Science in 1893, and that of Mechanical Engineer a year later. He was instructor in mechanical drawing for one year at Drexel Institute, and then instructor in mechanical engineering at the University of Pennsylvania until 1902. From 1902 to 1907 he was professor of mechanical engineering at the University of Missouri (junior dean, 1906-1907), resigning therefrom in the latter year to assume his present position. He was assistant engineer of the Philadelphia Traction Company at different periods between 1893 and 1909, and mechanical engineer and chairman of a group jury of the National Export Exposition in 1899.

Professor Greene entered the Society as a junior in 1895, and was elected to full membership in 1903. He has been a Manager since 1913, and is at present serving on the Research and Boiler Code Committees, as well as Society Representative on the Constitutional Convention and on the Joint Conference Committee of the Society and the American Society for Testing Materials.

He is a Fellow of the American Association for the Advancement of Science, and a member of the Society for the Promotion of Engineering Education, and of The Franklin Institute.

He is the author of Pumping Machinery (1911), Elements of Heating and Ventilation (1912), and Heat Engineering (1915); also, at an earlier date, in collaboration with H. W. Spangler, of Elements of Steam Engineering. In 1907, he presented a paper before the Society entitled Entropy Lines of Superheated Steam.

CHARLES T. PLUNKETT

Charles T. Plunkett, cotton manufacturer, was born in Adams, Mass., in 1855, and was educated in the high school of that city. He has been identified with cotton manufacturing in Adams since 1877, and has given much study to the mechanical and hydraulic problems of mill work, resulting in improved mill construction and in new designs of water-wheel casings and draft tubes.

Mr. Plunkett was elected to membership in the Society in 1909. He was made a member of the Sub-Committee on Textiles in 1912, of which committee he has been chairman since 1913. He was president of the National Association of Cotton Manufacturers in 1908 and 1909, and is a member of engineers' clubs in New York and Boston.

He is president of the Berkshire Cotton Manufacturing Company, of Adams, and of the Industrial Mutual Insurance Company, of Boston; also a director of the Greylock National Bank, the Cotton-Woolen Mutual Fire Insurance Company, and the Rubber Mutual Fire Insurance Company.

ROBERT HEYWOOD FERNALD

Robert Heywood Fernald, professor of dynamical engineering at the University of Pennsylvania and consulting engineer of the U. S. Bureau of Mines, was born in Orono, Me., in 1871. After being graduated from the University of Maine in 1892, he spent one year as graduate student at the Massachusetts Institute of Technology, and then accepted appointment as instructor in mathematics and mechanical engineering at Case School of Applied Science. In 1896 he became assistant professor of mechanical engineering, leaving that institution in 1900 to take up graduate study at Columbia University. From 1902 to 1908 he was professor of mechanical engineering at Washington University, when he was appointed to the same chair at Case School of Applied Science. In 1912 he accepted the position he now holds. From 1902 to 1909 he was also engineer in charge of the technologic branch of the U. S. Geological Survey, and since 1912 he has been consulting engineer of the first division of the U. S. Bureau of Mines. In 1898 he received the degree of Mechanical Engineer from Case School of Applied Science, and in 1901 and 1902 the degrees of Master of Arts and Doctor of Philosophy, respectively, from Columbia University.

Doctor Fernald became a junior member of the Society in 1900, and was elected to full membership in 1903. He has served on many committees in the past, and at present is a member of the Committee on Meetings and the Special Committees on Am.Soc.M.E. Junior and Student Prizes. He is also chairman of the Philadelphia Section of the Society.

He is a Fellow of the American Association for the Advancement of Science, and a member of the Society for the Promotion of Engineering Education, the American Society for Testing Materials, The Franklin Institute, the Engineers' Club of Philadelphia, and the Philadelphia Chamber of Commerce. In 1912 he was president of the Cleveland Engineering Society.

He has been engaged almost continuously for fifteen years in research work in connection with the Bureau of Mines, and is the author of numerous monographs on fuels, producer gas for power purposes, gas-engine investigations, etc., in addition to the following papers presented before the Society: Method of Determining the Temperature of Exhaust Gases (1902); Working Details of a Gas Engine Test (1902); Results of the Preliminary Producer Gas Tests of the United States Geological Survey Coal Testing Plant at St. Louis (1906).

WILLIAM BENJAMIN GREGORY

William Benjamin Gregory, professor of experimental engineering at Tulane University, was born at Penn Yan, N. Y., in 1871. His education was received at Cornell University,

from which he was graduated in 1894 with the degree of Mechanical Engineer (M.M.E., 1908). From 1894 to 1897 he was instructor in drawing at Tulane University, from 1897 to 1902 assistant professor of experimental engineering, from 1902 to 1905 associate professor, and since that date full professor. His vacations have been largely spent in erecting sugar machinery and power plants and in drainage investigations. In addition to his educational activities he has served as consulting engineer for the Mississippi River Commission on tests of hydraulic dredges and accessory machinery.

Professor Gregory was elected to junior membership in the Society in 1895, and to full membership in 1903. He was a member of the Nominating Committee, and chairman of the Special Committee for the Spring Meeting of 1916.

He is a member of the American Society of Civil Engineers, the American Society for Testing Materials, the Louisiana Engineering Society (president, 1910), and the New Orleans Academy of Sciences (president, 1914).

His investigations have been largely along hydraulic lines, dealing with drainage, rice irrigation, the raising of large volumes of water through small lifts, and with the allied subjects dealt with in the following papers which he has presented before the Society: Tests of a Centrifugal Pump (1901); Pitot Tube (1904); Test of a Rotary Pump (1907); Some Pitot Tube Studies (1908); The Evolution of Low Lift Pumping Plants in the Gulf Coast Country (1916).

CLARENCE RAYMOND WEYMOUTH

Clarence Raymond Weymouth, mechanical engineer, was born at Oakland, Cal., in 1876. In 1898 he was graduated from the University of California, receiving the degree of Bachelor of Science. For the eight years prior to graduation he served apprenticeship periods in various shops during vacations. In 1899 he began work as draftsman for the firm of Chas. C. Moore & Company, of San Francisco, Cal.; in 1902 he became chief draftsman, and a little later inspector of work under construction and in charge of installation. In 1909 he was made chief engineer of the firm, which position he now holds.

Mr. Weymouth entered the Society as a junior in 1904, and was elected to full membership in 1907. In 1913-14 he served as a member of the Committee on International Engineering Congress, 1915, and also as member of the committee in charge of the San Francisco Section of the Society. He has given much attention during the course of his practice to the use of oil fuel, as the following papers presented by him before the Society attest: Fuel Economy Tests at a Large Oil Burning Electric Power Plant Having Steam Engine Prime Movers (1908); Unnecessary Losses of Firing Fuel Oil and an Automatic System for Their Elimination (1908); Dimensions of Boiler Chimneys for Crude Oil (1912).

WILLIAM H. WILEY

William H. Wiley was born July 10, 1842, in New York City, and received his A.B. degree from the College of the City of New York in 1861, and the degree of C. E. from Rensselaer Polytechnic Institute in 1866. He also studied as a special student at the Columbia School of Mines in 1868.

At the outbreak of the Civil War he joined the Seventh Regiment of New York Volunteers, and in 1862 was made first lieutenant. When the regiment was mustered out in 1864 he was given the title of Major U. S. V.

Since 1876 Major Wiley has been a publisher of scientific works. He served as a member of the 58th, 59th and 61st Congresses from New Jersey. In 1897 he was president of the International Jury of the Brussels Exposition, and was a member of the Superior Jury, Brussels. He was a commissioner from New Jersey at the St. Louis Exposition in 1904.

Major Wiley is the author of a book on Yosemite, Alaska, and Yellowstone, published in 1888, and has acted as New York Correspondent for London Engineering. He is a member of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Association for the Advancement of Science, the National Geographic Society, the Order of Leopold, Belgium, and the Loyal Legion.

Major Wiley has been a member of the Society since its organization. He was appointed on the Finance Committee in 1882. While serving as Chairman of this Committee he was elected Treasurer of the Society, in 1884, and has been regularly nominated and elected for the period of thirty-two years which has since elapsed.

ROLL OF HONOR

The Society is desirous of publishing lists of all members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Naval Militia, the Navy, or in any other capacity in the services of the country. Every member who is, or who knows of any other member who is engaged in the service of the country is requested to notify the Secretary.

The first Roll of Honor was published in the August issue of The Journal, the second in the September issue, and the third, comprising further names received to date, appears below.

ADAMS, CARROLL E., Private, Battery A, Rhode Island National Guard

ALLISON, JOHN F., First Lieutenant, 3d Regiment, Penn Machine Gun Company, Fort Bliss, Tex.

ALLYN, ROBERT S., Major, 9th Coast Defense Command, C. A. C., National Guard, New York

BERGER, J. G., Aide, Naval Consulting Board, Mercer Co., N. J.

BRENNAN, JAMES, Captain and A.D.C., 7th Division, U. S. A.

BROOM, BENJ. A., Field Aide, Naval Consulting Board, Woodbury Co., Ia.

BUCKLER, ALBERT, Assistant Superintendent, U. S. Lighthouse Service

BURROUGHS, JOS. H., JR., First Class Private, Company B, Engineer Battalion, National Guard, Pennsylvania

BUSH, HAROLD M., Major, Ohio Battalion of Artillery, National Guard

CLUETT, SANFORD L., R. L. Signal Corps, National Guard, New York

COMSTOCK, CHARLES W., Second Lieutenant, Field Artillery, National Guard, Colorado

CRUIKSHANK, BARTON, Captain, R. L., First Cavalry, National Guard, New York

DAVIS, FRANCIS P., Second Lieutenant, Coast Artillery Corps, New York National Guard. Assigned to 33d Co., 8th C.D.C.

DEWOLF, ROGER D., Lieutenant, 7th Division, 3d Battalion, Naval Militia, New York

DOYLE, M. A., Second Lieutenant, Engineers, U. S. Coast Guard

DURAND, W. F., Member, National Advisory Committee on Aeronautics

EAGER, WILLIAM G., Sub-Chairman, Industrial Census, Naval Consulting Board, South Georgia. Member, American Legion

EHRMANN, JOHN P., Ordnance Department, Watervliet Arsenal

FITZGERALD, EDWARD T., Captain, 2d Battalion, Naval Militia, New York

FRY, ALFRED BROOKS, Captain, Naval Militia and Engineers' Reserve List, U. S. N.

FULLER, RAY W., Captain, Company A, Engineers, U. S. and Penna.

GUNBY, FRANK M., Captain, Artillery Engineer, C. A. C., Massachusetts National Guard

HALL, HARRIS F., Captain, Company M, 6th Infantry, Illinois National Guard

HUBBELL, LYMAN P., Captain, Quartermaster Corps, 74th New York Infantry, National Guard. On duty at Pharr, Texas

HUTCHISON, MILLER REESE, Member and Assistant to Chairman, Naval Consulting Board of the United States

INGHAM, HOWARD M., Corporal, 1st Motorcycle Battery of Englewood, N. J.
JOHNSTONE, EDWARD J., Lieutenant, Junior Grade, Naval Militia
KESSLER, ARMIN GEORGE, Lieutenant, Senior Grade, Naval Militia, Erie, Pa.
KILPATRICK, JOHN D., Major, Quartermaster Corps, N. J.
KING, CHARLES G. Y., Lieutenant Commander, Illinois Naval Reserve
KRAUSE, ARTHUR E., Field Aide, Naval Consulting Board, Hudson Co., N. J.
LAWRENCE, SAMUEL E., Junior Mechanical Engineer, U. S. Engineer Department
LOEWENSTEIN, LOUIS C., Plattsburg Military Training Camp, August 1916, preparatory to Reserve Officers' Corps
McMUNN, WILLIAM N., Commander, Illinois Naval Reserve
MAAS, E. F., Chief Draftsman, Machinery Division, Navy Yard, Puget Sound, Wash.
MANSFIELD, JULIAN B., Captain, Infantry and Artillery, Reserve
MARTIN, KINGSLEY G., Private, Class B, Depot Battalion, 22d Regiment of Engineers
MOON, HARTLEY A., Major, Infantry, 4th Battalion, 3d Regiment
NAEGELEY, JOHN C., Engineer and Architect, Member Navy League, U. S.
NORRIS, ALEX. MURDOCH, Ensign, Engineer Duties, Maryland Naval Militia
OATLEY, HENRY B., Naval Militia
PELLY, JOHN F., Corporal, Battery A, 1st F. A. Pa.
PIGOTT, R. J. S., Chairman Local Committee, Naval Consulting Board, Bridgeport, Conn.
RICHARDSON, EDWARD BRIDGE, Captain, Battery A, Massachusetts Field Artillery
ROBINSON, C. SNELLING, Associate Member, Naval Consulting Board, Director for State of Ohio
SCHLANK, ELIAS, Private, Sanitary Division, 7th N. Y. Infantry, National Guard.
SCOTT, ROSSITER STOCKTON, Corporal, Battery A, Maryland National Guard
SIMPSON, COLIN C., JR., Private, Depot Battalion, 7th New York Infantry
TAYLOR, DONALD F., Private, Squadron A, Machine Gun Battery, New York Division
TURNER, ROBERT T., JR., Gunner, N. Y. Training Battery
VIETS, HARRY A., Sergeant, 13th Coast Defense Command, National Guard, New York
WHITNEY, HERBERT A., Assistant Battery Commander, Coast Artillery, National Guard
WILSON, ALFRED BARBER, Acting Corporal, Company B, 8th Training Regiment, Plattsburg, N. Y.
WILSON, HENRY C., Major, 8th Coast Defense Command, National Guard, New York
WOODRUFF, CLARENCE A., Second Lieutenant, Connecticut Coast Artillery Corps
YORK, HERBERT W., Lieutenant Commander, Naval Militia, New York
ZIMMERMAN, OLIVER B., Major, Engineers, Engineers Supply Service

CORRESPONDENCE

To the Secretary:

I have been interested to note, in the Roll of Honor published in the August and September issues of The Journal, that a large part of our membership is rendering most valuable service in the work now being undertaken to put the country in a state of preparedness against attack.

This prompts me to call attention to those members of the Society I happen to think of just now who have served their country in the past, and to whom credit should also be given for the work they did in their time. For example, your past and present membership includes a number who, to my knowledge, had actual war service in the War of the Rebellion or the Spanish-American War.

To cite cases familiar to me, the list of Past-Presidents includes Thurston, Leavitt, Loring, and Melville of the Navy, and Meier and Hunt of the Army. Vice-Presidents include Shock, Charles Emery, Kafer, Manning and Morgan of the Navy, and Gilmore, a distinguished officer in the Army. Your present Treasurer, Maj. William H. Wiley, was an officer in the Army, and there must be many I cannot recognize among your deceased or living members who served in the War of the Rebellion or the Spanish-American War.

To mention my own service, it included four years' active duty as an Engineer in the Navy, 1861 to 1866, and I had also the privilege of serving on the Endicott Fortification Board in 1887.

My late illness and my age have put me on the shelf, but I am proud of being one of the old timers who did their task when they were able.

Joseph Morgan.

Johnstown, Pa.

ENGINEERING SOCIETIES BUILDING UNDERGOING ALTERATION

Alterations to the Engineering Societies Building to accommodate the Civil Engineers and provide for an enlarged library are now in progress. The existing framework of the building was not designed to take care of increases in loading, and so to carry the three stories to be added it is necessary to put in four new columns from the foundation up through the existing building. The additional load entailed by the three new stories will be carried by an ingenious truss system from which the stories will be hung.

It is anticipated that this preliminary work will be finished before our Annual Meeting, and that the entire work of adding the three stories will be completed within a year.

THE ENGINEER

Under the above title, the New York *Globe* published, on August 25, an article by Dr. Frank Crane, which will be of interest as illustrating the light in which the engineer is regarded by a noted editorial writer. Incidentally, Dr. Crane quotes H. L. Gantt, Mem.Am.Soc.M.E., Chairman of the Meetings Committee. The article follows:

THE ENGINEER

Dr. Frank Crane

The man of the future will be the engineer.

He is the man who can Do things; and is better than the man who Owns things.

The Millionaire is a temporary, passing, makeshift product of civilization. He is merely holding things together until the people get sense enough to do their own owning.

Some day little boys will read that the world once had millionaires and huge private wealth units, just as they will one day read and wonder that men once had kings.

But the official who will forever be indispensable is the engineer.

The time will come when the President of the United States will be chosen as the man who has the greatest talent and skill in organizing public works. There will be no more politics in his selection than there is now in choosing the master mechanic of a railway or factory.

When a nation goes to war nowadays, that is, when it becomes necessary to exert its supreme collective strength, nobody dreams of electing the most popular politician or the cleverest speechmaker to lead the armies. It is the man who can get the last ounce of efficiency out of men and metal that is wanted.

Some day the nation will realize that it is continually in a crisis, and that in peace as in war we need the highest order of efficiency and organization.

We need the Engineer to arrange the transportation of people and goods from place to place, without waste, without competition, without graft, looking only to the public good.

We need the Engineer to get meat, bread, and milk from farm to citizen, without the present inefficient tangle of trusts and middlemen working at cross purposes.

We need the Engineer to turn the profit of public enterprise toward building good roads and bridges, instead of enriching a few shrewd manipulators.

We need the Engineer to manage a city as economically and smoothly as if it were a manufacturing plant.

We need the Engineer to organize the farmers so that all can work together for each and their products be marked without being preyed upon at every step of the way from farm to household.

Wealth can be taken away from us. But the power to Do things cannot be taken away.

The Millionaires could go and not be missed. The Engineers we cannot spare.

"What availeth all thy wealth?" said the ancient philosopher. "He that hath better iron than thou will come and take away all thy gold."

Says H. L. Gantt:

"The man who knows what to do and how to do it is pre-eminently the engineer. The new world which is being ushered in by the great struggle now taking place is one in which the engineer is destined to be the supreme power, for it is becoming clear that, in future, the man who OWNS THINGS will not be as important a factor in the world as the man WHO CAN DO THINGS."

NATIONAL RESEARCH COUNCIL

The National Research Council, established by the National Academy of Sciences at the request of the President of the United States, held its organizing meeting, on September 20, at the Engineering Societies Building in New York City.

The purpose of the council is to bring into coöperation existing governmental, educational, industrial, and other research organizations, with the object of encouraging the investigation of natural phenomena, the increased use of scientific research in the development of American industries, the employment of scientific methods in strengthening the national defense, and such other applications of science as will promote the national security and welfare.

The council is composed of leading American investigators and engineers, representing the army, navy, Smithsonian Institution, and various scientific bureaus of the Government; educational institutions and research foundations, and the research laboratories of industrial and manufacturing establishments.

The members of the council have been appointed as broadly representative of the scientific and engineering professions of the country, but without attempting to represent officially the great number of societies whose activities are related to its work.

Arrangements are now making for close coöperation with the leading national societies. The members of the council thus far appointed are:

Dr. L. H. Baekeland; Dr. John A. Brashear, Hon.Mem.Am. Soc.M.E.; Dr. John J. Carty, Chief Engineer, American Telephone and Telegraph Company; Dr. Edwin G. Conklin, Professor of Zoölogy, Princeton University; Dr. John M. Coulter, Professor of Botany, University of Chicago; Brigadier-General William Crozier, Chief of Ordnance, U. S. A.; Mr. Gano Dunn, Mem.Am.Soc.M.E., President, The J. G. White Engineering Corporation; Dr. Simon Flexner, Director Rockefeller Medical Institute; Brigadier-General William Crawford Gorgas, Surgeon-General, United States Army; Dr. W. F. M. Goss, Mem.Am.Soc.M.E.., Dean of Engineering, University of Illinois; Dr. George E. Hale, Director, Mt. Wilson Solar Observatory; Mr. Clemens Herschel, President American Society of Civil Engineers; Dr. William H. Holmes, Curator, United States National Museum; Dr. W. W. Keen, President American Philosophical Society; Mr. Van H. Manning, Director, Bureau of Mines; Prof. Charles F. Marvin, Chief, United States Weather Bureau; Prof. A. A. Michelson, Director Ryerson Physical Laboratory, University of Chicago; Dr. Robert A. Millikan, Professor of Physics, University of Chicago; Dr. Arthur A. Noyes, Director Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology; Prof. E. C. Pickering, Director Harvard College Observatory; Dr. Michael I. Pupin, Professor of Electro-Mechanics, Columbia University; Mr. Charles F. Rand, President, United Engineering Society; Prof. Theodore W. Richards, Director of the Walcott Gibbs Memorial Laboratory, Harvard University; Mr. O. E. Skinner, Director, Research Laboratory, Westinghouse Electric & Manufacturing Company; Lieutenant-Colonel George O. Squier, U. S. A., Chief Signal Officer, United States Army; Dr. S. W. Stratton, Mem.Am.Soc.M.E., Director, Bureau of Standards; Mr. Ambrose Swasey, Hon. Mem.Am.Soc.M.E.; Chief Constructor David W. Taylor, U. S. Navy; Dr. Elihu Thomson; Dr. C. R. Van Hise, President of the American Association for the Advancement of Science; Dr. Victor Clarence Vaughan, Director Medical Research Laboratory, University of Michigan; Dr. Charles D. Walcott, Secretary, Smithsonian Institution; Dr. William H. Welch, President of the National Academy of Sciences; Dr. W. R. Whitney, Director of the Research Laboratory, General Electric Company.

The Engineering Foundation has given its coöperation and support, and is putting the services of its Secretary, Dr. Cary T. Hutchinson, at the disposal of the Council.

FEDERAL NITRATE PLANT

The National Defense Act (H. R. 12766) empowers the President to make an investigation "to determine the best, cheapest, and most available means for the production of nitrates and other products for munitions of war and useful in the manufacture of fertilizers and other useful products by water power or any other power as in his judgment is the best and cheapest to use," and authorizes him to construct and operate such a plant or plants, appropriating the sum of $20,000,000 to carry out the purposes of the act.

At the request of the Secretary of War, the president of the National Academy of Sciences has appointed a committee to act in coöperation with the American Chemical Society for the purpose of furnishing the War Department with "a report containing such information as will aid the Department, to the greatest degree which the Academy finds practicable, in reaching a conclusion as to the best method to be followed in the manufacture of nitric acid by a process not involving dependence upon a foreign source of supply, the report to take into consideration the legislation contained in Section 124 of the National Defense Act, approved June 3, 1916. This committee, which is a sub-committee of the National Research Council, consists of the following members: Dr. Arthur A. Noyes (Chairman), Director Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology; Dr. W. R. Whitney, Director of the Research Laboratory, General Electric Company; Dr. L. H. Baekeland, President of the General Bakelite Company; Dr. Charles H. Herty, President of the American Chemical Society; Warren K. Lewis, Professor of Chemical Engineering, Massachusetts Institute of Technology; Prof. Theodore W. Richards, Director of the Wolcott Gibbs Memorial Laboratory, Harvard University; Dr. Elihu Thomson, General Electric Company, Lynn, Mass.; Gano Dunn, Mem.Am.Soc.M.E.; President, The J. G. White Engineering Corporation; and Dr. M. I. Pupin, Professor of Electro-Mechanics, Columbia University.

The American Electrochemical Society, through its Committee on Public Relations, constituted of the president and past-presidents of the society (among them Lawrence Addicks,

Mem.Am.Soc.M.E.), has expressed the opinion that this legislation is unwise.

In a note addressed to the President, the Secretary of the Navy, and the Secretary of War, it is pointed out that the prime necessity of the hour is the prompt provision of an 18-months' supply on a war basis of Chilean nitrate, to be stored at various strategic points. They deprecate the entrance of the Government into an industrial field that can, in their opinion, be much better and more rapidly developed by private interests.

They further state that the processes to be considered may be classified into those producing nitric acid by direct union of the nitrogen and oxygen of the air, such as the Birkeland-Eyde and the Pauling processes; those producing ammonia by direct union of nitrogen and hydrogen, such as the Haber process; those which fix nitrogen in a complex compound, such as the cyanamid process; the action of nitrogen-fixing bacteria in natural fertilizers; and finally, natural sources of fixed nitrogen, the only one which is of sufficient magnitude to warrant consideration being by-product ammonia derived from the distillation of coal.

All of the foregoing processes, except the arc processes, produce ammonia, and, as this and not nitric acid is the chief desideratum for fertilizer purposes, there is not sufficient commercial incentive for the carrying of these ammonias of varying degrees of purity through the nitric acid required in the manufacture of explosives. The Committee urges that instead of direct action toward the production of nitrate, the research facilities of the Government be concentrated (1) on the oxidation of ammonia, and (2) on the *modus operandi* of nitrogen-fixing bacteria, the former investigation to be carried out by the U. S. Bureau of Mines, and the latter by the U. S. Bureau of Soils.

NAVAL CONSULTING BOARD

The members of the Naval Consulting Board met in Washington on September 19 to take the oath of allegiance prescribed by the recently enacted naval appropriation law, which gives legal status to the members of this body. Those present were Thomas A. Edison, Hon. Mem.Am.Soc.M.E.; Dr. M. R. Hutchison, Mem.Am.Soc.M.E.; Dr. W. R. Whitney and Dr. L. R. Baekeland, both members of the American Chemical Society; Frank J. Sprague, Mem.Am.Soc.M.E.; R. S. Woodward, President of the Carnegie Institute, and Professor Arthur G. Webster, both members of the American Mathematical Society; A. M. Hunt, Mem.Am.Soc.M.E.; Spencer Miller, Mem.Am.Soc.M.E., and William Le Roy Emmet, Mem.Am.Soc.M.E., both representing the Society; Matthew B. Sellers and Hudson Maxim, representing the American Aeronautical Society; Dr. Peter Cooper Hewitt and Thomas Robins, representing the Inventors' Guild; Howard E. Coffin, Mem.Am.Soc.M.E., and Andrew L. Riker, Mem.Am.Soc.M.E., representing the Society of Automobile Engineers; Elmer A. Sperry, Mem.Am.Soc.M.E., representing the American Society of Aeronautic Engineers; Wm. L. Saunders, Mem.Am.Soc.M.E., representing the American Institute of Metals; and Lawrence Addicks, Mem.Am.Soc.M.E., representing the American Electrochemical Society. Four members of the Board were unable to attend the meeting, namely, B. G. Lamme, of the American Institute of Electrical Engineers; Alfred Craven, of the American Society of Civil Engineers; Benjamin B. Thayer, of the American Institute of Mining Engineers; and Dr. J. W. Richards, of the American Electrochemical Society.

The board elected Mr. Edison as Chairman, Messrs. Saunders and Hewitt as Vice-Chairmen, and Mr. Robins as Secretary. Considerable time was given to the discussion of plans for the establishment of the $1,500,000 naval research laboratory to be built by the Government, and a special committee consisting of Messrs. Edison, Whitney, Baekeland, Sprague, Robins, and Addicks was appointed to report to the board as to the best site for it. It is stated that while most of the members of the board favor the selection of New York City, officials of the Navy Department prefer Washington as a site, in order to have the laboratory close to the Navy Department, the naval gun shops, and the naval proving grounds.

CORRECTION

Prof. E. A. Fessenden calls attention to a typographical error in the authors' closure to the discussion of the paper by Professor Hedrick and himself, entitled On the Transmission of Heat in Boilers, published in the August issue.

On pages 624 and 625, in equations [1a], [1b], [1] and [2], and the unnumbered equation in the middle of the first column on page 625, in every case the division sign (÷) should be a plus sign (+).

BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th Street, New York.

There will be a public hearing on the Code, the first since the adoption of the Code two years ago, on Friday, December 8, at 2 p. m.

NEW YORK SECTION EXCURSION

On Friday, September 15, seventy-one members and guests of the New York Section visited the plants of the Ford Motor Company and the Loose-Wiles Biscuit Company at Long Island City. At the Ford plant the visitors had an opportunity to witness the complete assembling of the various models of cars, including the body, chassis, and motor.

At the Loose-Wiles Company special arrangements were made to give the visitors every opportunity to inspect the mechanical features of the various labor saving machines which have been developed in the baking industry.

This is the fourth technical excursion held by the New York Section during the summer.

It is the endeavor of the New York Committee to develop the interest of the members in each other, and on these excursions the opportunity for increase of acquaintanceship is offered, as well as the visit to places of engineering interest.

RUTGERS COLLEGE ANNIVERSARY

The celebration of the 150th anniversary of the founding of Rutgers College, New Brunswick, N. J., will take place on October 13-15.

The program of the celebration includes commemoration exercises, an historical address by Dr. W. H. S. Demarest, president of the college, an anniversary pageant and an anniversary dinner to delegates and guests.

The President and Secretary of the Society will attend.

APPLICATIONS FOR MEMBERSHIP

MEMBERS are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every Member to promote. Unless objection is made to any of the candidates posted by November 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected to membership will be notified about December 15, 1916.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ADAMS, ROBERT B., Assistant Superintendent, New England Westinghouse Co., Meriden, Conn.

BENNETT, HOWARD D., Consulting, Mechanical and Dredge Engineer, Baltimore, Md.

BUCHANAN, R. H., Mining Engineer, Coal Department, The Delaware & Hudson Co., Scranton, Pa.

BURKE, JAMES, President, Burke Electric Co., Erie, Pa.

BURROUGHS, CHARLES F., President, Charles Burroughs Co., Newark, N. J.

CLARK, EARL A., Consulting Engineer, Clark & Shade, Tulsa, Okla.

CLARK, EZRA E., Inspector and Engineer, Associated Factory Mutual Fire Insurance Cos., Boston, Mass.

CLEMONS, SAMUEL W., in Mechanical Engineering Department, Draper Co., Hopedale, Mass.

COONEY, ROBERT L., Automatic Sprinkler Co. of N. Y., Atlanta, Ga.

COOPER, GEORGE H., Chief Engineer, Manhattan Electrical Supply Co., Jersey City, N. J.

CURRY, FREDERICK H., Plant Superintendent, Hudson Motor Car Co., Detroit, Mich.

DATZ, LOUIS C., Engineer, Southern Properties, United Gas & Elec. Engrg. Corp., Birmingham, Ala.

DOD, FREDERIC H., Locomotive Superintendent, Manila Railroad Co., Rizal, P. I.

DORON, WILLIAM H., Maintenance Engineer, Standard Aniline Products, Inc., Wappingers Falls, N. Y.

DOURSON, LOUIS A., Designer and Checker, The Lunkenheimer Co., Cincinnati, O.

DUGDALE, RICHARD M., Supervisor, Remington Arms & Ammunition Co., Ilion, N. Y.

EVANS, VICTOR W., Sales Engineer, The Jeffrey Mfg. Co., New York, N. Y.

FERRY, OLIVER N., Mechanical Engineer, Ashcroft Mfg. Co., Bridgeport, Conn.

FORSYTHE, CLAYTON E., Consulting Engineer, Morrow Mfg. Co., Elmira, N. Y.

GASSMAN, HOWARD M., Consulting Engineer, Birmingham, Ala.

GOODMAN, WILLIAM, Manager, Laidlaw Plant, Worthington Pump & Mchy. Co., Cincinnati, O.

HAY, PAUL L., Contracting Engineer, Samuel W. Hay's Sons, Pittsburgh, Pa.

HENDERSON, JOHN M., Mechanical Engineer and Master Mechanic, Rome Brass & Copper Co., Rome, N. Y.

HUGHES, HENRY E., Mechanical Engineer, E. I. Du Pont de Nemours & Co., Wilmington, Del.

HULSE, GEORGE E., Chief Engineer, Safety Car Heating & Lighting Co., New York, N. Y.

HUNT, HARRY B., Engineer, Sales Department, American Locomotive Co., New York, N. Y.

ILLGES, GEORGE M., Manager and Engineer, Chicago Office, Harrisburg Fdry. & Mch. Co., Heine Safety Boiler Co., Chicago, Ill.

JOHNSON, J. ADOLPH, Mechanical Superintendent, The M. B. Schenck Co., Meriden, Conn.

JOHNSON, J. EDWARD, Superintendent, Mechanical Department, Connecticut Tel. & Elec. Co., Inc., Meriden, Conn.

KAISER, WILLIAM, Genl. Supt. of Operation and Construction, The Barrett Co., Birmingham, Ala.

KESSLER, CLAUDE H., Senior Mechanical Engineer, Interstate Commerce Commission, San Francisco, Cal.

MERRIAM, I. B., JR., President, Chattanooga Boiler & Tank Co., Chattanooga, Tenn.

MOHLER, VALENTINE J., Woodcliff-on-Hudson, N. Y.

NEILD, ROBERT R., Manager, Victoria Machinery Depot Co., Ltd., Victoria, B. C.

PATTON, THOMAS A., In Charge of Gages and Gage Supervision, Baldwin Locomotive Wks., Eddystone, Pa.

PAULI, CARL F. G., Advisory Engineer, Lincrusta Wks., Pallas, N. Y.

PERSIANI, CHARLES C., Treasurer, Clark Bros. Bolt Co., Milldale, Conn.

POLLAK, JULIAN A., Secretary, The Pollak Steel Co., Cincinnati, O.

POWER, GEORGE S., Dept. Mgr., Supt. and Mech. Engr., Wickes Bros., Saginaw, Mich.

RICE, GEORGE B., Consulting Chief Engineer, Schoelkopf Aniline & Chemical Wks., Inc., Buffalo, N. Y.

SCRIBNER, CHARLES F., Industrial Engineer, New England Westinghouse Co., Springfield, Mass.

STAPLE, SYDNEY J., Draftsman and Designer, Homestake Mining Co., Lead, S. D.

STEWART, ANDREW M., Factory Manager, The National Supply Co., Toledo, O.

SWEENY, ROBERT O., Chief Draftsman, Car Department, Chicago, St. Paul, Minneapolis & Omaha Ry., Hudson, Wis.

TITUS, FORREST M., Foreign Representative, American Locomotive Co., New York, N. Y.

WOOD, CLARK O., Special Agent in Ohio, The Home Ins. Co. of New York, Columbus, O.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BAUGHMAN, ISAAC N., Agri. Engr. and Mgr., Marseilles, Ill.

BONNET, FRANK H., Assistant Mechanical Engineer, The Buckeye Steel Castings Co., Columbus, O.

CAMP, EUGENE V., Vice-President and Chief Engineer, H. S. Jaudon Engrg. Co., Savannah, Ga.

CHASE, HENRY A., Superintendent, Cummings Mch. Works, Boston, Mass.

DENSE, JOHN C., Chief Draftsman, Morrow Mfg. Co., Elmira, N. Y.

GILL, MURRAY F., Electrical Engineer, Texas Power & Light Co., Dallas, Tex.

HARKNESS, V. F., Engineering Assistant, Public Service Elec. Co., Newark, N. J.

HELLYAR, CHARLES H., Mechanical Engineer, Remington Arms Co., Bridgeport, Conn.

HILMER, OTTO E., Consulting Engineer, With Walter G. Franz, Cincinnati, O.

JAGER, GEORGE W., Mechanical Draftsman, National Lock Washer Co., Newark, N. J.

KELLER, KAUFMAN T., Master Mechanic, Cole Motor Car Co., Indianapolis, Ind.

KOTZ, EMIL F., Designer in Engineering Department, Semet-Solvay Co., Syracuse, N. Y.

McGRATH, F. P., Engineer of Tests, Carnegie Steel Co., Duquesne, Pa.

McLEAN, JOHN, Efficiency Engineer, H. E. Harris Engrg. Co., Bridgeport, Conn.

McMILLAN, WILLIAM L., Chief Insp. and Cons., Ordnance Engr., American Can Co., New York, N. Y.

MAAK, CHARLES, Assistant Chief Engineer, Metals Production Equipment Co., Springfield, Mass.

MACY, R. G., Superintendent, East Norwalk Municipal Elec. Wks., East Norwalk, Conn.

PADRON, AGUSTIN, Engineer, M. Galdo & Co., Cardenas, Cuba

PEASLEE, WILLETTS, Production Engineer, The Cincinnati Milling Mch. Co., Cincinnati, O.

RANTZ, CHARLES F., Consulting and Contracting Refrigerating Engineer, New Orleans, La.

ROONEY, H. LLOYD, Cons. Power Plant Engineer, Newport, R. I.

ROYAL, JAMES M., Designer, Diesel Engine Department, Seattle Astoria Iron Works, Seattle, Wash.

SAGENDORPH, GEORGE A., Treasurer, Penn Metal Co., Boston, Mass.

SALMON, Daniel E., Superintendent, H. E. Harris Engrg. Co., Bridgeport, Conn.

SLOCUM, Myles S., Associate Engineer, Slocum, Avram & Slocum, Inc., New York, N. Y.

SMITH, Jule C., Field Engineer, Seattle, Wash.

SNODGRASS, Larned I., President, Snodgrass, Hewetson Co., Cincinnati, O.

VOCKELL, William H., In charge of Tool Designing Dept., Cincinnati Milling Mch. Co., Cincinnati, O.

WESTON, Samuel C., Safety Engineer, The Remington Arms-U. M. C. Co., Inc., Bridgeport, Conn.

WOODS, George R., Assistant to President, Allied Machinery Co. of America, New York, N. Y.

FOR CONSIDERATION AS JUNIOR

BENSON, Robert F. A., Graduate Student Course, Westinghouse Elec. Mfg. Co., Pittsburgh, Pa.

BUELL, Maurice L., Robert W. Hunt & Co., New York, N. Y.

FREDERICK, Alvah B., In Service Office, Burroughs Adding Mch. Co., Detroit, Mich.

GIFFELS, John E. W., With John A. Stevens, Lowell, Mass.

KAEMMERLING, Gustav H., Designer, Lehigh Car, Wheel & Axle Works, Catasauqua, Pa.

KREISER, Walter W., Mechanical Engineer, Western Union Telegraph Co., New York, N. Y.

LEWIS, George C., Sales Engineer, Hersh & Brother, Allentown, Pa.

LEWIS, Harry I., Mechanical Engineer, Dolphin Jute Mills, Paterson, N. J.

LOGAN, Lloyd, Mechanical Draftsman, Semet-Solvay Co., Syracuse, N. Y.

McKISSICK, Ellison S., Engineer, Grendel Mills, Greenwood, S. C.

MANN, Carl P., Engineer, With MacMullen, Riley & Durley, Toronto, Ont., Can.

NENNINGER, Lester F., Chief Draftsman, Cincinnati Milling Mch. Co., Cincinnati, O.

NUTTER, Asa P., Draftsman, S. M. Green Co., Springfield, Mass.

REID, Geoffrey L., Cost Clerk, General Elec. Co., Lynn, Mass.

SCHWANHAUSSER, Edwin J., Engineer, Condenser Department, Worthington Pump & Mchy. Corp., Harrison, N. J.

SHAFFER, Layton S., Assistant Chief Engineer, Ohio Locomotive Crane Co., Bucyrus, O.

TAUGEMAN, Walter W., Sales Engineer, Cincinnati Milling Mch. Co., Cincinnati, O.

VALDES, Jesus M., Engineer, With John A. Stevens, Lowell, Mass.

VARIAN, Howard M., Chief Draftsman, Great Lakes Engrg. Wks., Detroit, Mich.

WILLETT, Francis M., Mechanical Engineer, H. & B. American Machine Co., Pawtucket, R. I.

PROMOTION FROM ASSOCIATE

VIETS, Harry A., Chief Draftsman, Shell Department, E. W. Bliss Co., Brooklyn, N. Y.

PROMOTION FROM JUNIOR

BAILEY, Alex D., Asst. Ch. Engr., Stas. 1 and 2, Commonwealth Edison Co., Chicago, Ill.

FABER, John P., Chief Engineer, Ransome Concrete Machinery Co., Dunellen, N. J.

NORTHRUP, Francis B., In charge of Drawing Room, The Charles Burroughs Co., Newark, N. J.

RIGDON, Carl, Superintendent, Light and Power Department, Chattanooga Railway & Light Co., Chattanooga, Tenn.

RIPSCH, Charles W., Secretary, The Sheffield Machine & Tool Co., Dayton, O.

ROBINSON, Parker M., Industrial Engineer, representative for H. L. Gantt, The Celluloid Co., Newark, N. J.

ROWLEY, Ridgway L., Assistant Engineer, Board of Fire Underwriters, San Francisco, Cal.

STAPLES, Horace A., Superintendent, Raw Materials Dept., Bridgeport Brass Co., Bridgeport, Conn.

STUNTZ, John E., Superintendent and Chief Engineer, The Cape Cruz Co., Ensenada de Mora, Cuba

VAUGHAN, Aubrey W., Industrial Engineer, Saco-Lowell Shops, Lowell, Mass.

WILCOX, Joseph, Jr., Machine Designer, Norton Grinding Co., Worcester, Mass.

SUMMARY

New Applications	106
Applications for change of grading:	
Promotion from Associate	1
Promotion from Junior	11
Total	118

GEOGRAPHICAL LIST

(Applications for promotion from any grade will be indicated by the initials of that grade)

Alabama
Birmingham—Datz, L. C.
Gassman, H. M.
Kaiser, W.

California
San Francisco—Kessler, C. H.
Rowley, R. L. (J)

Canada
Toronto—Mann, C. P.
Victoria, B. C.—Neild, R. R.

Connecticut
Bridgeport—Ferry, O. H.
Hellyar, C. H.
McLean, J.
Salmon, D. E.
Staples, H. A. (J)
Weston, S. C.
East Norwalk—Macy, R. G.
Meriden—Adams, R. B.
Johnson, J. A.
Johnson, J. E.
Milldale—Persiani, C. C.

Delaware
Wilmington—Hughes, H. E.

Georgia
Atlanta—Cooney, R. L.
Savannah—Camp, E. V.

Illinois
Chicago—Bailey, A. D. (J)
Illges, G. M.
Marseilles—Baughman, I. N.

Indiana
Indianapolis—Keller, K. T.

Louisiana
New Orleans—Rantz, C. F.

Maryland
Baltimore—Bennett, H. D.

Massachusetts
Boston—Chase, H. A.
Clark, E. E.
Sagendorph, G. A.
Hopedale—Clemons, S. W.
Lowell—Giffels, J. E. W.
Valdes, J. M.
Vaughan, A. W. (J)
Lynn—Reid, G. L.
Springfield—Maak, C.
Nutter, A. P.
Scribner, C. F.
Worcester—Wilcox, J. Jr. (J)

Michigan
Detroit—Curry, F. H.
Frederick, A. B.
Varian, H. M.
Saginaw—Power, G. S.

New Jersey
Dunellen—Faber, J. P. (J)
Harrison—Schwanhausser, E. J.
Jersey City—Cooper, G. H.
Newark—Burroughs, C. F.
Harkness, V. F.
Jager, G. W.
Northrup, F. B. (J)
Robinson, P. M. (J)
Paterson—Lewis, H. I.

New York
Brooklyn—Viets, H. A. (A)
Buffalo—Rice, G. B.
Elmira—Dense, J. C.
Forsythe, C. E.
Ilion—Dugdale, R. M.
New York—Buell, M. L.
Evans, V. W.
Hulse, G. E.
Hunt, H. B.
Kreiser, W. W.
McMillan, W. L.
Slocum, M. S.
Titus, F. M.
Woods, G. R.
Pallas—Pauli, C. F. G.
Rome—Henderson, J. M.
Syracuse—Kotz, E. F.
Logan, L.
Wappingers Falls—Doron, W. H.
Woodcliff-on-Hudson—Mohler, V. J.

Ohio
Bucyrus—Shaffer, L. S.
Cincinnati—Dourson, L. A.
Goodman, W.
Hilmer, O. E.
Nenninger, L. F.
Peaslee, W.
Pollak, J. A.
Snodgrass, L. I.
Taugeman, W. W.
Vockell, W. H.
Columbus—Bonnet, F. H.
Wood, C. O.
Dayton—Ripsch, C. W. (J)
Toledo—Stewart, A. M.

Oklahoma
Tulsa—Clark, E. A.

Pennsylvania
Allentown—Lewis, G. C.
Catasauqua—Kaemmerling, G. H.
Duquesne—McGrath, F. P.
Eddystone—Patton, T. A.
Erie—Burke, J.
Philadelphia—Akimoff, N. W.
Pittsburgh—Benson, R. F. A.
Hay, P. L.
Scranton—Buchanan, R. H.

Rhode Island
Newport—Rooney, H. L.
Pawtucket—Willett, F. M.

South Carolina
Greenwood—McKissick, E. S.

South Dakota
Lead—Staple, S. J.

Tennessee
Chattanooga—Merriam, I. B., Jr.
Rigdon, C. (J)

Texas
Dallas—Gill, M. F.

Washington
Seattle—Royal, J. M.
Smith, J. C.

Wisconsin
Hudson—Sweeny, R. O.

Cuba
Cardenas—Padron, A.
Ensenada de Mora—Stuntz, J. E. (J)

Philippine Islands
Rizal—Dod, F. H.

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

CHANGES OF POSITION

Walter C. Beckjord, formerly with the Madison Gas and Electric Company, has accepted a position with the American Light and Traction Company, New York.

John A. Malone, recently connected with the E. W. Bliss Company of Brooklyn, N. Y., has accepted a position with the Allied Machinery Company of America, New York, N. Y.

John B. Price, formerly identified with the Price Electric and Machinery Company, Richmond, Va., has become associated with the Peerless Electric Company of Warren, O.

John R. Gray has severed his connection with the Louisiana State Rice Mill Company at New Orleans, and has taken charge of the Iota, La., plant of the Iota Rice Milling Company, Inc.

Henry R. Cobleigh, formerly mechanical editor of The Iron Age and more recently managing editor of Power, has become a partner in the Power Plant Management Company, New York.

Howard S. Riddle, consulting engineer of the Ohio Board of Administration, Columbus, O., resigned October 1 to accept a position with the Jeffrey Manufacturing Company, also of Columbus.

Oscar H. Wiese, formerly employed by the Mackintosh and Seymour Company, Auburn, N. Y., has been engaged by the Baltimore Oil Engine Company, Baltimore, Md., as designer.

Perry S. Toney has entered the employ of Neiler Rich and Company, Chicago, Ill., as mechanical engineer. He was until recently clerk with the Automatic Electric Company of the same city.

Cyrus W. Bassett, until recently engineer with the Elevator Supply and Repair Company, Chicago, Ill., has become affiliated with the Budd Manufacturing Company of Philadelphia, Pa.

Frank L. Eidmann, formerly efficiency engineer with the American La France Fire Engine Company, Elmira, N. Y., has resigned to accept a position with the Heald Machine Company, Worcester, Mass.

W. Howard Zabriskie, until recently foreman of the Standard Oil Company of New York, Long Island City, N. Y., has become affiliated with the Standard Oil Company of California, Richmond, Cal.

David R. Swinton has accepted a position in the engineering department of The Perfection Spring Company, Cleveland, O. He was formerly in the employ of the Tuthill Spring Company, Chicago, Ill.

Carroll D. Billmyer, formerly draftsman of the Norfolk and Western Railway, Roanoke, Va., has accepted the position of instructor of mechanical engineering at Throop College of Technology, Pasadena, Cal.

Harry Kaplan, formerly efficiency engineer with the Lewiston Bleachery and Dye Works, Lewiston, Me., has accepted a similar position with the Winchester Repeating Arms Company, New Haven, Conn.

Barton Cruikshank has assumed the position of New York manager of The C. G. Garrigus Machine Company. He was until recently associated with the Ashcroft Manufacturing Company of Bridgeport, Conn.

David A. Chapman, formerly mechanical engineer with Wm. Filene's Sons Company, Boston, Mass., has become associated with The Touraine Company of Boston, Mass., and the Dangel Company, Everett, Mass.

Alfred L. Kenyon, formerly manager of the Anniston and Attala operations of the Alabama Power Company, Anniston, Ala., is now connected with the Columbia Railway, Gas and Electric Company, Columbia, S. C.

Wilbur C. Prior has assumed the duties of chief draftsman of The Merrow Machine Company, Hartford, Conn. He was formerly identified with the Aetna Life Insurance Company of the same city as inspector.

E. R. Kenner, formerly sales engineer for the Allis-Chalmers Manufacturing Company in their Cleveland district, has resigned and entered the engineering department of the Firestone Tire and Rubber Company, Akron, O.

Albert C. Thomas, formerly resident chief engineer of the Alpha Portland Cement Company, Cementon, N. Y., has assumed the duties of mechanical superintendent of the Canadian Salt Company, Windsor, Ont., Canada.

Frank E. Watkins has resigned his position as works manager of the East Jersey Pipe Corporation at Paterson, N. J., to accept a similar position with the Canadian Fairbanks-Morse Company, Ltd., Toronto, Ont., Canada.

Horace R. Wentzell, until recently production engineer with the Curtiss Motor Company of Buffalo, N. Y., has become connected with the Buick Motor Car Company, Flint, Mich., in the capacity of assistant master mechanic.

Elmer E. Gibson has assumed the duties of superintendent of The Ashcroft Manufacturing Company, Bridgeport, Conn. He was formerly associated with The Jones Speedometer Company of New Rochelle, N. Y., in a similar capacity.

T. E. Buck has accepted a position with the Donora Steel Company, Donora, Pa., as draftsman. He was formerly connected in a similar capacity with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

Frank E. Bardrof has severed his connection with the Rensselaer Polytechnic Institute, Troy, N. Y., and has assumed the duties of draftsman in the mechanical engineers' office of the Pennsylvania Railroad, Altoona, Pa.

Thomas M. Lynch has accepted a position with the Babcock and Wilcox Company, Bayonne, N. J. He was until recently connected with the Buena Vista Extract Company, Buena Vista, Va., in the capacity of assistant manager.

Merritt Van Valkenburgh, formerly in the employ of the De La Vergne Machine Company, New York, as draftsman in the power installation department, is now associated with Westinghouse, Church, Kerr and Company of New York.

Samuel P. Blakeman, until recently associated with The Terry Steam Turbine Company, Hartford, Conn., in the capacity of draftsman and designer, has joined the staff of the S. K. F. Ball Bearing Company, Hartford, Conn., as mechanical engineer.

Hugh H. Hargrave has become affiliated with the piping department of the Newport News Shipbuilding and Dry Dock Company, Newport News, Va. He was formerly connected with W. J. Rainey of Uniontown, Pa., in the capacity of designer.

James H. Marks, formerly superintendent of the buildings and grounds department of the University of Michigan, Ann Arbor, Mich., is now superintendent of maintenance and construction of the Packard Motor Car Company, Detroit, Mich.

William E. Moshea has entered the employ of the Fruit Dispatch Company, New York. He was until recently associated with the horticultural and pomological investigations of the U. S. Department of Agriculture, Washington, D. C.

Edwin A. Fessenden has severed his connection with the University of Missouri, Columbia, Mo., as associate professor of mechanical engineering to become professor of mechanical engineering at Pennsylvania State College, State College, Pa.

Lee E. Walker has accepted the position of foreman with the Baldwin Munition Company at Eddystone, Pa. He was until recently in the employ of The Good Roads Machinery Company, Inc., Philadelphia, Pa., in the capacity of district manager.

Charles H. Phillips has severed his connections as tool designer with the Pierce-Arrow Motor Car Company, Buffalo, N. Y., and is now associated with the Curtiss Aeroplane and Motor Corporation, Buffalo, N. Y., in the capacity of superintendent of tools.

Jiles W. Haney has accepted a position in the mechanical engineering department of Pennsylvania State College, State College, Pa. He was until recently connected with the Commerce Power Company, Kansas City, Mo. in the capacity of chief engineer.

Geo. H. Cunningham has resigned his position as superintendent of construction with the Anaconda Copper Mining Company and accepted the position of chief engineer for the Electrolytic Zinc Company of Australia, with headquarters at Hobart, Tasmania.

Howard M. Chandler, formerly superintendent of construction of the Board of Home Missions of Presbyterian Church of New York at San Germán, P. R., has become affiliated with the Honolulu Iron Works Company, New York, in the capacity of mechanical engineer.

William H. Tabor has entered the employ of the Winchester Repeating Arms Company, New Haven, Conn., in the capacity of assistant industrial engineer of the tool department. He was until recently instructor of industrial engineering at Pennsylvania State College, State College, Pa.

M. William Ehalich, formerly editor of Electrical Age, associate editor of Metal Worker and who has had seven years practice with consulting engineers, has joined the Lefax editorial staff, Philadelphia, Pa. He will assist in standardizing the magazine and will carry out the plan for issuing a new Lefax cost data class which will consist of four additional sheets a month.

Walter G. Holmes, formerly associated with the Wilmot Castle Company, Rochester, N. Y., as mechanical engineer, has become identified with the Standard Medical Supply Company of Minneapolis, Minn., manufacturers and jobbers of physicians', dentists', hospital and veterinaries' supplies and manufacturers of X-ray apparatus and pharmaceutical preparations. Mr. Holmes, patentee of the Holmes sterilizer, has spent many years in the manufacture of medical appliances and is now superintending the manufacture of the sterilizer, the Campbell electric cabinet and white enamel furniture and also the X-ray machines.

APPOINTMENTS

Thomas E. Keefe has been appointed New York representative of the Franklin Oil and Gas Company of Bedford, O.

Emile J. Bayle has been appointed assistant to the president, and production engineer with the Pfaudler Company, Rochester, N. Y.

G. L. Knight has recently been appointed chairman of the Electrical Apparatus Committee of the National Electric Light Association.

O. W. Cook, manager of works with the Canadian Cartridge Company, Limited, Hamilton, Ont., Canada, has recently been appointed manager of that company.

S. M. Maashall, manager of the turbine department of the Southwark Foundry and Machine Company, Philadelphia, Pa., has been appointed chief engineer of the company.

Carl Stenbol, mechanical engineer of the steel department of the Canada Cement Company, Limited, Montreal, Canada, has been appointed superintendent of the steel and forge departments of the company.

James Macfarlane, for many years superintendent of the dredging division of the Panama Canal, Paraiso, has been appointed to succeed J. J. Eason as assistant superintendent of the mechanical division at Balboa.

William McClellan, consulting engineer of New York City and former chief engineer for the New York Public Service Commission for the Second District, has been appointed dean of the Wharton School of Finance and Commerce of the University of Pennsylvania, Philadelphia, Pa.

H. Schreck has been appointed chief engineer of the Diesel engine department of the Fulton Iron Works of St. Louis. His former position with this company has been assistant chief engineer. Mr. Schreck has had a wide experience with one of the most prominent concerns in Europe in whose shops he superintended for years the manufacture of the Diesel engine, participating as a co-worker in their development, both of the marine and the stationary type.

ANNOUNCEMENTS

Laurel E. France has become associated with the Braden Copper Company, Rancagua, Chile.

Samuel S. Wyer is in the Petrolia, Texas, natural gas fields investigating natural gas conditions there.

William I. Ballentine has become identified with The Chain Belt Company of Milwaukee, Wis.

John J. Matson has become associated with the General Electric Company of Schenectady, N. Y.

Charles W. Lummis of Worcester, Mass., has recently been granted a patent for an ingot mold.

W. J. Stoop has assumed the duties of superintendent of the Wilmington Steel Company, Wilmington, Del.

A. A. Potter has been elected a member of the Council of the Society for the Promotion of Engineering Education.

Stephen Thomas has accepted a position in the efficiency department of the Barney and Smith Car Company, Dayton, O.

Hollis Godfrey has been elected First Vice-President of the Society for the Promotion of Engineering Education.

Peter Junkersfeld of Chicago has been elected president of the Association of Edison Illuminating Companies.

W. M. Thornton has been elected Second Vice-President of the Society for the Promotion of Engineering Education.

H. M. Byllesby, president of H. M. Byllesby and Company, is making a tour of inspection of the company's properties in Colorado.

A shaft coupling has been patented by Julian Kennedy, Vice-President, Am.Soc.M.E. The patent number is 1,194,028.

Alfred R. Bench has become identified with the sales department of the Taylor-Wharton Iron and Steel Company, High Bridge, N. J.

Robert E. Caanston, mining engineer of San Francisco, Cal., is on an extended professional trip through Colorado, Montana and Nevada.

Samuel E. Flexer has been promoted to the position of general superintendent of the Kingsport, Tenn., plant of the Clinchfield Portland Cement Corporation.

James L. Myers, formerly with the Philadelphia, Pa., office of The Barrett Company, has been transferred to the Gray's Ferry Plant in the capacity of fuel and power engineer.

Robert E. Hall, formerly vice-president and sales manager of The Goulds Manufacturing Company, Seneca Falls, N. Y., has been transferred to the Chicago, Ill., office of the company.

Charles C. Jamieson and George H. Houston have formed a partnership under the name of Jamieson and Houston, for investigating, consulting and management work, with offices in New York.

William McClellan, F. B. H. Paine and Horace T. Campion announce that they have formed the partnership of Paine, McClellan and Campion, engineers, with offices in New York City and Philadelphia.

John F. Magee, formerly connected with the engineering department of the Alpha Portland Cement Company, Easton, Pa., has been transferred to the Martins Creek, Pa., plant in the capacity of superintendent of Mill No. 4.

John L. Thompson, supervising engineer of The Travelers Insurance Company and the Travelers Indemnity Company, Hartford, Conn., is now in general charge of the engineering and inspection division with the title of superintendent.

Charles E. Beck has opened an office in the Victor Building, Kansas City, Mo., as district manager for the De La Vergne Machine Company of New York. The company's Chicago office, formerly in charge of Mr. Beck, will be discontinued.

Allan D. Risteen, affiliated with the engineering and inspection division of the Travelers Insurance Company and the Travelers Indemnity Company, Hartford, Conn., has assumed the duties of director of technical research and safety publication work.

Harry C. Lane, formerly chief draftsman and superintendent of construction of the Maryland Steel Company, has been made assistant chief engineer and superintendent of construction, since the purchase of the plant by the Bethlehem Steel Company.

H. R. Setz, for the past four years in charge of the oil engine department of the Fulton Iron Works, has resigned this position. He will devote the next few months to research and development work preparatory to bringing out a new type of engine.

Geo. G. Schmidt, secretary of The New York School of Heating and Ventilating, announces the opening of the fourth annual season of the school, and the inauguration of a second year course comprised of twelve lectures.

Burt H. Weston, formerly instructor in mechanical and engineering drawing and machine design, David Ranken Jr. School of Mechanical Trades, St. Louis, Mo., has resigned and opened an office in Dayton, O. Mr. Weston will enter business as a consulting and equipment engineer.

Erwin W. Thompson, commercial attaché for Germany, the Netherlands and the Scandinavian countries, has returned to this country to spend several months on official duty, and will be prepared to confer with representative bankers, merchants and manufacturers regarding trade conditions in his district, as well as to address commercial gatherings. During his incumbency of the post of commercial attaché, Mr. Thompson was temporarily stationed at The Hague, Netherlands, and a large part of his time was devoted to assisting American merchants and manufacturers in connection with the various prohibitory trade enactments of the warring nations. He has been instrumental in obtaining the lifting of several embargos and in effecting a change in some of the methods adopted by the governments and by the Netherlands Overseas Trust in regard to the operation of the enactments referred to.

AUTHORS OF PAPERS, ETC.

An article on Laying Out Skew Bevel Bears by Reginald Trautschold, appears in the September number of *Machinery*.

H. L. Gantt has contributed an article entitled, What is Preparedness, to the September number of *The Engineering Magazine*.

William A. Knight has contributed an article on Cutting Speeds and Feeds to the September 7 issue of the *American Machinist*.

Roy A. Seaton is the author of a book entitled Concrete Construction for Rural Communities.

Howard E. Coffin is the author of an article entitled The Council of National Defense, published in the September issue of *The Engineering Magazine*.

An article on Power Equipment for the Steam Plant by Robert L. Streeter, is published in the September issue of *The Engineering Magazine*.

H. J. Macintire has contributed an article entitled Factors that Influence the Selection of a Condenser, to the September 5 issue of *Power*.

John H. Bernhard delivered a lantern slide talk on River Craft and River Terminals at the September 13 meeting of The Engineers' Club of St. Louis.

David B. Rushmore delivered a lecture on The Nitrogen Industry as a Power Load, at the 37th annual convention of the Association of Edison Illuminating Companies, held at Hot Springs, Va.

Dabney H. Maury is joint author with R. E. Horton of a brief article entitled Old Brick Intake Tunnel Shows Low Kutter Factor, which appears in the September 7 number of *Engineering News*.

William G. Housekeeper presented a paper on Probability Curves as Applied to Photometric Measurements, at the tenth annual convention of the Illuminating Engineering Society, held in Philadelphia, Pa., September 18 to 20.

Robert Thurston Kent, consulting engineer, is the author of a new book on Power Transmission by Leather Belting. This is one of a new Wiley engineering series in which each book will be devoted to a single subject of engineering practice.

Oberlin Smith is the author of Pressing and Stamping Metals, which appears in the September issue of *The Engineering Magazine*. This is the first of a series of articles reviewing the more recent developments and processes in this field.

Among the papers presented at the September 14 to 16 convention of the National Association of Cotton Manufacturers held at New London, Conn., were: Individual Caution the Most Effective Accident Preventive, M. W. Alexander; Presentation of the Proposed Plan for Enlarging the Scope of the Association, Albert G. Duncan; The Moisture Conditioning of Cotton with Relation to Picker Fires, F. J. Hoxie.

NECROLOGY

FRANK BARTLETT McSOLEY

Frank Bartlett McSoley was born at Providence, R. I., on December 11, 1885. He received his early education in the common schools and was graduated from the Providence Technical High School, where he took a special mechanical, electrical and steam engineering course. He was also graduated from the Rhode Island School of Design, where he specialized in mechanical and steam design.

In 1905 Mr. McSoley entered the service of the Narragansett Electric Lighting Company of Providence, where he had full charge of the service department and of output computation of generating and sub-stations, also the estimating of construction and extension costs. He was, in addition, personal assistant to the General Manager.

He was much interested in wireless telegraphy, and delivered a number of lectures on this subject. He organized the Rhode Island Wireless Telegraphic Association, of which he was first president. He was later made chairman of the advisory board of the association.

Mr. McSoley was a member of the National Electric Light Association, the American Institute of Electrical Engineers, and The Institute of Radio Engineers. He became a member of the Society in 1911. He was also very active in the Boy Scout Movement. He died at his home in Providence on August 15, 1916.

WILLIAM BAYLY UPTON

William Bayly Upton was born in San Francisco, Cal., on October 30, 1856. He received his education in the home schools and served his apprenticeship at the Union Iron Works in San Francisco. Up to 1892, he was associated with cable road construction in San Francisco and Kansas City, when he was called to Washington, D. C., for similar work with the Capital Traction Company. He served later as engineer in charge of the construction of several of the important underground and overhead electric lines now under the control of the Washington Railway & Electric Company, and was engineer in charge of the joint construction by the two traction companies of the lines approaching the Union Station. Among other of his achievements in Washington was the planning and installation of the lighting and wiring system in the Municipal Filtration Plant. He recently returned to San Francisco to take charge of the construction of the Argentine Pavilion at the Panama-Pacific International Exposition, 1915.

Mr. Upton became a member of the Society in 1894. He died in Alameda, Cal., on July 30, 1916.

EMPLOYMENT BULLETIN

THE Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed by the Society. Copy for notices should be in hand by the 18th of the month.

DESIGNER, on heavy machine tools and similar machinery; good opportunity for high-grade man with chiefly drawing-office experience. Location Pennsylvania. 40

SALESMAN with technical education as mechanical engineer to become head salesman of company manufacturing heavy-capacity automatic scales for factory and warehouse uses. Man between 30 and 40; must be master salesman. Broad selling experience absolutely essential; educational requirement secondary. 42

DRAFTSMAN experienced in heavy machinery, and, if possible, on chemical apparatus. Salary $25-$30. Location New Jersey. 50

ASSISTANT CHIEF ENGINEER. Young man who has had experience in or made special study of power plant operation, to assist in running woodworking factory of 1000 h.p. Knowledge of design of exhaust steam heating on large scale desirable. Answer, stating age, past positions and salary expected. 83

DRAFTSMAN, experienced in design of heavy machinery, rolling mills, etc. Location Connecticut. 98

RECENT GRADUATES in mechanical engineering from schools of recognized standing, desired for testing work in large steam-operated electric power plants. Applicants with experience in testing work will be given preference. State particulars of education, experience and salary desired. 167

TOOL DESIGNER who is resourceful and can follow work through to completion. Technical man with practical shop experience. Salary $25 to $35 per week according to ability. Location Connecticut. 185

MECHANICAL ENGINEER to take charge of research department in development and manufacture of underfeed mechanical stokers. Experienced in designing, construction and operation. Good opportunity for right man. Old established corporation. State age, experience, when at liberty, salary expected, etc. Location Middle West. Apply by letter. 238

ASSISTANT in mechanical laboratories in eastern technical school at least a year out of college, with some practical experience in the care and handling of mechanical equipment. Give full details of education, practical experience and references. Wanted for present college year. Location near New York. 366

DRAFTSMEN familiar with design of piping and layout and equipment for power plants. State training, experience and salary expected. Location New England. 379

INDUSTRIAL ENGINEER, 22 to 25 years of age, with knowledge of cane sugar house work and experience in drafting department, for concern of consulting and contracting engineers, sugar factories and equipment, marine work, etc. Location New York. 387

EXPERIENCED MAN on twist drills, one thoroughly familiar with twist-drill-making machines and able to help on the design for new factory, to have charge of this department as soon as started. 413

YOUNG ENGINEER who has had some shop experience and has the ability to develop into an executive. Location New York. 495

SUPERINTENDENT for small plant to take general charge of operations of textile-treating industry in fire- and water-proofing as well as dyeing piece goods. Some one preferred with knowledge of dyeing, especially with logwood. Location New York State. 505

DRAFTSMAN. Opening for capable draftsman, experienced in conveying machinery. Good opportunity with splendid chance of advancement to proper party. In reply, state experience, references, age and salary expected. Location Middle West. Communications treated confidentially. 507

YOUNG ENGINEER for tractor factory. Position offers exceptional opportunity to energetic man. 510

FOUNDRY FOREMAN. Would have charge of about 60 molders, making gray iron and semi-steel castings for gas engines, steam engines and separators. Total number of men employed will run as high as 120 during some seasons; this includes men in core room, cleaning room, etc. Prefer a man with experience in agricultural machinery. Must have ability to handle men, and a record showing thorough experience in foundry lines. Salary determined by previous experience and qualifications. Location Ohio. 511

ASSISTANT WORKS MANAGER and FOUNDRY SUPERINTENDENT, to be combined in one position provided man can be found with ability and experience, well acquainted with machine shop practice and up-to-date in foundry management; or two positions will be created, one of Assistant Works Manager, the other Foundry Superintendent. Company manufactures power specialties. Location Pittsburgh. 512-513

ENGINEER with experience to become member of staff being organized for design and construction of new metallurgical plant. Location New Jersey. 521

INVESTMENT of $20,000 to $25,000 and practical working interest in business near Philadelphia, engaged in operation on a limited scale for making silica brick. Present owner desires capable assistant in running well-established business. 522

SHOP INSTRUCTOR for foundry work and forging. Would like man who is industrious and thoroughgoing, would get along well with students and be anxious to improve his department. Good equipment in each line of work, and ample opportunity for man to conduct special investigations. Salary $1200. Location Nebraska. 523

CHECKER, SQUAD-BOSS AND DRAFTSMAN, experienced in industrial engineering, wanted by large Eastern smelting company. State age, education, experience and salary desired in first letter. Permanent positions to capable men. 524

DRAFTSMAN, capable of designing large machines for boring and milling; also to design fixtures and tools for use on such machines, to hold and perform work shown by drawings. Location Providence. 525

YOUNG MECHANICAL ENGINEER for concern on Long Island building automobiles; man of unusual ability and broad calibre desired, who will develop in this work. Past experience in automobiles not necessarily essential. 528

ENGINEER, experienced in machine design, for executive position in experimental department of large industrial concern. Chemical knowledge helpful. Permanent position with attractive future. Advise experience and salary expected. 529

CHEMICAL ENGINEER, experienced in aniline dye manufacturing, to become department engineer; $40 to $60 per week, depending upon ability. Name confidential. Location New York State. 530

YOUNG MECHANICAL ENGINEER on design and building of pumping stations. Technical graduate preferred. Salary $1800 to $2100. Location Brooklyn, N. Y. 531

YOUNG COLLEGE GRADUATE in electrical or mechanical engineering (preferably electrical) with some experience in purchasing, estimating or contracting, and some practical business experience in connection with steam-engine and hydraulic work or gas business would be most serviceable. Location Boston. 534

GENERAL SUPERINTENDENT for modern manufacturing plant in Middle West. Large gas engines, steam engines and heavy special machinery principal products. Successful experience in shop management and practical knowledge of modern foundry and machine shop methods required. Town of 12,000. Desirable living conditions. Apply first by letter. 535

MECHANICAL DRAFTSMAN for general power plant work. Salary $125. 538

PLANT ENGINEER for up-to-date electrical plant of 5,000 employees. Address, giving age, weight, height, experience, salary expected and references in first letter. Location Middle West. 541

YOUNG ENGINEER, preferably class of '16, to start in testing department of machinery concern building pumps, turbines and condensers. Location fifty miles from New York City. 542

MECHANICAL ENGINEER, with experience in petroleum refining. Position calls for work in Mexico. Preference to applicants who are

single and have had training in European country. State experience and education. 543

FOREMAN, competent to run shop making castings and forgings. Employ upwards of 200 men. Man of some education and who knows how to handle men and get work done. Hours from 7 to 5.30. Location Middle West. 545

DESIGNING DRAFTSMAN, familiar with cam motions and gears. Location New York State. 546

HIGH-GRADE EXPERIENCED MAN to do rate-setting and time-study work and take general charge of efficiency work of machine shop. Require man who has had actual experience along these lines and who has made good. Technical graduate desirable, but not essential. Prefer man over 30 years of age. Location Massachusetts. 547

DESIGNERS and DRAFTSMEN with experience in design and construction of crude oil engines, two- and four-cycle, stationary and marine type. Give particulars of salary expected, previous experience, etc. Location Maryland. Apply by letter. 548

GENERAL SUPERINTENDENT in munitions and later in electrical factory. Salary $3600. Location New Jersey. 552

MACHINERY SALESMAN experienced in obtaining work for a contract shop. Location Boston. 556

YOUNG ENGINEER, with technical education and special training in design of automatic machinery for manufacture of small interchangeable parts. Excellent chance for advancement to one who displays ability and application. Location Chicago. 139

DESIGNER for special machinery and labor-saving devices, capable of following work through shop to completion. Location New York State. 248

SALESMAN. Man having experience in tool steel and alloy steels preferred. Opportunity for advancement. State age, experience and salary expected. Location New York. 360

ENGINEER AND DESIGNER, with experience either in forging and die pressing of brass or die casting machines. Must be capable of making investigations of materials, methods of manufacture, etc., and work out principles of design of necessary equipment. New lines of work in large manufacturing concern in middle west and excellent opportunity for men who have originality and initiative. 554

ASSISTANT in mechanical engineering, University of Idaho; mechanical engineering graduate; send photograph, full record of experience and credentials in first letter. Compensation $800 for nine months, from September 15 to June 15, 1917. 555

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 18th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

SALESMAN, SALES ENGINEER. Associate-Member, age 35. American born, single, technically educated. Fifteen years' wide experience as designing and structural engineer in 10 cities of U. S. and 3 foreign countries. Now in Canada. Pleasing personality, especially adapted for dealings with foreigners. Must leave responsible work at $200 a month on account of eye strain. Will start for $100 a month with large firm as traveling salesman. Some selling experience and many references. J-327

EXECUTIVE ENGINEERING or SALES. Technical graduate. Familiar with sale of oils and handling by pipe lines, motor trucks and ships. Able to design and install pipe lines, power-plant equipment, tanks, etc. Capable of handling accounts and cutting costs. Several years experience in conducting efficiency tests of power-plant equipment, lubricants, air compressors and shop material. Initial salary a secondary consideration. Can handle men without friction and obtain results. J-328

ADMINISTRATIVE or EXECUTIVE position. Member, with electrical, mechanical and commercial training. Experience includes electric-traction projects; design and construction of manufacturing plants; design of factory product, machine-tool operations, cost and general accounting; systematizing of shop, office and drawing room; familiarity with efficient management methods, production control, etc. Has just completed important electrical installation and desires to obtain permanent and responsible position with a manufacturing or industrial plant. Central New York preferred. J-329

ENGINEERING, EXECUTIVE or confidential position by a man just completing a standardization proposition. Experienced theoretically and practically. Would consider connecting with a new enterprise, development or installation of a new project or system, or taking charge of the engineering or confidential interests of an individual or corporation. Best of references as to ability, standing, etc. Willing to go anywhere. J-330

MECHANICAL SUPERINTENDENT or MASTER MECHANIC. Associate-Member, age 32, technical graduate. Eight years experience in construction and repairs. Available at once. J-331

MANAGER, WORKS MANAGER or GENERAL SUPERINTENDENT. Technical education, M. E. Good executive abilities, thorough in modern methods and practices, japanning, wood-working, etc. Over 25 years broad and varied experience in heavy, medium, small and interchangeable work (electrical and metal-working). Practical mechanic. Thoroughly capable in shop organization and supervision of manufacturing, qualified in office, buying, sales, cost, piece, bonus or premium methods. J-332

ENGINEER-SALESMAN, capable of approaching with confidence architects and engineers or owners on larger construction operations in New York or New England and nearby states for concern desiring new business or development of special department. J-333

MECHANICAL ENGINEER of large experience as executive, sales representative and designer would like to communicate with concerns appreciating conscientious work for substantial results. Machine tools or special machinery preferred. J-334

ENGINEER-EXECUTIVE. Member. Fourteen years experience, eight years in charge. Any location in U. S. J-335

SALES MANAGER. Member, age 38. Successful, reliable salesman and practical mechanic with unusual business training. At present connected with sales force of prominent eastern jobbers. Seven years as department sales manager. Qualified to represent manufacturers of steel products, machinery, hardware or kindred lines; would consider group of non-conflicting lines. Fully conversant with Spanish language and the Latin people; diplomatic, forceful and energetic. Wishes to correspond with firms desiring to extend their field in manufacturing lines suited to South American trade. Open for engagement in South America or Spain. Nominal initial salary. J-336

CHECKER. Experienced man, able to take charge of design on any line of steam goods, particularly valves and fittings. J-337

SUPERINTENDENT or CHIEF DRAFTSMAN. Member, age 38. Mechanical engineer, 14 years drawing-room and 6 years shop experience on steam and combustion engines, hydraulic machinery, tools, etc. Expert designer of molds for shellac and pyroxylin compounds and phenol condensation materials. Desires position in vicinity of Newark, N. J. Salary $2000. J-338

GENERAL MANAGER or CHIEF ENGINEER. Age 40, technical training. 15 years experience on hoisting machinery, contractors plant, dredges, locomotive cranes, etc. Has successfully held positions as designer, chief draftsman, chief engineer and general manager. J-339

ASSISTANT MANAGER or SUPERINTENDENT. Associate-Member, age 30. Technical graduate with shop training. Broad experience in design and engineering work; familiar with costs, production and modern business methods. J-340

ASSISTANT CHIEF ENGINEER or ASSISTANT SUPERINTENDENT of manufacturing plant. Columbia M. E., age 32. About ten years experience, embracing design of coal- and ore-handling machinery, railway electrification and acid plants. Practical experience in shops before entering college. Has been assistant chief engineer on acid plants and assistant superintendent in charge of maintenance, repair and construction of industrial plants. J-341

SALES MANAGER. Member, with exceptional experience and record. Familiar with electrical and mechanical power equipment from coal pile to shipping room. Draws the line between system and red tape and gets results. Wants larger field, responsibilities and compensation than possible in present position. J-342

MECHANICAL ENGINEER. Member, age 33. Specialty: design and erection of shops and power plants, including selection and installation of equipment. J-343

MECHANICAL ENGINEER. Twenty years experience in the practical management of power-plant equipments; 15 years as an executive. Has had broad experience with steam, electrical, hydraulic and refrigerating machinery. At present chief engineer and superintendent of maintenance of large industrial plant. Would like to connect with large concern desiring to improve their conditions. No position considered below $2500. J-344

FACTORY MANAGER. Technical graduate, M. E., age 30. Ten years experience in costs, efficiency engineering and factory management. Can refer to several successful concerns as to ability and results secured in increased output and decreased costs. Desires position as manager of plant where compensation will be in proportion to results obtained. J-345

ASSISTANT SUPERINTENDENT. Technical graduate. Four years manufacturing experience. Thoroughly familiar with modern methods of cost accounting, production and management. References furnished. Location, Middle West preferred. Salary $125. J-346

MECHANICAL ENGINEER. Columbia graduate. Eighteen months experience as machinist, draftsman, inspector, also head inspector in power-plant-testing work. Desires position in or near New York City with manufacturing or engineering concern. J-347

SALES ENGINEER or ASSISTANT TO EXECUTIVE. Member. Eighteen years engineering experience in design, shop, sales and executive work, railroad equipment, special machinery, structural-steel and power plants. At present employed as sales engineer but desires change to concern offering greater opportunities. Can report anywhere on short notice. Good working knowledge of Spanish. J-348

MECHANICAL ENGINEER, age 42. Twelve years experience in design, testing and operation of boilers and mechanical stokers. Now employed in executive capacity. Desires position with boiler or stoker manufacturer, or with large plant as power efficiency engineer, or as sales engineer with boiler or stoker manufacturer. J-349

DRAFTSMAN. 1914 M. E. graduate from University of Illinois desires position as power-plant draftsman. Location preferably Chicago. J-350

MECHANICAL ENGINEER. Technical graduate. Two years experience in handling labor and in scientific management work. Desires change in location and a permanent position. J-351

MECHANICAL ENGINEER. Cornell graduate. Extended experience in designing, constructing and installing large, small and special machine tools. Has held positions as chief engineer and manager while engaged in the sale, design and manufacture of high-duty pumping engines, condensers, large air and gas compressors and special machine tools. Willing to take stock for part salary if desired. J-352

TECHNICAL GRADUATE. Four years apprenticeship in railroad shops, seven years drafting-room experience, twenty-one months in charge of construction work. Desires position where shop and executive experience will be of value to employer. J-353

CHIEF DRAFTSMAN, CHIEF ENGINEER or MASTER MECHANIC. Fifteen years experience in quantity manufacture, automatic machinery, factory maintenance, experimenting, etc. Available October 1. Salary $2600. J-354

DIRECTOR OR INSTRUCTOR. Member. Technical education and over twenty years practical experience. At present superintendent of industrial school. Desires position in vocational or industrial school, Eastern part of United States preferred. Salary $1800. J-355

SUPERINTENDENT or ASSISTANT MANAGER. Twenty years' experience on large variety of machine work. At present superintendent in a large plant. Desires position with machinery manufacturing concern. New England preferred. J-356

MECHANICAL or CHIEF ENGINEER. Graduate M. E., age 35, experience as superintendent of erection and operating engineer of power plants. Master mechanic of large factory. Last six years chief engineer in charge design, construction and maintenance of engineering work, including city light and water departments. Good executive ability. Capable of assuming responsibility and handling men. J-357.

MEMBER. Graduate of U. S. Naval Academy, age 33, married. Tactful and able organizer and manager of manufacturing propositions. Large experience in executive positions, particularly in public-service corporations and munitions work. J-358

JUNIOR MEMBER. Age 27, experienced in building construction. Has been associated with big New York builder for six years, for whom he is now acting as purchasing agent and in executive capacity. Can design heating and electrical systems, write specifications, award subcontracts and supervise construction. Desires connection with industrial concern doing its own building or with general contractor. J-359

MEMBER of the A.S.M.E. and A.I.E.E. College and technical graduate. 18 years broad experience in design, construction and operation of power plants, substations, motor applications and high-tension transmission. Has proven executive ability, good correspondent, adaptable, systematic and reliable. Desires position, subordinate or otherwise, preferably in or near New York. J-360

MANUFACTURERS' REPRESENTATIVE. Mechanical engineer. Excellent business training and experience particularly in prime movers, boilers and power plant equipment. Desires to represent manufacturers in New York City, preferably on commission basis. English, German and French correspondent. J-361

MECHANICAL ENGINEER in New York City holding very responsible position, desires an additional position on half time in same city or vicinity. M.E. graduate. Five years experience in economic plant engineering. Possesses initiative and thoroughness. J-362

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

ADDITIONS BY THE SOCIETY

American Society of Mechanical Engineers. Power Test Code. Rules for conducting performance tests of power plant apparatus. 1915. Gift of Society.

——— Report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other pressure vessels and for their care in service, known as The Boiler Code Committee. 1914. Gift of Society.

Efficiency and Life. E. E. Purinton, with introduction by Melvil Dewey. *New York, 1916.* Gift of A. S. M. E.

The Flow of Air Thru Nozzles and Orifices. A Thesis presented to the Department of Mechanical Engineering, Leland Stanford Jr. University by J. L. Reynolds and Homer J. Ling. Gift of Homer J. Ling.

Normal Losses Occurring in Every Industry, Frederic Schreibman. Gift of author.

St. Louis Public Library. Annual Report, 1915-16. *St. Louis, 1916.* Gift of Public Library.

Smoke Prevention Association (Chicago). Proceedings, 10th Annual Convention. *Chicago, 1915.* Gift of Smoke Prevention Association.

EXCHANGES

U. S. Patent Office. Annual Report of the Commissioner of Patents, 1915. *Washington, 1916.*

TRADE CATALOGUES

Bridgeport Engineering Co. *Bridgeport, Conn.* Woodworking tools. Descriptive catalogue.

Diamond Power Specialty Co. *Detroit, Mich.* Power Notes. *July, 1916.* Bulletin 118. Insulminum. *July 1, 1916.*

Leschen, A., & Sons, Rope Co. *St. Louis, Mo.* Leschen's Hercules. *Aug. 1916.*

Stephens-Adamson Mfg. Co. *Aurora, Ill.* Labor Saver. *Aug., 1916.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

The Adelong Goldfield. New South Wales. Department of Mines. Mineral Resources, no. 21. *Sydney, 1916.*

American Fertilizer Handbook, 1916. *Philadelphia, Ware Bros. Company, 1916.* Gift of the publishers.

American Society for Testing Materials. Membership List, 1916. *Philadelphia, 1916.*

Coals of Letcher County. Kentucky Geological Survey. Ser. IV, vol. 4, pt. 1. *Frankfort, 1916.*

Construction and Operation of a Single Tube Cracking Furnace for Making Gasoline. U. S. Bureau of Mines Technical Paper 161. *Washington, 1916.*

Emission of Electricity from Hot Bodies, O. W. Richardson. *London, 1916.*

Financing the City of New York. Two lectures by Wm. A. Prendergast, Comptroller, delivered March 14, 28, 1916. Gift of New York City Dept. of Finance.

Geological Society of London. List of Members, July, 1916. *London, 1916.*

Geology of the Shawneetown Quadrangle in Kentucky. Kentucky Geological Survey. *Frankfort, 1916.*

Heat Treatment of Tool Steel, Harry Brearley. ed. 2. *New York, 1916.*

Hebekrane. A. S. Ratnovski. Vol. I, pt. 1-3; vol. II, pt. 1. *Petragrad, 1910, 1912, 1915.*

Institute of Metals. Journal, vol. XV. *London, 1916.*

Institution of Mechanical Engineers. Proceedings. January-May 1916. *London, 1916.*

Introduction to the Theory and Practice of Boot and Shoe Manufacture, Frank Plucknett. *London, 1916.*

Kungl. Tekniska Högskolan I Stockholm. Program 1916-17. *Stockholm, 1916.* Gift of Kungl. Tekniska Högskolan I Stockholm.

Manufacture of Chemical Manures, J. Fritsch, translated from the French by Donald Grant. *London, 1911.*

McGraw Electric Railway List, August, 1916. *New York, 1916.*

Mesozoic and Tertiary Insects of Queensland and South Wales. Queensland. Department of Mines. Publication no. 253. *Brisbane, 1916.*

Methods of Sampling Delivered Coal. U. S. Bureau of Mines. Bulletin 116. *Washington, 1916.*

Motor Cylinder Lubrication, Lieut G. S. Bryan. Reprinted from Jour. Amer. Soc. of Naval Engineers, vol. 27, Feb., 1915. Gift of The Texas Company.

Nebraska State Railway Commission. 8th Annual Report. *Lincoln, 1915.* Gift of Commission.

The New Anaconda. July, 1916. *New York, Eugene Meyer, Jr. & Co., 1916.* Gift of publisher.

New England Water Works Association. Index, Transactions 1883-1885. Journal volumes 1-XXIX. *Boston, 1916.*

New York Times Index. Vol. IV, April-June, 1916. *New York, 1916.*

Notes on Screw Gauges. National Physical Laboratory. Feb., 1916. *London, 1916.*

Pennsylvania. Department of Forestry. Report of the Chief Forest Fire Warden for the year 1915. Bulletin 13. *Harrisburg, 1916.*

Pennsylvania. Department of Internal Affairs. Part IV. Railroad, Canal, Navigation, Telegraph and Telephone Companies, 1915. *Harrisburg, 1916.*

Petroleum Prospects on Bruny Island. *Tasmania, 1916.* Report by Arthur Wade.

Practical Lubrication, Lieut. G. S. Bryan. Reprinted from Jour. Amer. Soc. of Naval Engineers, vol. 27, Nov. 1915. Gift of The Texas Company.

Preparedness for Aerial Defense, Alexander Graham Bell. Address delivered before the National Convention of the Navy League of the United States. April 10-13, 1916. Gift of author.

Production of Explosives in the United States During the Calendar Year 1915. U. S. Bureau of Mines. Technical Paper 159. *Washington, 1916.*

Public Utilities Professional Reference List. First Issue. *Rochester, 1916.* Gift of Lawyers Co-operative Publishing Co.

Public Utilities Reports. 1916-C. *Rochester, 1916.*

The Railway Library and Statistics, 1915. Compiled by Slason Thompson. *Chicago, 1916.* Gift of Slason Thompson.

Rapport sur les Gisements de Cuivre des Cantons de l'Est de la Province de Québec, J. A. Bancroft. *Quebec, 1916.*

Second Good Roads Institute. Proceedings, Held at the University of North Carolina, Feb. 23-27, 1915. Economic Paper 43, North Carolina Geological and Economic Survey. *Raleigh, 1916.*

Sensitiveness to Detonation of Trinitrotoluene and Tetranitromethylanilin. Technical Paper 145, U. S. Bureau of Mines. *Washington, 1915.*

Sessile Barnacles (Cirripedia) Contained in the Collections of the U. S. National Museum, Including a Monograph of the American Species. U. S. National Museum. Bulletin 93. *Washington, 1916.*

Silver City, New Mexico. U. S. Geological Survey, Folio 199. *Washington, 1916.*

Sources of Nitrogen Compounds in the United States. Publication 2421, Smithsonian Institution. *Washington, 1916.*

The South Hemmskirk Tin Field, with Maps. Tasmania. Geological Survey. Bulletin no. 21. *Tasmania, 1916.*

Spirit Leveling in West Virginia. U. S. Geological Survey. Bulletin 632. *Washington, 1916.*

Spur Gearing, Daniel Adamson. Excerpt Minutes of Proceedings of Institution of Mechanical Engineers, May 19 and 23, 1916. *London, 1916.* Gift of author.

Svenska Teknologföreningen. Ledamotsförteckning. July, 1916. *Stockholm, 1916.*

Table of the Eighty-four Research Papers and Scientific Addresses by Sir Robert Hadfield, 1888-1912. Gift of Sir Robert Hadfield.

Tariff Systems of South American Countries, F. R. Rutter. U. S. Dept of Commerce, tariff series, no. 34. *Washington, 1916.*

Technology of Marble Quarrying. U. S. Bureau of Mines. Bulletin 106. *Washington, 1916.*

Theory and Calculation of Alternating Current Phenomena, C. P. Steinmetz. ed. 5. *New York, 1916.*

Theory and Experiments in Following Plane Machines, Chas. R. Witteman. Presented at a meeting of Aeronautical Society, June 3, 1915. Gift of Aeronautical Society.

Training of Our Captains of Industry, Sir Robert Hadfield. Reprinted from Iron & Coal Trades Review, June 9, 1916. Gift of Sir Robert Hadfield.

Traité de la Mécanique des corps solides et du calcul de l'effet des machines, G. Coriolis. ed. 2. *Paris, 1844.*

Traité des Machines-outils, Gustave Richard. 2 vols. *Paris, 1895, 1896.*

U. S. Bureau of the Census. Census of manufactures: 1914. Power Laundries. *Washington, 1916.*

Vanadium Steels—Their Relation to Machine Design. Aeronautical Society, Bulletin, July 27, 1911. Gift of Aeronautical Society.

Van Depoele Electric Manufacturing Company, manufacturers of dynamo electric machines, arc and incandescent lamps, electric motors and electro-plating machines. Chicago. Gift of T. C. Martin.

Virginia—Report of the progress of the Geological Survey. 1839. *Richmond, 1840.*

West Virginia Geological Survey. Raleigh County and the Western Portions of Mercer and Summers Counties, with maps. *Wheeling, 1916.*

Who's Who in America. vol. IX, 1916-1917. *Chicago, 1916.*

Die Wirkungsweise der Rektifizer und Destillier Apparate, E. Hausbrand. ed. 3. *Berlin, 1916.*

Wireless Telegraphy, J. Zenneck. *New York, 1915.*

Wirtschaftliche Verwertung der Brennstoffe, G. de Grahl. *Munchen, 1915.*

The Wolfram, Molybdenite and Bismuth Mines of Bamford, North Queensland. Queensland Geological Survey. Publication 248. *Brisbane, 1915.*

Year Book of Photography. 1871, 1891. Gift of Arthur Worischek.

Zircon, Monazite and Other Minerals Used in the Production of Chemical Compounds Employed in the Manufacture of Lighting Apparatus. Bulletin no. 25, North Carolina Geological and Economic Survey. *Raleigh, 1916.*

Zoology of Michigan. Publication 20, biological Ser. 4, Michigan Geological and Biological Survey. *Lansing, 1916.*

GIFT OF BUREAU OF RAILWAY ECONOMICS

Accidents at Grade Crossings and to Trespassers. Address by Alex. Gordon.

Cooperating with Farmers. A paper read by G. E. Cassel, May 14, 1915.

Failure of Government Ownership in Canada, S. O. Dunn. Reprinted from Journal of Political Economy, June, 1916.

Local Freight Agent. An address before the American Association of Freight Agents, by Fairfax Harrison, June 20, 1916.

New London Situation and Labor Problems, H. Elliott. Address to the Chamber of Commerce of New London, Conn., April 12, 1916.

Some Difficulties of the Transportation Business, H. Elliott. Address to the Chamber of Commerce of Ansonia, Conn., April 4, 1916.

South and the Southern Railway. The statement of a record and of an ambition. An address before the Virginia Bankers' Association, by Fairfax Harrison, June 23, 1916.

Value of Co-operation, H. Elliott. Address at the 50th anniversary of the Organization of the Y. M. C. A., New Haven, Conn., April 3, 1916.

Railways as a Part of a System of National Defense. An address by W. L. Park. Read before the International Association of Railway Special Agents and Police, New Orleans, May 25, 1916.

Remarks at Middlebury College on Commencement, Howard Elliott, June 21, 1916.

Under Forty-nine Masters, Francis H. Sisson. Reprinted from Moody's Magazine, June, 1916.

GIFT OF F. H. COLVIN

A collection of various numbers of Journal of The Franklin Institute; American Engineer and Railroad Journal; New York Railroad Club; Locomotive Engineer and Locomotive Engineering.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY.

HIGH-SPEED CENTRIFUGAL BLOWER.
TURBO COMPRESSOR.
INVAR.
NICKEL STEELS.
COPPER-CLAD STEEL WIRE.
RUBBER VULCANIZATION ACCELERATORS.
COPPER, ANNEALING PROPERTIES.
SILVER IN COPPER AS AN IMPURITY.
COLD-ROLLING STRIP STEEL.
CONCRETE, EFFECT OF SUGAR ON.
CHAIN SCREEN DOORS.
OIL-BURNING WITH NATURAL DRAFT.
WASTE MOLDING SAND, RECLAIMING.
PIPE CASTING, CENTRIFUGAL MACHINE FOR.
WASTE FOUNDRY SAND.
ALUMINUM CASTINGS AND FORGINGS.
ALUMINUM-MANGANESE ALLOYS.
WOOD PIPES.
KEROSENE ENGINE, MACLAREN MARINE.
CARBURETER, KEROSENE-GASOLINE.
BLOWLAMP HEATING FOR STARTING ON KEROSENE.
WASTE HEAT SAVING BY THERMO-COUPLES.
GAS ENGINE WITH WASTE-HEAT SAVING.
MERIAM SYSTEM OF COOLING ON LARGE GAS ENGINE.
ENGINE, TWO-CRANK, FOUR-CYLINDER.
HIGH ELEVATION AND DIESEL ENGINE WORKING.
BURRO MOUNTAIN COPPER COMPANY'S PLANT.
SCREW THREADS, I. S. SYSTEM.
FRENCH ARTILLERY ADOPTS I. S. THREAD.
FRICTION CLUTCHES.
SKEW BEVEL GEARS.
VENTURI METERS ON LIVELY LINES.
TRACK SCALE, HEAVY.
SHRAPNEL FUSE BODIES, RECLAIMING.
PILE EXTRACTOR.
PUMP, MERCURY HIGH-VACUUM HIGH-SPEED.
PUMP, CENTRIFUGAL, CASING.
ICE, RAW-WATER CAN.
BOILER ROOMS ON WARSHIPS, AIR SUPPLY.
EVAPORATORS, TUBES FOR.
SUPERHEATERS.
SCREWDRIVERS, TESTING OF.

A good test of engineering achievement is a machine running at extremely high speeds. A speed of some thirty to sixty thousand revolutions per minute tries out in a most searching manner the design, the strength of the parts, the material used, and the balancing of a machine. From this point of view a blower running at 40,000 to 60,000 is worthy of notice. A description of it will be found in the section Air Engineering.

THIS MONTH'S ARTICLES

A turbo compressor built in England is described.

Data from a publication of the U. S. Bureau of Standards are reported on Invar, a nickel steel remarkable for its extremely small thermal expansion at ordinary temperature.

Methods of production of copper-clad steel wire are abstracted from the *Electric Railway Journal,* as well as some data on its physical properties.

From an advance notice specially supplied to The Journal by the U. S. Bureau of Standards are taken data on the freezing point of mercury.

The annealing properties of copper at temperatures below 500 deg. cent. are discussed by G. V. Caesar and G. C. Gerner, Mem.Am.Soc.M.E., in a paper before the annual meeting of the American Institute of Metals. An interesting feature of this investigation is the observation made on the important influence of silver in copper, indicating that silver is quite an important impurity in electrolytic copper.

The production of cold-rolled strip steel is described in some detail.

In the section Firing and Fuel, a brief abstract is given of an article on chain screen doors. In the same section are described interesting experiments in natural draft oil burning on the *U. S. S. Fulton.* A description of a burner developed at the Fuel Oil Testing Plant, Navy Yard, Philadelphia, is included.

Two articles on waste foundry sand are abstracted in the section Foundry, where will be found also a description of a novel centrifugal machine for casting pipe. According to the statement of the inventors, they have succeeded with this machine in casting pipe which requires no further treatment except tarring.

Data on the physical properties of manganese aluminum alloys are reported from a paper by P. E. McKinney, presented at the recent annual meeting of the American Institute of Metals.

In the section Internal Combustion Engineering are reported descriptions of a marine kerosene engine using a somewhat novel type of carburetor; a large gas engine utilizing waste water-jacket heat in the form of by-product steam; a two-crank, four-cylinder combustion engine, and finally the Burro Mountain Copper Company's power plant. This latter is of interest because it uses Diesel engines at an elevation of nearly 6,000 ft.

A notice concerning the adoption of the International System Standard of screw threads by the French Artillery will be found in the section Machine Design. In the same section is presented an enumeration, with brief remarks, of some standard makes of friction clutches, as well as data on the laying out of skew bevel gears.

That venturi meters are not reliable on lively lines is the contention of Allan Hazen in an article abstracted from *Engineering News.*

From *Canadian Machinery* are taken some suggestions on reclaiming rejected Russian three-inch shrapnel fuse bodies.

A steam-driven pile extractor of novel design is described and illustrated.

In the section Pumps, particular attention is called to a high-vacuum, mercury-vapor pump of high speed, invented by an American engineer. This pump is a material improvement on the Gaede diffusion pump. An improved centrifugal pump casing is described and illustrated in the same section.

In the next section, Refrigeration, is presented some information on the high-pressure method of producing raw-water can ice, a branch of refrigeration practically created in this country and developed here exclusively.

An abstract showing an improved heat-transmitting device for evaporators is presented from a paper in the *Mechanical Engineer.*

Air Machinery

Small High-Pressure Centrifugal Blower, Henry F. Schmidt

The blower described in this article and developed by the Westinghouse Machine Company is of interest, as it is claimed to have created the highest pressure ever obtained from a single-stage blower.

The speed selected for the blower was 43,500 r.p.m. at normal pressure, extended to 60,000 r.p.m. during the tests. Such high speeds require many interesting refinements of design. In the first place, as there is no means of transmitting the 350 to 400 h.p. required to drive the blower to a shaft running at these speeds, a small turbine had to be designed to drive the blower. In this turbine blade speeds from 1330 ft. per sec. (normal) to 1850 ft. (maximum) were used, which made it necessary to form the blades integral with the wheel,

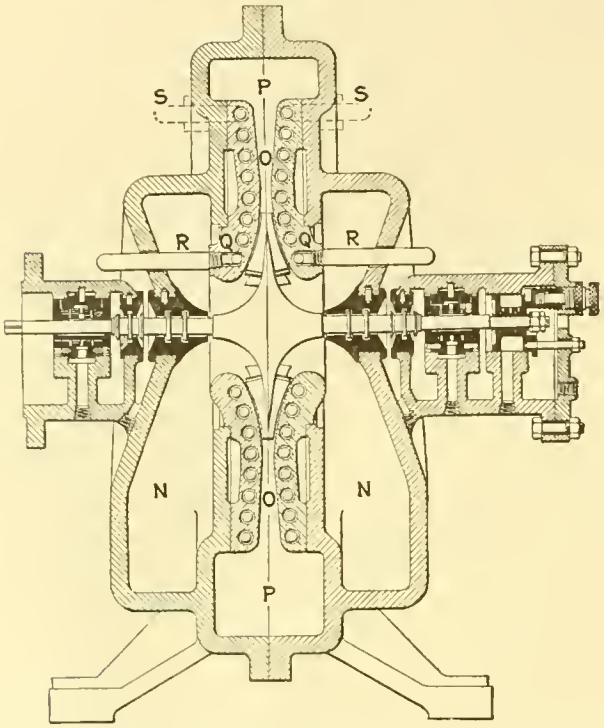

Fig. 1 Cross-section Through Westinghouse High-Pressure High-Speed Centrifugal Blower

since the centrifugal forces became so great that no known method of blade attachment would suffice.

For the same reasons the blower rotor had to be constructed from one forging, the blades being formed by milling out the material between them. The use of rotor tip speeds of from 1520 to 2100 ft. per sec. necessitated the use of high-grade forgings and exceptionally rigid specifications for the metal.

As an example of the enormous forces resulting at the high speeds used, it is stated that the pull on one of the blades of the blower rotor, which were only about $^1/_{16}$ in. thick by an average of $^{11}/_{16}$ in. wide and 2 in. long, amounted to a little over a ton, though the actual weight of one blade is about $^1/_{40}$ lb.

The article describes in detail the methods of production of the blower and turbine.

In the blower, Fig. 1, the air enters through the inlets N, which are made of the "snail" form, with a whirl chamber so as to direct the incoming air in the direction of rotation. The proportions are such that the air has the same velocity as the inside edges of the blades, thus permitting it to enter the blades without shock and tangentially instead of at an obtuse angle, as it would were the inlet not so formed.

From the inlets the air enters the blades of the rotor, is there partly compressed, and is finally discharged into the whirl chamber O, where the velocity is gradually reduced to less than half that with which it leaves the tips of the blades. The loss of kinetic energy reappears in the increase in pressure that occurs in the whirl chamber. Over half of the total increase in pressure occurs in the whirl chamber, the efficiency of which at the designed capacity reaches over 90 per cent of the theoretical. The whirl chamber has no guide vanes or reversed nozzles, the velocity conversion being accomplished by a free vortex the efficiency of which exceeds that obtainable by the most perfect guide vanes. This has the advantage of a high efficiency at all discharge rates, whereas the diffusion tubes or guide vanes have a good efficiency only at their designed capacity, for at all other capacities the blade angles are incorrect as well as the areas.

The cooling area exposed to the air does not appear large, but it must be remembered that with air velocities of 1500 to 2000 ft. per sec. on the outside and a water velocity of 30 to 50 ft. per sec. through the tubes, an extremely high rate of heat transfer per square foot of air surface per degree per hour can be obtained. Actually, owing to a defect in the castings for the side rings, the water cooling was not used.

TABLE 1. DATA OF TESTS OF THE WESTINGHOUSE HIGH-PRESSURE HIGH-SPEED CENTRIFUGAL BLOWER

Barometer	28.88	....	....	....	....
Steam-chest pressure	....	10	20	30	88
Air-discharge pressure	4.5*	9.1*	14.25*	18.5*	24 lb.
Temperature of discharged air, deg. fahr.	94	122	153	178	348
Rev. per min.	12,600	16,800	21,000	23,000	32,000
Vacuum	....	26 in.	26	26.5	26
Vacuum at blower nozzle throat, in. water	0.66	1.22	1.78	2.09	3.00
Adiabatic efficiency, per cent.	64	68	67.5	66	66.8
Cu. ft. of free air per min. discharged	633	860	1,040	1,130	1,360
Temperature of air at inlet nozzle, deg. fahr.	59	59	58	56	78

* These pressures are in inches of mercury.

One of the most serious problems in the design of this blower was that of getting a suitable coupling for transmitting 400 h.p. at 60,000 r.p.m. Neither attached couplings nor couplings that would require an increase in the diameter of the shaft could be used, and the old square sleeve-type coupling was employed, the squares being made ⅜ in., with a 6-in. space between them. The long space between the squares made the coupling comparatively flexible, though the fit on the squares was kept down to less than 0.001 in. It was made of tool steel, oil-tempered, and was entirely satisfactory. The blower failed through the failure of the coupling to slip. An interesting point about this failure is that none of the men on test noticed anything wrong with the blower except a little smoke coming from the turbine thrust bearing.

Table 1 shows a few readings taken before the rotor was damaged, the efficiencies being those calculated from the increase of temperature of the air in passing through the blower.

The tip speed up to 20,000 r.p.m. was taken by various tachometers; beyond 20,000 r.p.m., the speed was calculated from the pressure created by the blower.

The characteristic curve of the blower shows that for a large variation of the capacity the pressure remains practically constant, and then falls off with a further increase in the delivery.

The most remarkable feature about the performance of this blower was its action with the discharge entirely shut off and with the discharge open only a small amount. At no discharge the pressure variation was surprisingly slight, and opening the discharge ever so little caused it to decrease to such an extent as to be hardly noticeable. At 2 per cent of the rating of the blower all traces of upsetting disappeared, and with water cooling all signs of upsetting would doubtless have ceased, in the opinion of the writer, at less than 1 per cent of the rating. The writer believes that this result could not have been obtained in a blower fitted with guide vanes. (*Power,* vol. 44, no. 9, p. 294, August 29, 1916, 6 p., 6 figs. *de.*)

Turbo-Compressor for a Midlands Colliery

Description of the turbo-compressor built for a large colliery in the Midlands, by the British Thomson-Houston Company, Ltd., Rugby, England.

This machine is designed to deliver 5000 cu. ft. of free air per min. at a pressure of 80 lb. per sq. in., but is capable of taking a considerable overload. While the demand varies within 30 sec. from as little as 1500 cu. ft. per min. up to its full rated capacity, the efficiency of the governing is such that the consequent change in the pressure does not exceed 2 lb. per sq. in.

The compression is effected in 13 stages grouped into two independent casings mounted in line with and driven by a Curtis steam turbine running at 4600 r.p.m. No intercooler has been provided between the two sections of the compressor casings, but each stage is carefully water-jacketed, so that the compression curve lies well below the adiabatic.

The impellers are of high-tensile steel, fitted with bronze rings in their hubs so that when forced on to their shafts the contact is between bronze and steel and not between steel and steel. This among other things makes it possible to adopt forced-fit allowances sufficient to insure that the impellers remain tight on the shaft even at the highest speeds of rotation. The large ratio of casing diameter to impeller diameter has been adopted so as to obtain more effective jacketing, and to increase the cooling effect special cast-iron blades are provided in the air passages between the stages which increase the cooling surface and also serve as guides to the fluid as it flows. (*Engineering,* vol. 102, no. 2642, p. 152, August 18, 1916, 2 pp., 3 figs. *d.*)

Engineering Materials

Invar and Related Nickel Steels

Invar is a nickel steel containing about 36 per cent nickel, together with about 0.5 per cent each of carbon and manganese. Its most remarkable property is its extremely small thermal expansion at ordinary temperatures.

The account presented by the Bureau of Standards is largely a compilation of results obtained during the last 25 years by various investigators.

The mean coefficient of linear expansion between 0 and 40 deg. cent. is of the order of one millionth for the ordinary invar, and samples have been prepared with even small negative coefficients; the amounts of carbon and manganese present appear to exercise considerable influence on the expansion. Small quantities have been manufactured with a coefficient $(+0.028 - 0.00232\,t)10^{-6}$, equivalent to a change in length of 0.4 mm. in 1 km. between 0 and 20 deg. cent. This was for one alloy containing 0.06 per cent carbon and 0.39 per cent manganese, the other elements being negligible. Above 200 deg. cent. the expansion of invar is nearly that of Bessemer steel.

Invar is subject to changes in length due to "after effects" following cooling from a high temperature, and to changes in length following even slight alterations in temperature. For example, at 15 deg. cent. the elongation of 1 m. is 0.07 to 0.08μ per day after forging and 0.03μ after annealing to 40 deg. cent. After a long rest at room temperature (10 to 20 deg. cent.) the contraction setting in after bringing the metal to a higher temperature is completed in about one-half hour at 100 deg. cent., and only after several days at 40 deg. cent. The range of transitory length variations following temperature changes is given approximately by the formula

$$\Delta L/L = -0.00325.10^{-6}t^2$$

which holds for temperatures between 0 and 100 deg. cent.

Invar also gradually elongates with time, forged and drawn material behaving somewhat differently in this respect, so that there is a determinable, seasonal correction to be applied to its length when used as a length standard. This effect may be reduced, but not entirely eliminated, by special heat treatments consisting in an annealing process extending over several weeks and carried out at successively decreasing temperatures.

The invar from a single melt will not, in general, be of absolutely uniform properties throughout, the expansion variations not being more than $+0.03.10^{-6}$, so that, in determining lengths to one part in ten million, it appears safe to use the same expansion formula for all the pieces from a given melt.

The mechanical properties are about as follows: Tensile strength, 35 to 60 kg. per sq. mm., or 50,000 to 85,000 lb. per sq. in.; elastic limit, 5 to 21 kg. per sq. mm., or 7,000 to 30,000 lb. per sq. in.; elongation, 40 to 50 per cent; reduction of area, 40 to 65 per cent; scleroscope hardness, 19; and Brinell hardness, 160. (*Circular of the Bureau of Standards,* vol. 4, no. 58, 1916, 68 pp., 38 figs., and a selected bibliography of books and articles on nickel steel. *g.*)

Copper-Clad Steel Wire

Some data on the manufacture and properties of the so-called "Copperweld" wire.

This wire is manufactured by taking a steel bar about 4 in. in diameter by about 30 in. long, pickling, cleaning, and covering it with a specially prepared flux. This bar is then placed in a mold 5⅛ in. in diameter by about 30 in. long. The bar and mold are placed in a furnace and allowed to remain there until the desired temperature is obtained, when copper heated to a temperature of 1980 deg. is poured over the steel bar, filling the space between the bar and the mold. The bar thus obtained is reheated, hot-rolled, and drawn into wire.

The wire is said to have an absolute weld between the copper and the steel without voids, so that torsions, twists or hammering will not separate the copper from the steel core. Neither is the weld affected by a change of temperature from extreme heat to a sudden plunge in cold water. According to the claim of the maker, the wire has a tensile strength about 60 per cent greater than hard-drawn copper wire of the same size, and will stand approximately 126 per cent more strain than copper wire before reaching the elastic limit. It weighs approximately from 7 to 10 per cent less than copper wire of the same diameter and length. (*Electric Railway Journal,* vol. 48, no. 10, p. 409, September 2, 1916, 2 pp. *d.*)

Rubber Vulcanization Accelerators, Andrew H. King

The degree of vulcanization can be greatly influenced by a change in either time or temperature. Thus a stock which cures ordinarily in 40 min. at 40 lb. steam pressure can be vulcanized in 25 min. at 60 lb. However, the increase in working steam pressure is expensive and sometimes unsatisfactory. It is far better to add from 1 to 2 per cent of some good accelerator and properly cure the rubber at low pressure than to run chances of injuring the nerve at high temperature.

The author discusses several accelerators, mineral and organic. A peculiar fact is brought out. By a combination of accelerators the resulting increase in speed is greater than the sum of the individual increases when acting alone. For example, the effect of 1 per cent tetramethylenediamine and 1 per cent piperidine exceeds the sum of the effects of the same catalyzers when mixed in separate batches. (In connection with this article attention is called to the following two abstracts: Journal, December, 1915, p. 725, and September, 1916, p. 751.) (*Metallurgical and Chemical Engineering,* vol. 15, no. 5, p. 231, September 1, 1916, 4 pp. *p.*)

The Freezing Point of Mercury, R. M. Wilhelm

The temperature at which mercury freezes is of importance to thermometry. It marks the lower limit to which mercurial thermometers may be used, and its location at about—39 deg. cent. makes it of value as a fixed point of the temperature scale below 0 deg. cent. A paper by the Bureau of Standards, and which is now in press, gives the result and describes in detail the method used in making a redetermination of this constant. The temperature measurements were made by means of platinum resistance thermometers whose constants had been previously determined by calibration at 0 deg., 100 deg., and 444.6 deg. (the boiling point of sulphur). All the evidence at present available indicates that the platinum resistance thermometer so calibrated defines temperatures in agreement with those given by the standard gas thermometer down to 40 deg. The value obtained at the Bureau,—38.87 deg., is in very good agreement with that found by Henning in 1913 at the Reichsanstalt, Germany, who also used platinum resistance thermometers and obtained—38.89 deg. (*Bureau of Standards,* Scientific Paper, no. 294, advance abstract.)

The Annealing Properties of Copper at Temperatures Below 500 Deg. Cent., with Particular Reference to the Effect of Oxygen and of Silver

G. V. Caesar and G. C. Gerner

Brief historical sketch of the research on the relations between the physical properties of copper and annealing conditions on one hand and chemical composition on the other, followed by a report of an experimental investigation carried out by the authors.

This experimental investigation was conducted along the following lines:

(*a*) A study of half-hour annealing effects (as measured by the scleroscope) produced by the addition of known small amounts of oxygen and silver alone and combined to specially prepared pure copper free from all but the smallest traces of oxygen, and of similar effects observed in the case of commercial electrolytic (multiple) copper. All samples were reduced 66⅔ per cent in area of section before annealing.

(*b*) A determination of the position of the zone of rapid softening (*zone de détente*) in the commercial samples (electrolytic copper) after annealing for such periods of time as appeared to produce an equilibrium effect at each respective temperature. In this work both hardness and tensile tests were made and three sets of results corresponding to three separate values of reduction by cold rolling were obtained.

The method of investigation adopted was essentially that used by Rose in studying the effects of impurities on the annealing properties of gold (*Journal, Institute of Metals,* 1913). Among other things these tests confirmed the fact that slight changes in temperature brought about by annealing and consequent recrystallization are very sharply indicated by scleroscopic tests, and the writers indicate certain precautions necessary to insure a good performance from this instrument.

The data of the tests are presented in the form of tables and curves. In general, the writers come to the conclusion that it seems reasonable to believe that an impurity which is completely dissolved in the solid metal and thus constitutes an integral part of each strain-hardened grain will be more effective than an undissolved impurity in promoting or retarding the structural changes brought about by annealing. The influence exercised by cuprous oxide on the softening characteristics of copper is ascribed to its property of preventing gas absorption by the copper. As regards the softening properties exhibited by the different grades of copper tested it was found that in the case of pure copper softening begins at some temperature close to 200 deg. cent., and that the effect is most rapid between 225 and 275 deg. cent., the softening being complete at some temperature between 300 and 350 deg. cent. In samples containing oxide it was found that a marked softening effect is associated with the presence of mechanically entangled cuprous oxide. Recrystallization apparently occurs at a lower temperature than in the case of the material termed pure copper, but an increase in oxygen content from about 0.03 to 0.09 per cent does not materially affect the softening characteristics.

The effect of 0.10 per cent of silver in solid solution in the absence of oxide is pronounced. The original strain-hardened condition persists up to some 300 deg. cent., and the most rapid softening effects take place in the neighborhood of 350 deg. cent. In order to test the effect of a definitely known but small amount of silver together with a rather large amount of oxygen, an alloy was prepared containing 0.002 per cent of silver and 0.08 per cent of oxygen. Its softening properties approximate very closely those of pure copper, and the oxygen and silver appear to have effectively neutralized one another in this respect. Since silver is a common impurity in electrolytic copper and since even in small quantities its effect on the annealing properties is so profound, it is probable that variations in silver content are largely responsible for the wide lack of agreement among the annealing curves obtained by different investigators, and to interpret the curves obtained it is almost indispensable to have information with respect to the nature and extent of the contaminations of the copper, as well as the degree of reduction and time of anneal.

The paper discusses also the position of the zone or rapid softening in one grade of electrolytic copper ("D R W") after periods of annealing intended to develop equilibrium effects; scleroscope control tests; method of annealing the tensile test strips; hardness tests on the rolled and annealed tensile test strips and tensile tests on the rolled and annealed test strips. In connection with the hardness tests there was observed in certain cases a marked difference in the hardness values obtained from duplicate strips which were treated side

by side under the same conditions, the variations in the hardness values obtained from different strips annealed under strictly comparable conditions being as high as two- to four-point. These annealing variations are ascribed to segregation of silver in the original cake from which these strips were obtained. Among other things the writers come to the following two conclusions:

1. That strain-hardened copper softens and recrystallizes as would be required by the theory (Tammann) that the permanency of the strain-hardened condition depends upon the number or concentration of inner surfaces developed by deformation in any region and the temperature (and time) of anneal, and in accordance with a recent interpretation (Mathewson) of the conditions encountered in material rolled to a succession of gages.

2. That after what appears to be a complete anneal there still remains some effect due to the manner of working before the anneal, as shown by the higher tensile strength found in those specimens which had received the most severe reduction. (Paper presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio).

Cold-Rolling Strip Steel, Edward K. Hammond

Cold-rolled steel is produced by rolling the metal cold, which gives two advantages: first, the tendency to oxidize and form a scale (which cannot be avoided when steel is rolled hot) is entirely overcome by cold-rolling, so that the steel may be given what is known as a bright finish; second, the elimination of oxidation enables the gage of the steel to be held within very close limits, such as on the thicker gages within 0.0015 in., while the thinnest gages are guaranteed to be within 0.00025 in. of the specified thickness. Further, the process of cold-rolling enables the steel to be rolled true to gage as thin as 0.003 in., which would not be practicable with hot metal because of uneven heating and expansion.

The article describes the selection of the raw materials, the annealing gas medium furnaces, the pot annealing furnace and muffle annealing furnace, as well as the machinery used for the operations of rolling.

After the steel has been annealed it goes to the pickling department where it is subjected to a treatment which removes all the oxide scale that was produced on the metal during the hot-rolling process. The pickling process consists of immersing the rolls of steel in vats of sulphuric acid, which causes the scale to be removed. The acid consists of a 5 per cent solution of sulphuric acid which has a density of 66 deg. Baumé at 60 deg. fahr. In the case of low-carbon steel the time that the metal is left in the vat is not important, but with high-carbon steel great care must be taken and the steel should not remain in the acid for more than three or four minutes. It is important for the stock to be uniformly covered with scale before pickling, otherwise the pickled stock will have a "pitted" surface and therefore cannot be converted into good cold-rolled steel. After the pickling operation has been completed, the steel must be washed immediately in order to remove the acid. To make assurance doubly sure, the steel is removed from the water and plunged into a vat containing a diluted solution of lime water, which has the further advantage that when the steel is removed from the vats and given time to dry it is coated with a film of lime, which keeps both air and moisture from coming into contact with the metal, and so protects it from rusting. The cold-rolling in the plant described in the article (Schwartz-Herrmann Steel Company, Floral Park, Somerville, N. J.) is done in mills imported from Germany.

In cold-rolling it is highly important to avoid chatter and vibration, as such a condition would be shown by irregularities in the surface of the product. This feature is taken care of by having the power transmitted to the rolls through herring-bone gears and shackle bars, which serve as a double precaution against vibration.

The amount of reduction which can be obtained for each pass through the rolling mills depends upon the analysis of the steel; with low-carbon steel the reduction may be as great as 0.022 in. for each pass, and this will be gradually decreased until the final pass will only reduce the thickness of the metal about 0.005 in. In the case of high-carbon stock the reduction is much less.

The rolls are lubricated with a special grade of oil known as "Roll Oil," which is of about the same consistency as cylinder oil, but very carefully compounded, to be sure that it has neither acid nor alkaline admixtures, as either condition would spoil the bright finish of the cold-rolled steel.

The article describes further the methods of trimming the edges of stock, cutting strips into stock length, hardening and tempering, and, when necessary, polishing. (*Machinery*, vol. 23, no. 1, p. 1, September, 1916, 6 pp., 14 figs. *d.*)

Effect of Sugar on Concrete

The fact that even a very small amount of sugar in a concrete mix is injurious to good work has long been known. The author cites tests which show that as small an amount of sugar as 1 lb. to ten bags of cement will cause failure.

The knowledge of this fact of the influence of sugar on concrete may save serious loss. For example, it is not advisable to place concrete floors in a candy factory.

It appears, however, on the other hand, that weak solutions of sugar will not affect concrete once it has become thoroughly hardened. In fact, a sugar solution has been recommended as a hardener and dust preventive. (*Concrete*, vol. 9, no. 2, p. 61, August, 1916, 1 p. *e.*)

Firing and Fuel

Chain Screen Doors, H. H. Wiegand

Description of chain screen doors, mainly of the Wiegand type.

These chain screen doors consist usually of a multitude of freely hanging individual strands of steel chain suspended close together from a bar in a manner to form a continuous sheet or curtain of chain not unlike the Japanese screen. This curtain of chain hung before the uncovered opening of a furnace effectively hinders the heat, glare, gases and sparks from leaving the furnace and checks the entrance of cold air. The loosely hanging strands of light chain are parted with ease and pressed aside by the tools or other objects projected into the furnace, only to fall together again when entrance has been effected. The interstices in the links of chain permit an unhampered view of the interior; in fact, a better survey may be obtained than under ordinary conditions, as the glare is toned down and the effect is similar to looking into a furnace through a piece of wire gauze.

In a boiler room where the Wiegand chain doors have been employed for about three years, experiments were made to obtain an idea of the effectiveness of the device in avoiding the losses arising from the frequently opened stoking door.

A thermometer was fixed on a standard in the fire room at a point opposite this door and 10 in. therefrom. This position was chosen as being near to the one usually taken by the fireman when stoking or cleaning the fire. When the ordinary fire door was thrown open and the incandescent fire bed exposed, as is the case whenever the furnace is coaled or cleaned, the thermometer rose to 400 deg. fahr. On covering the furnace opening with the auxiliary chain door the thermometer dropped to 135 deg. fahr., and the bare, unprotected hand could be held anywhere in front of the screen opening without discomfort. (*The Journal of Industrial and Engineering Chemistry*, vol. 8, no. 9, September, 1916, p. 836, 2 pp. *d.*)

Some Experiments in Natural-Draft Oil Burning, Lieut. L. R. Ford, U. S. N.

An interesting description of experience in oil burning on the U. S. S. *Fulton*.

At the time the ship was commissioned, the steam necessary to operate the auxiliaries was supplied by a Roberts water-tube boiler equipped with one large burner, which used either steam or air as an atomizing agent. The air for combustion was supplied by natural draft through two small ventilators and through the door between the engine room and fire room. After a disastrous furnace explosion, due to the burner flame being extinguished and the furnace becoming filled with explosive gas, which ignited, the boiler was fitted with two of the Bureau's Standard Type B air registers and Type I burners. These burners atomize the oil mechanically and are designed for use with forced draft. In addition, a second boiler of the Almy water-tube type was installed, which made the room quite crowded and curtailed the already limited air supply.

As soon as the ship was ready to leave the Navy Yard troubles began. When the burners were lighted under one boiler, it became evident that the combustion was very poor. Several schemes were resorted to. Small portable electric blowers were placed on the fire-room floor plates so as to discharge against the registers in the furnace front. This helped only slightly. A sheet-metal box built on the boiler front so as to completely enclose the registers and burners and connected with two ¼-h.p. portable blowers proved to be a failure. A small box was then built that would stand on the floor plates in front of the burners, with the two ¼-h.p. blowers connected so as to discharge into the box. This improved the combustion, but far from sufficiently. So much soot was deposited that it became necessary to establish a routine requiring that the tubes be blown with steam once every hour or 24 times each day.

The oil pressure habitually carried with the Bureau type of burner was 200 lb. It was found that by reducing the oil pressure much better combustion was obtained, but the oil was then insufficient to maintain the steam pressure. Several types of experimental burners with either air or steam atomization were tried, but without much success. Finally, the following system was adopted on the advice of Lieut. A. M. Penn, U. S. N., in charge of the Fuel Oil Testing Plant at the Navy Yard, Philadelphia.

The Bureau Standard Type B registers were removed from the furnace front of the Roberts boiler and a bar of ¾-in. by 3-in. flat iron was supported across the front of each opening in the furnace front on ¾-in. studs, these studs projecting 10 in. from the furnace front and being provided with threads and nuts for adjusting the bar for distance. Each bar was drilled at its center large enough to permit the insertion of a burner.

The burner itself was modified as shown in Fig. 2A. A funnel-shaped diffuser was made of sheet iron and attached to the end of a piece of 1¼-in. pipe 4 in. long by means of a band clamp. This clamp method of securing the diffuser on the pipe was preferable to screws or rivets, as it permitted easy removal of the diffuser. The included angle of the diffuser was selected after several experiments as 90 deg., and the diameter at the large end was made 4⅝ in. The pipe was slipped over the tip in such a manner as to permit adjustment of the distance the burner tip projected into the diffuser.

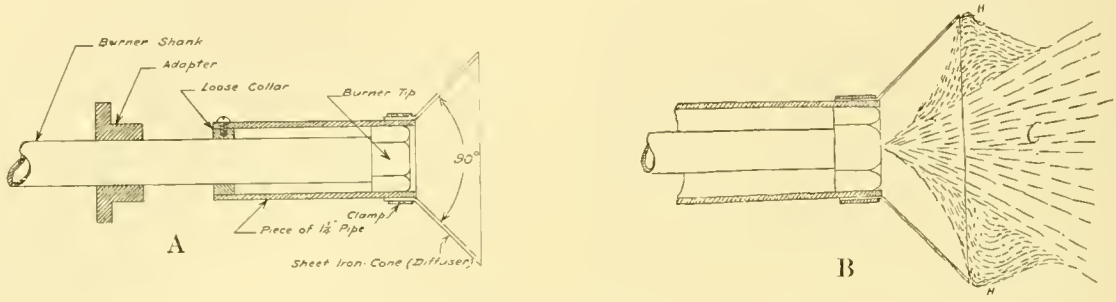

Fig. 2 Improved Natural-Draft Oil-Burner

When this burner was lighted a most interesting action was observed. With the diffuser drawn well back toward the rear, the flame would jump away from the burner, but when the diffuser was pushed forward it would pick up the flame, and a short cone of clean flame would result. When the diffuser was adjusted to the best operating position, a halo of white flame would appear around the edge, as shown in Fig. B. The main body of the flame retained its cone shape, as shown at C, this cone of flame extending back to the burner tip; but part of this flame seemed to draw out to the diffuser and curl down from the edge, as shown at H. The combustion obtained with this arrangement was very good, indeed. The article proceeds to describe in detail the rebuilding of the furnace apparatus.

Among the modifications introduced were the installation of vertical fins of thin sheet metal in the shape of a helix around the circumference of the conical openings in the furnace, to promote mixing of air and fuel by giving the entering air a rotary motion. Another improvement was the mounting on the head of the oil line of a large air chamber. This chamber kept the oil pressure steady, the effect of which was quickly noted at the burners. When the diffusers were adjusted to get the halo around the edges, it remained there without further adjustment. What surprised the ship engineers most was the low oil pressure required to maintain the steam

pressure and the wide range of pressure through which the burners could be operated smokelessly. Under the old conditions it had been necessary to operate the burners under an oil pressure of 200 lb. It was now found that the steam necessary to meet the normal demand of the ship could be evaporated with an oil pressure of 50 to 100 lb., and the pressure had to be raised to 200 lb. only when an extra demand for steam was made.

In fact, it was found that the steam pressure could be quickly and closely regulated by varying the oil pressure, which could be done by varying the spring tension of the regulator valve on the oil pump. Steam control was thus reduced to the mere screwing of a nut up and down with a wrench, a novelty which strongly appealed to the firemen.

The helical vanes, in addition to giving the air a rotary motion and thereby promoting mixture of air and oil, serve a useful purpose in intercepting the radiant heat from the flame. It is found that since they were installed the heat in front of the boiler is now greater than when the closed registers were in use. (*Journal of the American Society of Naval Engineers,* vol. 28, no. 3, p. 641, August, 1916, 14 pp., 6 figs. *de.*)

Foundry

Reclaiming Waste Molding Sand

Description of the equipment recently installed by the Modern Foundry Company, Oakley, Cincinnati.

This equipment consists simply of two belt conveyors, one with 23-ft. centers and the other with 26-ft. centers. Jeffrey 18-in. belts are used, the pulleys and motors being mounted on structural-steel frames. The refuse is shoveled into the shorter conveyor and passes over a Cutler-Hammer magnetic pulley having the magnetic coils on the inside of the pulley. The metal as it passes over the pulley adheres to the belt, while the sand is discharged upon the second conveyor from which it is dumped into the car. The metal is carried partly around the magnetic pulley, and is dumped into a chute at the point where the belt leaves the pulley. These conveyors have a capacity of one ton a minute and are each electrically driven with a 1-h.p. motor.

The company states that the amount of material reclaimed in six weeks has more than paid for the original cost of the equipment. (*The Iron Age,* vol. 98, no. 10, p. 505, Sept. 7, 1916, 1 p., 2 figs. *d.*)

A Centrifugal Machine for Casting Pipe

Description of a new method of casting pipe by using centrifugal force, invented by two Brazilians, D. Sensaud de Lavaud and Fernando Arens, Jr.

The inventors have made numerous unsuccessful attempts to produce cast pipe in a permanent rotary mold. The metal did not spread evenly over the surface of the mold, the pipe was brittle, and there was great trouble in extracting the pipe. Finally, however, they claim to have succeeded in producing good pipe by working along the following lines: (1) A permanent, rotary, and *cold* mold (the condition of the mold being cold appears to be of the highest importance); (2) immediate extraction of the pipe after solidification; (3) the use of very hot iron; (4) a silicon content of 1.80 to 2.50 per cent.

It is stated that at present thirteen of the new machines are operated commercially in two plants in Brazil, turning out various sizes of pipe from 4 in. to 15 in. in diameter and from 4 ft. to 14 ft. long, and that a machine has been built in the Buffalo district which has produced for exhibition and other purposes a quantity of 4-ft. 4-in. pipe.

The operation of the machine is briefly as follows: Regulated quantities of cast iron are introduced into a rapidly revolving water-cooled cylinder, where, by the centrifugal force exerted, the metal is spread uniformly upon the surface of the mold, and within a few seconds the pipe is withdrawn from the other end of the machine at a white heat. The pipe is not subjected to any further treatment except tarring.

According to the theory of the inventors, the metal coming in contact with the cold mold will congeal at once, forming a solidified crust which creates a centripetal force; the pipe then detaches itself from the surface of the mold and the space between the mold and the pipe becomes an insulating chamber, in which the air, which is at a high temperature, graduates the solidifying of the molten mass, and at the same time anneals the crust first formed.

It is claimed that when casting by the new process the metal solidifies probably in two or three seconds. This means that the segregation or separation of impurities is impossible, so that a completely homogeneous mass is formed, in which all the parts are equally distributed and the metal is of a fine, close grain. It is also claimed that the action of the centrifugal force of the metal compresses and expels the air, preventing gas holes and forming a more solid and denser metal.

Tests have been made on various sizes of this new pipe by the Department of Water of Rio de Janeiro and the Department of Water and Sewerage Works of Sao Paulo, Brazil, in which it was found that the pipe could stand very high pressures. The figures are not reported, as there appears to be some uncertainty about them. It is also claimed that the new pipe is less subject to corrosion than ordinary cast pipe. (*The Iron Age,* vol. 98, no. 10, p. 506, Sept. 7, 1916, 4 pp., 8 figs. *d.*)

Waste Foundry Sand, H. B. Swan and H. M. Lane

The first part of the paper is written by H. B. Swan, who sent to a number of large American foundries a set of ten questions covering the use of foundry sand and the recovery of old sand. It was found that with one or two exceptions the burned sand was either loaded in freight cars or hauled away in wagons to some dumping ground, the cost of disposal varying from 30 cents to $1.50 per ton. Two or three replies from larger foundries stated a cost of $24.00 per day to dispose of their burned sand. One foundry disposes of some of its waste sand as a filler for a fertilizer, another uses some of its refuse sand for concrete mixture. Burned sand has been found good for putting in foundations for machinery. When it was used in making concrete walls for a building, the flour in the cores made the walls flake; this flaking continued for a period of at least one or two years after the structure was completed, and was especially noticeable after a continued wet spell.

The second part of the paper is written by H. M. Lane, a consulting engineer of Detroit, who was employed about two years ago by a number of Detroit manufacturers to experiment in washing and cleaning the refuse sand from their shops.

Two important considerations are treated in this paper, as follows: A process which is successful with steel foundry sand might fail utterly with brass foundry or aluminum foundry sand, owing to radical differences in characteristics of the different materials. The percentage of fire clay used in steel foundry mix is relatively small, and the so-called wearing-out of the sand is due mainly to the stopping of the fine passages

by small grains, resulting in the breaking up of the larger grains under heat and from dry or burned bond material.

Another fact is that the mass law of chemistry influences very largely the temperature at which a given size of grain will start to melt or burn into the casting. Very fine sand will burn into a steel casting several degrees lower than coarse sand, which makes it necessary to free the sand from these small and particularly angular grains. For such work a cleaning process that will remove the burned clay and the fine sand dust is necessary.

The process which will produce at lowest cost a product just good enough to use is the one that will ultimately be used, even if other systems may give a better though more expensive product. In steel foundry practice the ultimate factor is the cost of a ton of finished castings; and a process which recovers, say, 80 per cent of the sand in a fairly usable condition may be better than one which recovers 90 per cent in a better condition, but at a higher cost.

For the thorough cleaning of certain classes of sand, the wet process seems to be the best, but it necessitates first a scrubbing and then a washing, and takes quite a complicated plant, though the actual cost of cleaning per ton is low.

The author believes that it is advantageous to clean the coarse sand, but not the exceedingly fine brass or aluminum molding sand. In some cases, passing the sand over a series of sieves, which will first take out the coarse waste material and will next remove the fine or dust material, has been found to give a good product for rebonding for use in foundry work for a considerable line of gray iron castings. (Paper presented at the Annual Meeting of the American Foundrymen's Association, September 11-15, 1916, at Cleveland, O.)

Aluminum Castings and Forgings, P. E. McKinney

Discussion mainly of the influence of manganese on aluminum and the use of manganese-aluminum alloys for castings.

The most dangerous impurities encountered in aluminum alloys are carbon, silicon and iron; hence only carbonless manganese produced alumino-thermically has been used by the writer.

In producing an alloy for casting purposes, an empty crucible is set in the furnace and heated to a bright red. The requisite amount of hardening alloy is added and melted as quickly as possible. In cases where there is danger of introducing sand into the crucible, powdered flux, made by melting 60 per cent of potassium chloride and 40 per cent of cryolite and powdering the mixture, is used. This flux tends to dissolve the silicon and keeps it from combining with the aluminum.

The alloys of aluminum containing manganese have a slightly greater shrinkage than those containing copper alone, and due allowance must be made by using ample risers and chill plates on intricate castings.

The writer has made a number of tests on the physical properties of manganese-copper alloys.

The following are typical physical properties obtained on bars of this alloy forged to one inch square and turned to standard size tensile specimens.

No special melting furnaces or devices for handling the metal were found to be necessary for the production of alloys of aluminum containing manganese which can be melted in natural draft pit furnaces with only the ordinary precautions. A rich hardener of definite proportions and comparatively low melting point can be best made by alloying the hardening elements with a small amount of aluminum.

Soft alloy containing:

Manganese 1.00 per cent, copper 2.00 per cent, aluminum, 96.50 per cent.

	Tensile Strength	Yield Point	Elongation	Reduction
Cold finished	27750	27750	12.00	47.00
Hot finished	21083	12223	26.7	48.7
Intermediate	25617	22918	17.4	52.00

Hard alloy containing:

Manganese 2.00 per cent, copper 3.00 per cent, aluminum 94.50 per cent.

	Tensile Strength	Yield Point	Elongation	Reduction
Cold finished	31930	30000	9.75	35.3
Cold finished	34123	33000	4.00	11.25
Cold finished	30405	30000	11.25	30.78
Hot finished	27450	15000	21.95	56.0
Intermediate	28670	22000	21.00	50.4

Sections cut from thin drop forgings which were cold finished have shown tensile strength as high as 40,000 lb. per sq. in. (Paper presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, O.)

Hydraulics

Experience with Wood Pipes in New Hampshire, Arthur W. Dudley

Wood pipe has been in use for centuries, and when properly laid and made from proper material is remarkable for its long life. The writer states that he has in his office a section dug up in Bowdoin Square in Boston during the excavation for the subway that is as sound as when cut from the forest, although it is a part of Boston's first water system laid more than two hundred years ago.

Wood pipe was displaced by cast-iron because the old method of making it limited its inside diameter to the size of the log, 6 in. inside diameter being nearly the limit of such pipe. Modern methods of making wood pipe permit of producing practically unlimited diameters.

As to methods used in pipe making, the writer, after experiments, came to the conclusion that the sleeve method of connection may be strong, but the difficulty in coating the exposed ends of these sleeves, and the fact that they would not be saturated at all times, exposes them to danger from decay. He prefers tenon-and-chamber, flat-hooped pine pipe to pipe made of Douglas fir, because of the greater brittleness of the latter. The author describes several of his own experiences in laying wood pipe. In one case, at Pembroke, N. H., wood pipe was chosen mainly for the reason that the Manchester & Concord Electric Railway passes over almost the entire length of Pembroke Street, and, as no provision for a return current is made there, an iron pipe line would undoubtedly have formed this circuit, with imminent danger of electrolysis, while a wood pipe, being a non-conductor, was safe. To sum up the situation, wood pipe has besides the saving in cost of both pipe and installation these advantages:

1 It is preserved by water, and not rusted or corroded by it.
2 It is not corroded by any substance, or destroyed by acids or salts.
3 Its carrying capacity is 20 per cent greater than that of cast-iron pipe, and remains constant, while that of metal pipe decreases with age.

4 It does not taint or affect fluids going through it.
5 It does not burst if frozen, the elasticity of the wood preventing it.
6 It requires less labor and experience to lay in place than metal pipe, and a considerable saving can be made here.
7 It can, when service pipes are not taken off, be laid in shallower ditches than metal pipe, for it is not so easily affected by frost.
8 In the writer's experience, while more or less joints show slight leakage when the pipe is first filled, they soon swell up and give less trouble in the end than cast-iron pipe. (*Journal of the New England Water Works Association,* vol. 30, no. 3, p. 318, September, 1916, 8 pp., 2 figs. *dpc.*)

Internal Combustion Engineering

The Maclaren Marine Paraffin Engine

Description of an engine manufactured in Dumbarton, Scotland, in sizes from 8 to 28 h.p.

Of particular interest is the vaporizer and carburetor, which embodies the application to low-power engines of blowlamp heating for starting on kerosene. The arrangement consists of a simple casting, to the outside of which the blowlamp is applied for a few minutes before starting up. There is also a special arrangement whereby the engine can be started on gasoline and be changed over to run on kerosene by a movement of the throttle lever. In this arrangement the gasoline vapor does not go through the kerosene vaporizer, consequently a suitable combustible mixture is supplied at once to the cylinders whether the engine is hot or cold. This eliminates the difficulty often experienced at starting with the ordinary type of vaporizer when it is too cold for starting on kerosene and too hot for gasoline. (*Engineering,* vol. 102, no. 2642, p. 152, August 18, 1916, 2 pp., 6 figs. *d.*)

Silencing the Exhaust and Utilizing the Waste Heat of Internal-Combustion Engines

F. W. Rixon, Bristol, England, has recently patented in Great Britain a silencer for internal-combustion engines, in which thermopiles are employed for the recovery of the energy which would otherwise be dissipated as waste heat.

The cylindrical wall of the silencer is composed of a number of substantially triangular thermo-couples lying in transverse planes and spaced angularly by an insulating material. Each couple comprises a pair of triangular plates of different metals properly alternating, the apices of the plates being bent forward and united to one another by welding. The plates in each series are separated from one another by thin sheets of insulating material. It is expected that the gases when passing will heat the plates and at the same time lose most of their energy by friction. No data are given as to any tests. (*The Mechanical Engineer,* vol. 38, no. 969, p. 115, August 18, 1916, 1 p., 2 figs. *d.*)

Large Gas Engine Utilizing Water-Jacket Heat, F. L. Prentiss

The gas-engine plant installed in the new foundry of the Turner & Moore Mfg. Co., Detroit, is of interest because it has been designed to use comparatively expensive gas (55 cents per 1000 cu. ft.), and because the heat from the water jacket is utilized for producing by-product steam for heating a soda kettle and also for providing the hot-water supply.

The water-jacket cooling is designed according to the Meriam system previously described in The Journal (May, 1915, p. 295). This system is based on a discovery that with the water flowing through the jacket at a high rate of speed (about ten times higher than the usual) very good cooling of the cylinder can be obtained with the water even above the atmospheric boiling point. This is due to the fact that the high speed of the flow prevents the formation of steam and air bubbles and their adhesion to the cylinder walls, it having been found that it is these bubbles that, with the usual speeds of water, form at a certain temperature an insulating layer over the cylinder walls and interfere with their further cooling.

In the present instance the water passes from the water jacket into an enclosed tank which is connected with the suction side of the centrifugal pump, and a constant circulation is maintained between the cylinder jackets and the tank. A pressure of 4 to 5 lb. is maintained on the tank, while the pressure on the cylinder jackets is about 25 lb., this higher pressure being due to the resistance caused by forcing a large volume of water through the jackets rapidly. (*The Iron Age,* vol. 98, no. 8, p. 389, Aug. 24, 1916, 3 pp., 2 figs. *d.*)

Two-Crank, Four-Cylinder Combustion Engine, C. W. Shafer

A radically different design of internal-combustion engine, manufactured by the Field Motor Company, at Grand Rapids, Mich., is of the horizontal type, double opposed, and has but two cranks and two connecting rods for four pistons.

The engines are joined in pairs by rods, which practically gives a continuous piston. The tie rods have sliding fits on each side of the cranks and also on the top and bottom of each crankshaft bearing, so that the rods have no room for play and the amount of vibration is reduced to a minimum.

The carburetor (any standard type) is located above the cylinders, and one manifold only is used for 4- or 8-cylinder engines. Gasoline is used for starting the engine and kerosene or distillates for running it.

The arrangement of the manifold permits firing of the charges clockwise, 1, 2, 3, 4, a perfect balance being thus secured. With an 8-cylinder motor two explosions occur for every revolution of the crankshaft.

The article gives a sectional view of the engine and a view of the exterior of the motor. (*The Practical Engineer,* vol. 20, no. 16, p. 706, August 15, 1916, 2 pp., 3 figs. *d.*)

Power Plant of the Burro Mountain Copper Company, Charles Legrand

This power plant is of interest, first, because it uses the largest stationary Diesel engines in the United States, and second, because it is located at 5950 ft. elevation, which latter fact introduces certain complications in the operation of the engines. The plant has two five-cylinder vertical Diesel engines, which are rated at 1250 b.h.p. at sea level, and have cylinders of 20.6 in. diameter and 26 in. stroke. Each engine has a scavenging cylinder of 41.25 in. diameter and 23.6 in. stroke, also a three-stage four-cylinder high-pressure vertical compressor, both directly connected to the engine.

This compressor delivers the air necessary for fuel injection and for starting the engine. The scavenging pump, which is larger than usual, delivers the air to expel the products of combustion and fill the cylinders with fresh air at the beginning of the stroke. This pump was increased in size to be able to fill the cylinders with air at 2½ lb. gage pressure at

the beginning of the stroke, which gives nearly the same initial absolute pressure and allows the engine to generate nearly the same indicated horsepower as it would at sea level. The work done in the scavenging pump is, however, increased, and the horsepower available is approximately 95 per cent of the sea-level output.

The fuel consumption per horsepower is increased over sea-level conditions because of the extra work of the scavenging pump and the resulting lower mechanical efficiency of the engine when operating at the elevation of this plant.

The fuel used is California asphaltum base oil of 14-18 deg. Baumé gravity and about 18,360 B.t.u. The paper gives detailed costs of power per month and per kw-hr. available, the data of cost per month being given also in detail for labor, fuel oil, lubricating oil, miscellaneous supplies, and repairs. The repair cost is high, for soon after operations were started the construction account was closed, and several items, such as labor for installing recording thermometers, etc., were charged to repairs.

The greatest trouble was with the helical gears driving the cam shafts. These gears have a tendency to get loose, and one of them split from the keyway. The exact cause of this trouble has not been ascertained, but it has been much reduced since iron bands were shrunk on the hubs of the gears The lubricating-oil expense is given in detail. It does not seem to be excessive, and it is expected that it will be further reduced by the use of separate pumps to each point where the oil is delivered in the cylinders, insuring a definite quantity of oil. The present engines have one pump delivering to four points, and it happened once that one of the oil pipes became plugged and gave slight trouble on one piston. The maintenance cost is still in doubt.

The operation of the engines in parallel is very satisfactory, even when the load is slight, and on the whole the writer is satisfied with the operation of the plant and its cost as compared with what would be the case with a steam plant of the same capacity running under the same conditions. (*Bulletin of the American Institute of Mining Engineers,* no. 117, p. 1531, September, 1916, 8 pp., 4 figs. *dA.*)

Machine Design

Adoption of the International Standard of Screw Threads by the French Artillery

By a recent order dated March 22, 1916, the French artillery instructs all its contractors to use the International Standard (S. I.) for all screw-thread work done for that department.

The article gives a complete specification of the International Standard screw threads, together with instructions as to the use of the various gages, and in particular instructions for their use for all work done for the French artillery department. (*Bulletin de la Société d'Encouragement pour l'Industrie Nationale,* vol. 126, no. 4, p. 74, July-August, 1916, 30 pp., illustr. *d.*)

Some Standard Makes of Friction Clutches

A description of a number of types of friction clutches of American manufacture, taken from the literature of the several manufacturers. No attempt was made by the publishers to verify the claims made, but the collection is of considerable interest, as it affords a general view of the state of the art of manufacturing friction clutches. The following clutches are described and illustrated:

Moore & White high-speed clutch (metal-to-metal, multiple-disk type. Interesting system of lubrication)

Reeves wood split-pulley clutch

Caldwell double-disk friction clutch

Universal Giant friction clutch (outer ring covers friction surfaces which are wood and iron)

Medart friction clutch pulleys (hubs and sleeves interchangeable)

Bicknell Thomas clutch (two friction shoes work on the inner surface of the hub, which latter is lubricated from special oil chambers)

Falls friction clutch (ring-type clutch pulley, sleeves made in halves)

Thomas Patent Empire friction clutch.

Edgemont countershaft clutch (solid cast-iron pulley, with ring cast on the spokes to receive the friction)

Ideal Multi-Cone clutch (multiple-disk cone type, the cones running constantly in oil)

Hilliard single-disk clutch (movable friction surface is drawn towards the stationary friction surface by a specially designed worm thread so that the friction plate comes in contact with the friction material smoothly and gradually)

Erie Standard friction clutch pulley (hard wood; the clutch pulley has a long, spiral, self-oiling hub made in halves)

Meeseco short shaft clutch (cone type, all-metal, with the friction wearing surface of hard babbitt)

Hanson friction clutch (dust-proof friction surfaces are either steel and iron bathed in oil, or steel and compressed friction paper)

OK combined friction and positive clutch (in engaging or starting the load the friction will gradually start the load, and when a certain point is reached the friction will slowly release, giving the steel points a chance to enter a series of holes in the driven part)

S. & S. friction clutch (friction furnished by two sets of wood blocks; clutch is self-centering)

Cleveland friction clutch (expanding-ring, self-oiled, friction surfaces metal-to-metal running in oil)

Conway solid compression clutch (friction-band type)

Johnson friction clutch

Brown friction clutch

Webster steel-plate friction clutch (clutch elements consist of a circular steel plate with rings of a special friction board attached to both faces and toggle-actuated iron mating rings which engage the friction disk for creating the driving connections)

S.-A. steel-plate clutch pulley (friction surface consists of a heavy steel plate or disk both sides of which are shod the entire circumference with hard paper friction board secured to the plate with maple dowels, thus giving a friction surface of both hard paper and hard wood.

Lemley friction clutch (friction contact wood to iron; adjustment made by means of a threaded ring secured to the clutch sleeve; this one ring adjusts all toggles at the same time assuring a like pressure on each toggle)

Hill friction clutch. Smith type (friction surfaces wood against iron. All working parts, including the inside jaws, may be removed parallel to the shaft from the mechanism side without disturbing the main spider casting or pulley; clutch is self-centering)

Frisbie friction-clutch pulley

Tester friction clutch

Dodge patented split friction clutch (friction through an outside disk into which are driven hard-maple blocks presenting end grain)

(*Mill Supplies,* vol. 6, no. 9, p. 41, September, 1916, 16 pp., 30 figs. *d.*)

Laying Out Skew Bevel Gears, Reginald Trautschold

The author claims that the skew bevel gear has been generally avoided by both designers and machinists; by the former on account of the difficulty experienced in laying it out, and by the latter because of a fancied intricacy in the method of cutting.

As a matter of fact they are not as difficult to cut as was assumed, although the cost of their manufacture is slightly greater than that of an ordinary bevel gear.

There are two general types of skew bevel gears which, for the sake of brevity, may be referred to as types A and B. In the former a pinion of the ordinary bevel-gear type is employed, the oblique teeth being confined to the gear, and in the latter the teeth are oblique in both pinion and gear. In each type the pitch surface of the pinion is the frustum of a figure generated by the revolution of a straight line about the axis of the figure, the generating line lying in a plane parallel to a plane through the axis, and being neither parallel nor at right angles to the axis, *i.e.*, the figure is a hyperboloid of revolution.

The author gives a general discussion of both types of gears, instructions as to their cutting, and formulae for both types. Only the latter are here reproduced.

Notation for Skew Bevel Gears

p = diametral pitch;
n = number of teeth in pinion;
N = number of teeth in gear;
X = offset of pinion shaft;
ϕ = angle of offset;
d = pitch diameter of pinion;
D_e = equivalent pitch diameter of gear;
D = pitch diameter of gear;
d' = outside diameter of pinion;
D' = outside diameter of gear;
p' = circular pitch of pinion;
P' = circular pitch of gear;
E' = center angle of pinion;
F' = face angle of pinion;
C' = cutting angle of pinion;
E = center angle of gear (shop angle);
F = face angle of gear (shop angle);
C = cutting angle of gear (shop angle);
E'' = center angle of gear (design angle);
F'' = face angle of gear (design angle);
C'' = cutting angle of gear (design angle);
J = angle increment of pinion;
K = angle decrement of pinion;
d'' = diameter increment of pinion;
D'' = diameter increment of gear;
s = addendum;
V = radius of circle of apexes for pinion;
W = radius of circle of apexes for gear;
X = total offset of pinion shaft = $V + W$;
y = angle of offset for pinion;
z = angle of offset for gear;
R = speed ratio = N/n;
J'' = angle increment;
K'' = angle decrement;
P'' = circular pitch;
d_e = equivalent pitch diameter of pinion.

Formulae for Skew Bevel Gears—Type A

$$d = n/p \quad [1]$$
$$D_e = N/p \quad [2]$$
$$\tan \phi = 2X/D_e \quad [3]$$
$$D = 2X/\sin \phi \quad [4]$$
$$P' = 3.1416D/N \quad [5]$$
$$\tan E' = d/D_e \quad [6]$$
$$\tan J = 2 \sin E'/n \quad [7]$$
$$\tan K = 2.314 \sin E'/n \quad [8]$$
$$F' = E' + J \quad [9]$$
$$C' = E' - K \quad [10]$$
$$s = d/n = D/N \quad [11]$$
$$d'' = s \cos E' \quad [12]$$
$$d' = d + 2d'' \quad [13]$$
$$E = 90 - E' \text{ (shop angle)} \quad [14]$$
$$\tan E'' = D - 2X/d \text{ (design angle)} \quad [14a]$$
$$D'' = s \cos E \quad [15]$$
$$D' = D + 2D'' \quad [16]$$

or, for greater accuracy:

$$D' = D + 2d''D_e/D$$
$$C = E - K \text{ (shop angle)} \quad [17]$$
$$C'' = E'' - KD_e/D \text{ (design angle)} \quad [17a]$$
$$F = E + J \text{ (shop angle)} \quad [18]$$
$$F'' = E'' + JD_e/D \text{ (design angle)} \quad [18a]$$

Formulae for Skew Bevel Gears—Type B

$$V = X/R + 1 \quad [1]$$
$$W = RV \quad [2]$$
$$D_e = N/p \quad [3]$$
$$\tan y = 2V/D_e \quad [4]$$
$$D = 2V/\sin y \quad [5]$$
$$d = Dn/N \quad [6]$$
$$p'' = 3.1416d/n = 3.1416D/N \quad [7]$$
$$\tan E'' = d/D \quad [8]$$
$$E = 90 - E' \quad [9]$$
$$\tan J'' = 2 \sin E'/n \quad [10]$$
$$\tan K'' = 2.314 \sin E'/n \quad [11]$$
$$F' = E' + J'' \quad [12]$$
$$C' = E' - K'' \quad [13]$$
$$F = E + J'' \quad [14]$$
$$C = E - K'' \quad [15]$$
$$s = d/n = D/N \quad [16]$$
$$d'' = s \cos E' \quad [17]$$
$$D'' = s \cos E \quad [18]$$
$$d_e = n/p \quad [19]$$
$$d' = d + 2d'' \quad [20]$$

or, for greater accuracy:

$$d' = d + 2d''d_e/d$$
$$D' = D + 2D'' \quad [21]$$

or, for greater accuracy:

$$D' = D + 2D''D_e/D$$

(*Machinery*, vol. 23, no. 1, p. 32, September, 1916, 5 pp. 2 figs., *pg.*)

Measuring Instruments

Venturi Meters on Lively Lines, Allen Hazen

Discussion of the accuracy of venturi meters when used for measuring non-uniform flow. The author believes that where variations in flow are rapid so that there are substantial changes in rate in a single second, an error may be introduced. This error may be of considerable importance on lines carrying water directly discharged from reciprocating pumps or from a reservoir into a system where wide and sudden fluctuations in rate of draft are taking place.

The theoretical reason for the error is that the venturi recorders in reality sum up the squares of the flows. The height of the mercury column that is the starting point in the registration is proportional to the square of the velocity. The author takes an extreme case: for half a second the velocity is nothing and for half a second it is 2 ft. per second. For the whole second the average velocity will be 1 ft. per second, but the height of the mercury column will tend to be for the first phase zero, and for the result corresponding to the average height of the mercury column, which is 2, the quantity indicated will be the square root of 2 or 1.41 in place of the true quantity, which is 1. In this case the error of over-registration will be 41 per cent. This is, of course, entirely excessive, but in actual practice errors from 2 to as high as 10 per cent may be anticipated, always in the same direction, namely, registration will be above the truth.

From the writer's experience, the percentage error with

lively lines is much greater at low flows. Errors like those in the venturi measurements resulting from rapid fluctuation in velocity also occur with all other methods of measuring water (pitometer, standard orifice, etc.), which depend upon the effect of velocities upon pressures. What is necessary is some better apparatus for integrating flows of venturi meters. (*Engineering News,* vol. 76, no. 7, p. 293, Aug. 17, 1916, 1 p. *gp.*)

Recent Development in Heavy Track Scale Construction, J. H. A. Bousfield

Reprint of paper delivered before the 1916 convention of the National Scalemen's Association at Cincinnati, Ohio.

Description of what is claimed to be the largest track scale in the world. It has been installed by the New York Central Railroad Company at West Albany, N. Y., is 100 ft. in length, and is built in six sections, each section designed for a con-

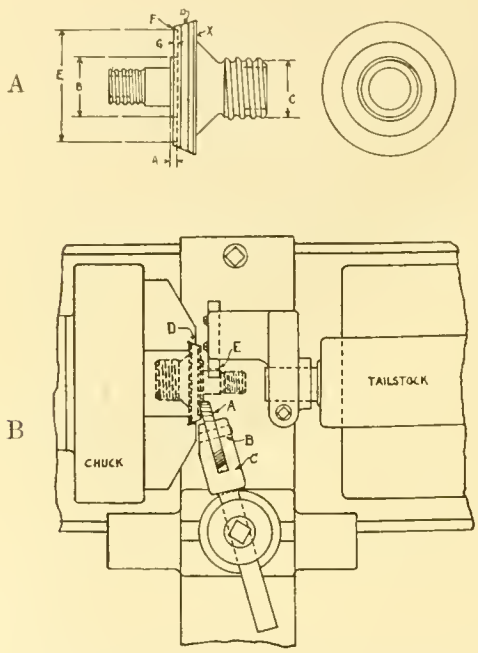

Fig. 3 Methods of Reclaiming Russian 3-in. Shrapnel Fuse Bodies: A, Outline Drawing of Fuse Body; B, Method of Lengthening Shoulder *A*, Fig. A

centrated load of 270,000 lb. The secondary or extension levers are designed to be of sufficient strength to transmit this load applied at each section simultaneously to the fifth lever and thence to the weighing beam, so that the lever system is capable of sustaining a load of six times 275,000 lb. or 1,650,000 lb.

The scale was built to be of sufficient length and capacity to weigh the largest locomotive or car built at the present time or likely to be built for many years to come.

With a concentrated load of 275,000 lb. per section and 137,500 lb. per main lever, the problem presented itself of producing a knife edge in the main levers of sufficient length to reduce the load per lineal inch below 7000 lb. (American Railway Association specification) and to properly support it so as to insure an equal distribution of the load throughout its length without undue deflection. To do this a double web construction was adopted, as with this construction connected by heavy transverse sections over and under the knife edges, a very efficient support is obtained throughout the full length of the knife edge. The load and fulcrum knife edges in the main lever are 21 in. long.

To preserve the true relative position of the main lever stands with the end and the middle extension lever stands and to insure stability, a system of transverse bracing is used. This bracing consists of heavy T-section members securely attached by flange connection to the lever stands.

The material used for pivots and bearing steels throughout the scale was high grade chromium-vanadium alloy steel with a tensile strength of 200,000 lb. per sq. in., hardened in oil. With this grade of steel very little trouble was experienced in keeping the long knife edges straight, and consequently very little grinding was necessary after the pivots and bearings were hardened.

After installation at West Albany the scale was tested with two test cars weighing respectively 80,000 and 60,500 lb. Each section was tested separately with each of the cars, and a variation of less than 10 lb. was established by the results. The same degree of accuracy was attained when both cars were used giving a test load of 140,500 lb., and the sensibility reciprocal was 20 lb. (*Scale Journal,* vol. 2, No 11, p. 5, August 10, 1916, 3 pp., 11 figs. *d.*)

Munitions

Effect of Gravitation on the Flight of Projectiles

A general, rather elementary discussion of the conditions governing the flight of projectiles, with an elementary formula concerning vertical, horizontal and angular projection. (*Canadian Machinery and Manufacturing News,* vol. 16, no. 11, p. 279, September 14, 1916, 3 pp., 4 figs. *g.*)

Reclaiming Russian Three-Inch Shrapnel Fuse Bodies, H. M.

Many manufacturers in the earlier stages of the development of the munitions industry did not realize the high degree of accuracy insisted upon by the inspection for the Russian fuse, and have undertaken to produce them by the usual various makeshift tools. The result was that much of the work was rejected and many producers are now, when they have learned more about the industry, turning their attention to the reclaiming of some of the rejected work.

Of course, much of this work either cannot be saved at all, or the parts are so simple that it is not worth the trouble. However, the case is different with some other parts.

One of the most expensive parts of the fuse is the body shown in Fig. 3A, which in the case of the 3-in. fuse is made from an aluminum composition casting which is compressed and machined all over. A large number of these bodies have been rejected owing to the shoulder *A* being too short. If the diameter *B* has sufficient stock to permit, this diameter can be rolled with a tool such as is shown in Fig. B, which compresses the metal lengthwise, thereby lengthening the shoulder *A*. The tool Fig. B consists merely of a roll *A* mounted on a stud *B* in a suitable holder *C* which is sufficiently strong to resist the pressure of rolling the aluminum over. The work is held on the large diameter in chuck jaws *D* and is supported by the back rest *E*.

Another trouble was that the pitch diameter *C*, Fig. A, was very slightly too small. As the tolerance on the outside diameter of the thread is greater than that allowed on the pitch diameter, it is often possible to reclaim bodies rejected from this cause by rolling the thread with the tool Fig. C. This tool

was made with the idea of jamming the top of the thread and thereby causing the metal to be squeezed outward at the pitch diameter.

This tool is smaller in construction than that shown in Fig. B, with the exception that it was made straight instead of offset.

To save bodies which had the diameter *E* bored out too much it was found that there were two chances to save them: First, if the diameter *D* had sufficient stock to permit of rolling with the tool Fig. D the top diameter was squeezed, thereby causing the metal to be compressed sufficiently to allow of boring the diameter *E* to the correct size. With this method it was usually found necessary to trim up the face *X* at the bevel side. The other method of reclaiming the bodies is to apply a roll on the surface *F* provided the depth *G* is long enough to permit

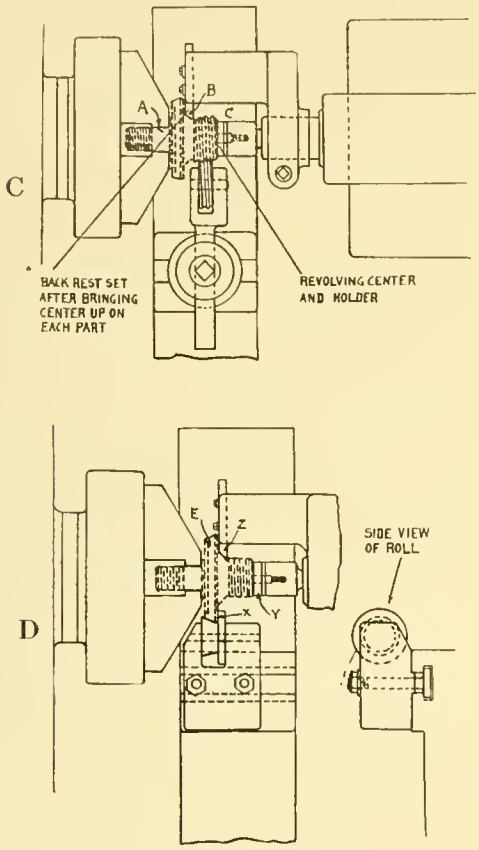

Fig. 3 Methods of Reclaiming Russian 3-in. Shrapnel Fuse Bodies: C, Method of Rolling Thread to Increase Pitch Diameter; D, Arrangement of Tools Used for Rolling Outside Diameter

this. A special roll for accomplishing this is shown in the original article. (*Canadian Machinery and Manufacturing News,* vol. 16, no. 11, p. 287, September 14, 1916, 1 p., 5 figs. *d.*)

Pile Drivers

Pile Driving

Description of a pile extractor built by the Ransome-ver-Mehr Machinery Company, Ltd., London, England.

The usual methods for drawing of piles are still somewhat primitive. In cases where the tops of the piles are under water level, as in bridge foundations, the usual procedure has been to attach the piles to the top of a barge or pontoon so that the rise of the tide and the buoyancy of the pontoon drew the piles from the bottom of the river or the sea bed. This is a slow and dangerous process and besides not applicable where there is no tide. In land operation equally crude methods are used, such as drawing the piles by jacks, union screws or pulley blocks suspended to a crane.

The extractor described here is devised to reverse the process of pile driving. Instead of the blow being struck by the force of gravity acting on a hammer dropped from a height onto the top of the pile, steam is utilized in the cylinder to give an upward blow to an anvil in the form of a crosshead which is con-

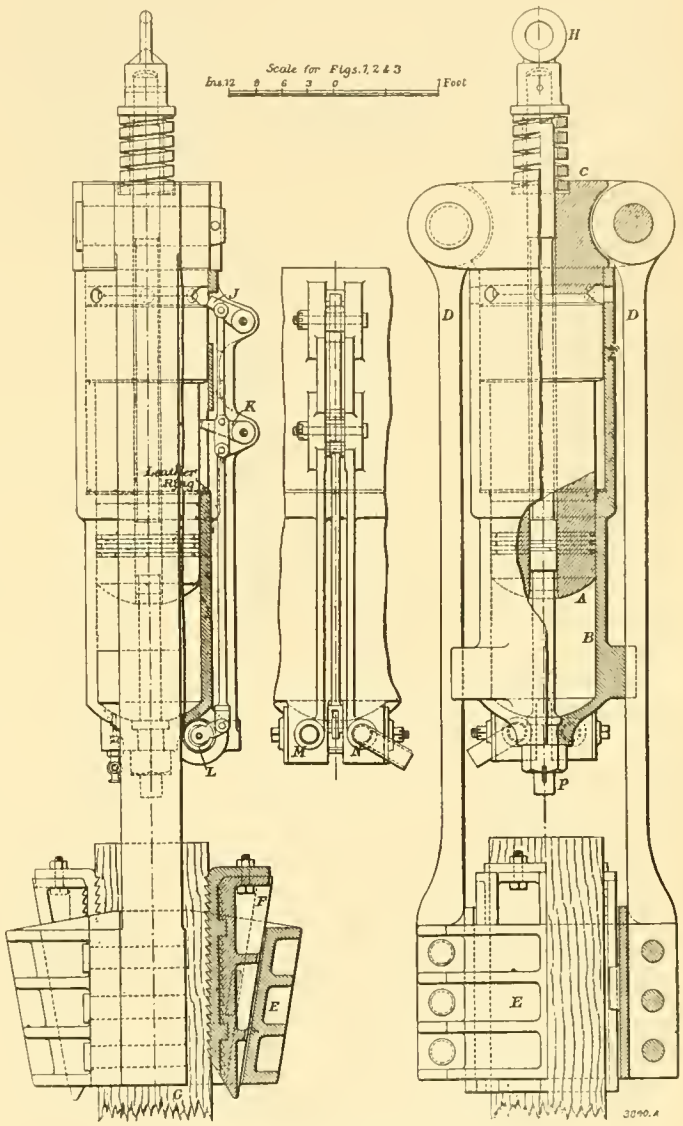

Fig. 4 Ransome Pile Extractor

nected by vertical links to a grip-box placed under the cylinder and carrying wedge-shaped serrated jaws which, with the grip-box, surround the pile, so that as the steam impinges on the piston and strikes the anvil, an upward pull is exerted on the top of the pile through the connecting links and the grip-box. Fig 4 shows in detail the main units of the extractor. *A* is the piston or monkey working in the cast-steel cylinder *B; D, D* are the forged-steel connecting rods to the cast-steel grip-box *E,* in which are fitted the serrated cast-steel jaws *F* to engage with the pile *G.*

Of course the cylinder cannot operate under the water level, but this can be overcome by increasing the length of the con-

necting rods between the anvil and the grip-box. An important element in the success of the extractor is the abundance of steam supply. This is transmitted through flexible tubing. Once the hammer action has commenced it is important that it should not cease until the pile has been extracted or is sufficiently loose to enable it to be easily withdrawn by a small crane or by winches arranged to do so. If there is any discontinuity in the hammering, the jaws are likely to get out of position.

The method of suspending the extractor is another important element in its success and rapidity of operation. In some cases it is hung on a pile-driving machine, but in one of the most effective installations a 10-ton steam derrick crane is utilized having a 60-ft. jib. The kingpost under the mast is mounted on a 3-wheeled bogie. One of the two guys is mounted on a 2-wheeled bogie and the other on a 3-wheeled bogie, which also carries the boiler to supply steam to the extractor. This crane installation has the advantage that the extractor is free to oscillate when in operation, which helps in slackening the pile. Moreover, when the extractor is working,

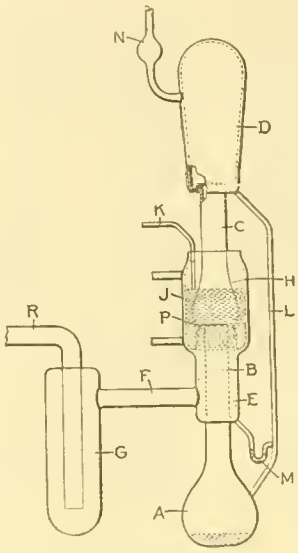

Fig 5 High-Vacuum Mercury Speed Vapor Pump of Extreme Speed

the crane engine is set in motion, maintaining a tensile strain on the suspension wire rope so that the hammer action of the extractor is assisted by the pull on the crane. Further, the crane does not have to be moved for every pile, as in the case described it commands an arc of 270 deg.

In one of the shipbuilding berths there were about 1200 piles 13 to 14 in. square, ranging in length from 29 to 36 ft. in the upper part of the berth and from 15 to 20 ft. at the lower part. All were driven for their full length into the London clay. The average time for drawing a pile was well under 3 min., although in a few cases as long as 10 min. have been taken. The plant as equipped and in operation cost about £1500 (roughly $7500). (*Engineering*, vol. 102, no. 2644, p. 198, September 1, 1916, 3 pp., 7 figs. *d.*)

Pumps

A High-Vacuum Mercury-Vapor Pump of Extreme Speed, Irving Langmuir

The new pump is based on the same principle as aspirators or ejectors, in which a blast of steam or air is used to produce a partial vacuum. In these devices the high velocity of the jet of steam causes a lowering of pressure, so that the air to be exhausted is sucked directly into the jet. If, however, the jet were surrounded by a perfect vacuum, there would be a blast of gas molecules escaping from the jet into this vacuum, and therefore it is not possible to obtain a very high vacuum by means of an instrument based on the principle of the ordinary ejector or aspirator.

The action of these instruments consists really of two processes: (1) the process by which the air is drawn into the jet; (2) the action of the jet in carrying the admixed air into the condensing chamber.

The aspirators cease operating at low pressures because of the failure of these processes. If air at low pressure could be made to enter the jet, and if gas escaping from the jet could be prevented from passing back into the vessel to be exhausted, then it should be possible to construct a jet pump which would operate even at the lowest pressures.

Gaede has recently described a pump, called a diffusion pump, in which a blast of mercury vapor carries along the gas to be exhausted into the condenser. In order to introduce the gas into the blast of mercury vapor, Gaede has used diffusion through a slit of a width comparable with the mean free path of the mercury atoms in the blast. A portion of the mercury blast escapes through the slit, and the gas to be exhausted diffuses in against this blast of mercury vapor. This renders it necessary to make the slit very narrow (about 0.1 mm), and for this reason the speed of the pump is necessarily low (only about 80 cc. per second as against 1300 cc. per second for the molecular pump.

The writer found that there are other methods by which the gas to be exhausted may be introduced in the blast of mercury vapor, and out of this has been developed the type of pump shown in Fig 5, which has given satisfactory results.

In this device a blast of mercury vapor passes upward from the heated flask *A* through the tubes *B* and *C* into the condenser *D*. Surrounding *B* is an annular space *E* connecting through *F* and the trap *G* with the vessel to be exhausted. The tube *C* is enlarged into a bulb *H* just above the upper end of the tube *B*. This enlargement is surrounded by a water condenser *J*, from which the water is removed at any desired height by means of the tube *K*, which is connected to a water aspirator. The mercury condensing in *D* and *H* returns to the flask *A* by means of the tubes *L* and *M*. The tube *N* connects to the "rough" or "backing" pump, which should maintain a pressure considerably lower than the vapor pressure of the mercury in *A*.

In this pump, the mercury atoms escaping from the upper end of the tube *B* radiate out in all directions. A part of them passes up into *C*, but the larger part strikes the walls of the enlargement *H*.

If there is no water in the condenser *J*, the mercury which condenses on the walls reëvaporates nearly as fast as it condenses. The molecules passing from the end of the tube *B* towards the walls *H* collide with the molecules with reëvaporate, and may then be deflected downward into the annular space *E*. This blast of mercury vapor down through *E* prevents the gas from *F* from passing up into *H*, so that under these conditions the gas from *F* may pass through the pump much more slowly than if no mercury vapor were produced in *A*.

On the other hand, when cold water circulates through the condenser *J*, all the mercury atoms striking the walls of *H* are condensed, so that no mercury passes down through *E*. The gas from *F* thus passes freely up through *E*, and when it

meets the mercury-vapor blast at P is blown outward and upward along the walls of the condenser H, and finally forced into the main stream of mercury vapor passing up through C into the condenser D.

A vessel of eleven liters capacity was connected to R. Air was admitted to the vessel and the pressure was found to decrease as follows:

Time Sec.	Pressure in Bars at R	Pressure in Bars at D	Time Interval, Sec.	Speed in Cc. per Sec.
0	1,470	1,160	..	....
30	294	720	30	590
60	12.8	218	30	1,150
80	0.015	18	20	3,700

The rough pump used had a speed of about 200 cc. per second at pressures of 400 bars, but this speed fell off to 60 cc. at 40 bars, and became zero at about 10 bars. The speed of the mercury-vapor pump increased rapidly as the pressure decreased and reached a limit of about 4000 cc. per second at pressures below 10 bars. Theoretical considerations would indicate that this speed should remain constant down to the very lowest pressures.

Several experiments with hydrogen showed that the maximum speed with this gas was about 7,000 cc. per second. (*Physical Review,*) vol. 8, no. 1, p. 48, July, 1916, 4 pp., 1 fig. *d.*)

Centrifugal-Pump Casings

Centrifugal pumps of the turbine type have been usually built with solid cylindrical casings or casings split in the horizontal center plane. Sometimes pumps have been made with casings divided at right angles to the axes—the number of units generally corresponding with the number of stages—and held together by bolts or studs passing from end to end. The design with one cylindrical casing for all stages has the drawbacks that special patterns are necessary for any required number of stages, and that dismantling may be troublesome owing to internal parts sticking to the casing due to rust. The drawback of the pump built in stages without an outer casing is the impossibility of dismantling the pump without breaking either the suction or delivery-pipe joint.

In order to obviate the drawbacks of both constructions, Rufener & Wiesengrund, of Horton Bridge, Yiewsley, Middlesex, England, have patented assembled-stage casings which have water-tight joints between each other in a plain outer cylindrical casing; this latter can be molded with a striking board, and is not subject to any water pressure, but merely serves to hold together the separate suction and delivery ends of the pumps, besides centering the stage casings.

The delivery end is made with such internal diameter that all the stage casings can be withdrawn without fouling the delivery end. It is an annular chamber with a circular cover which contains the automatic balancing device, varies the delivery-end bearing, and, when bolted to the annular delivery chamber, holds the various stage casings firmly together. In order to take the pump to pieces it is only necessary to take off the delivery-end cover, when all internal parts of the pump can be withdrawn without breaking any pipe connection.

Referring to the Fig. 6, A is the suction end of the pump bolted to the cylindrical outer casing B. C, J, etc., are the stage casings contained in outer casing B. The first-stage casing is fitted to the suction end A with water-tight joints, and similar joints are formed between the stage casings, the number of the latter varying according to requirements. The last-stage casing marked K is provided with a flange and projections E. A small clearance space is allowed between the flange of the last-stage casing and the flange of the outer casing. Into this clearance space a packing ring F, of suitable material, is inserted. Centered on the flange L of the outer casing and bolted to the latter is the annular delivery chamber D. Bolted to the delivery chamber is the end cover G. A clearance space is provided between the flange of the end cover and the delivery chamber, the water-tight joint being made by a suitable packing ring H. When the end cover G is bolted to the delivery chamber, its inside press against the projections E, and thus establishes the tight fit of the water-tight joints of the stage casings. It will be seen that with this construction the stage casings, with the parts which they contain, can be withdrawn after removal of the end cover G, while suction end A and delivery chamber D remain in position bolted to outer casing B, so that the pipes which join on to A and D, respectively, can remain undisturbed. (*Mechanical Engineer,* vol. 38, no. 968, p. 98, Aug. 11, 1916, 1 p., 1 fig. *d.*)

Refrigeration

Raw-Water Can Ice, Van R. H. Greene

Raw-water can ice was first put in use in St. Louis many years ago, but the process has lain dormant until the last two years because of the difficulties that were experienced in this St. Louis plant in making ice that was marketable. The system most frequently installed at first by the ice-machine builders was that of low pressure, which means that air was forced through a tube suspended vertically in an ice can filled with water with just sufficient pressure to agitate the water in the can. The result of this agitation was the washing of the air bubbles away from the sides of the forming ice and the rendering of the ice clear and transparent so long as the tube continued to blow air into the water in the can. When, however, the tube suspended in the water was reached by the formation of the ice, the outlet of the tube was closed and air ceased to blow from that point, making a core in the ice block which was opaque and white, due to the presence of air. This core could be eliminated by the removal of the tube just prior to the time that it would be frozen into the ice, sucking out the unfrozen core water and replacing it by distilled or by raw water which had previously been cooled.

The use of distilled water was objectionable because it gave the same unpleasant odor and core test as was characteristic of a distilled-water block, the avoidance of which is the whole aim of the raw-water can ice system. A better plan was to replace the core water by precooled fresh raw water.

Then Mr. Beals of Detroit discovered that it required some two pounds pressure to blow air through ice which had been formed around the outlet of the air tube, and that the presence of the ice surrounding the tube soon deposited out the moisture which is in all air and caused it to freeze inside of the tube, ultimately plugging it up entirely.

He therefore designed a double-pipe air dryer by which the air was thoroughly dried before being admitted into the ice-can tube, and the pressure was raised sufficiently high to cause the air to blow through the ice, even after the ice had frozen solid around the tube outlet (high pressure system).

In the high pressure system a pressure of approximately 45 lb. is used, the air being allowed to expand in the air tube from this pressure down to a pressure of approximately two pounds. The blowing of air against a pressure of 45 lb. requires, of course, much more horsepower than does the blowing of a smaller quantity of air against a pressure of four pounds. This increase of horsepower is, however, somewhat

compensated by the volume of air blown into the cans being smaller than with the low pressure system; nevertheless, the horsepower required in the high pressure system is approximately twice that used in the low pressure system.

Another system, in the development of which the writer was associated, has the ice tube suspended from the sides of the cans into the water and not made an integral part of the ice cans, as in the case of the Beals and York systems. The result is that it is only necessary to compress the air to a pressure sufficiently high that when cooled to 36 deg. fahr. and expanded to 2 lb. pressure or so the dew point of the air will be slightly below that of the temperature of the surrounding ice rather than the surrounding brine.

Tests which the writer made at the plant of the Independent Ice Company, of Baltimore, Md., show that the temperature of the ice surrounding the tube seldom gets below 20 deg. fahr., which makes it possible to keep this air blowing by compressing it to 25 lb. pressure per sq. in. instead of 45 lb., and producing the same results as do the other systems. With this system the air tube is frozen into the ice block and must be removed by some means before the cake can be placed on sale. At the plant in Baltimore this is accomplished by injecting a steam jet into the ice block. Where the plant must be operated by electric power or by an oil or gas engine, difficulty will be experienced in thawing out this tube economically. The writer has tried out a scheme of winding the air tube with resistance wires and thawing it out electrically. In his opinion, the only objection that can be found to such a method lies in the fact that with the additional winding the air tube becomes of a diameter slightly larger than ½ in., and leaves a hole remaining in the ice block which might be objectionable in appearance to certain classes of trade.

In the writer's opinion, the secret of manufacturing raw-water can ice lies in two points—the ability to agitate the water continuously until the block is frozen solid, and the making use of water for ice-making purposes which is suitable for this requirement. (*Refrigerating World*, vol. 51, no. 2, p. 27, August, 1916, 3 pp., 3 figs. *de.*)

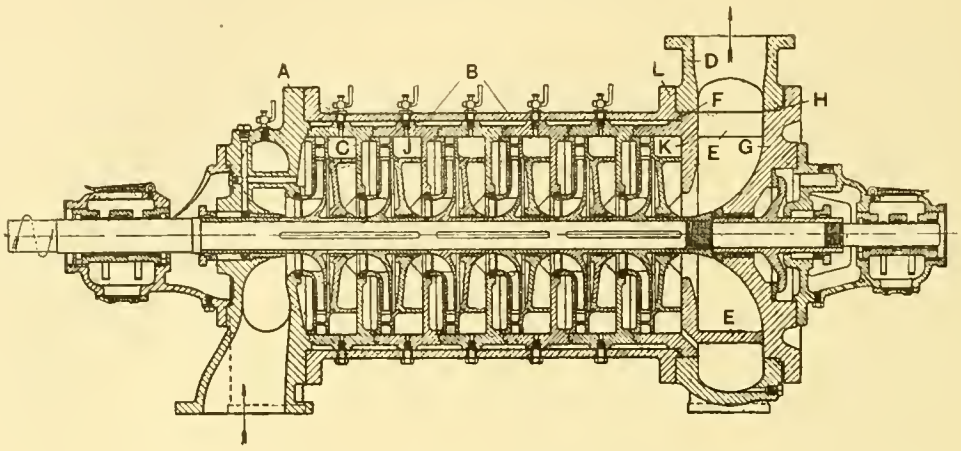

Fig. 6 Improved Turbine Pump Casing

Steam Engineering

The Air Supply to Boiler-Rooms on Warships

In a pamphlet recently published, Mr. R. W. Allen, M. Inst. C. E., of the Queen's Engineering Works, Bedford, has collected together some valuable data on the supply of air to boiler rooms. He lays special emphasis on the need of providing ample and unobstructed airways in order to avoid a waste of the head generated. The head wasted varies nearly as the square of the air velocity, as it is not practicable to reconvert into pressure head any substantial fraction of the velocity head of the moving fluid. Mr. Allen quotes a number of cases of excessive velocities in the air shafts of different warships, ranging from 48 ft. up to 78 ft. per sec. In practice a high velocity in the air ways means that the effective gage in the boiler room is reduced by the head equivalent to this velocity. With such an air speed as 78 ft. per sec. this reduction amounts to 2 in. That these excessive speeds are not unavoidable is shown by the quotation of other figures, where even on destroyers the air velocity has been kept down to 42 ft. per sec. In certain cases the air shafts have been thought convenient places for the storage of hose, etc. In other cases pipes have been led through them, with little or no consideration, to the consequent obstruction of the air way. Again, the openings above deck are often far from as free as is desirable. Deck erections, for example, may obstruct the access of air to the whole of one side of the intake, and some instructive examples of this are given. The armor bars or gratings are also commonly of bad form. Experiments made at Bedford with bars of "fair form" instead of rectangular showed with the fair form a zero pressure drop across the grating, while with the rectangular bars the loss of head due to the obstruction was 0.22 in. (water gage) with a velocity of 53.7 ft. per sec. Mr. Allen states that when two fans are mounted close together their performance can be greatly improved by fixing appropriate deflector plates so that the air currents as delivered shall not interfere with each other, and similar plates have also proved advantageous even with single fans, tests made with ribbons in the boiler rooms having shown that in many cases the air is far from taking the most direct line to the furnaces. In conclusion, Mr. Allen draws attention to the great progress which has been made of recent years in fan design, which he illustrates very strikingly by comparative photographs of the impellers of the old and of the new type. The same duty is now obtained from an impeller 52 in. in diameter as from one of 81 in. in diameter a few years ago. (*Engineering*, vol. 102, no. 2643, p. 174, August 25, 1916, 1 p. *p.*)

Heat-Transmitting Tubes for Evaporators

A patent has recently been granted to Watson and Billetop, of Newcastle-on-Tyne, England, in which heat-transmitting

tubes for evaporators are provided with a carrier plate adapted to form a longitudinal medial division plate in the tube, dividing the flow of fluid into two streams, and to carry a series of baffle plates alternately arranged so that successive plates are opposite one another, whereby each of the two streams is sigzagged and effectively baffled by the one set of plates as shown in Fig. 7-1. The tube A is fitted with a carrier plate B of width equal to the diameter of the tube. This plate is notched at F, Fig. 7-7. The baffles C and G are shaped as shown Figs 7-5-6, which show them reversely set; they are all of the same shape, but alternate sets are oppositely disposed as shown

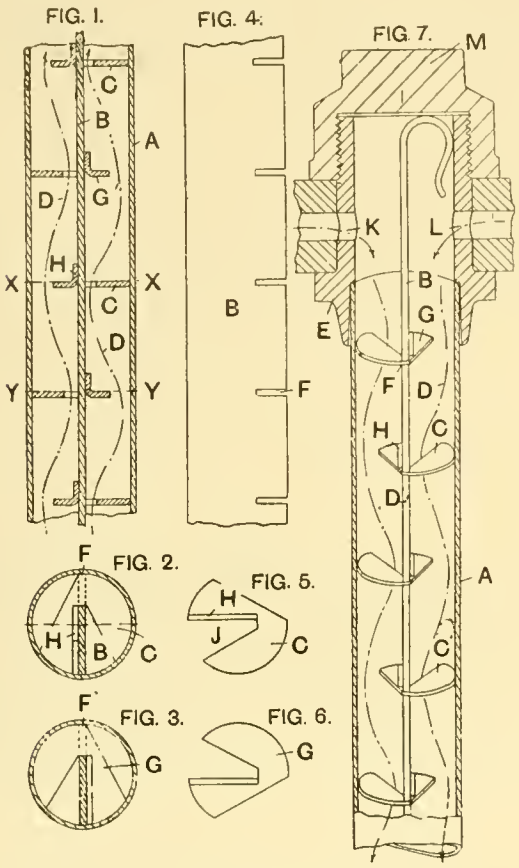

Fig. 7 Improved Evaporator Tube

in Figs 7-1-7. They are held in position by being fitted into the notches F of the plate B and are attached thereto by means of the lugs H which are turned up when forming the V-notches J in the baffles. The plate B divides the fluid passing through the tube into two streams, and the alternate arrangement of the baffles causes each stream to take a zigzag path, as shown by the dotted chain line D. Fig. 7-7 shows the tube connection E fitted with ports K and L and with the coupling nut M. Upon removal of this nut the plate B can be withdrawn with the baffles in position by means of the handle shown. (*The Mechanical Engineer,* vol. 38, no. 971, p. 171, September 1, 1916, 1 p., 7 figs. *d.*)

Design of Superheaters, William C. Strott

The writer gives a formula for calculating the amount of surface required for a superheater under varying conditions of service.

The formula is as follows:

$$x = \frac{10S}{2(T-t)-S}$$

where x = sq. ft. of superheating surface required per boiler horsepower

S = superheat required in deg. fahr.

T = temperature of furnace gas at superheater in deg. fahr.

t = temperature of saturated steam at boiler pressure in deg. fahr.

The value of T can be obtained from the following equation:

$$\frac{1}{(T-t)^{0.16}} = (0.172H + 0.294)$$

where H is the percentage of boiler-heating surface between the furnace and superheater.

The author gives an example for using this formula. It is to be remembered that it is assumed that steam is a perfect gas; for every one per cent of moisture in the saturated steam, allow fifteen per cent more superheater surface than found by the use of this formula. (*Power,* vol. 44, no. 6, p. 199, August 8, 1916, 2 pp. *p.*)

Testing

Apparatus for Testing Crescent Screwdrivers, C. L. L.

Description of an apparatus for testing the strength of screwdrivers and detecting soft blades or other hardening defects.

The apparatus is very simple. Upon the side of the testing wall a center stud is located on which a long lever is pivoted. The fulcrum point of this lever is slotted to receive the screwdriver blade. The lever is approximately 24 in. long and is attached at its outer end to the weight hook of a spring balance after the weighing pan has been removed.

The inspector inserts the blade of the screwdriver in the slot at the center of the pivot arm and with a wrench turns the arm and pulls down the scale beam until the indicator reaches a predetermined number of pounds. If the blade fails to bend or break the screwdriver is adjudged perfect, otherwise it is rejected. (*Machinery,* vol. 22, no. 12, p. 1025, August 1916, 1 p., 1 fig. *d.*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

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Present state of aerodynamics (serial).

LES HYDRAVIONS ALLEMANDS, L'HYDRAVION BIMOTEUR. L'Aérophile, 24 Annee, nos. 13-14, 1-15 Juillet 1916, 6 pp., illustrated.
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THE BERKSHIRE MAGNETO. Aerial Age, vol. 3, no. 24, August 28, 1916, 1 p., illustrated.

EXPERIMENTS ON A DIHEDRAL ANGLE WING, J. C. Hunsaker and D. W. Douglas. Aerial Age, vol. 3, no. 24, August 28, 1916, 1 p., 2 figs.

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DRY COMPRESSED AIR FOR POWER MACHINERY. Steel and Iron, vol. 50, no. 8, August 1916, 1½ pp.

ACTUAL COSTS OF MINE HAULAGE BY HORSES AND BY COMPRESSED AIR, Ravul Green. Compressed Air Magazine, vol. 21, no. 9, September 1916, 1¼ pp.

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ALUMINUM CASTINGS AND FORGINGS, P. E. McKinney. A paper presented at the Annual Meeting of the American Institute of Metals, September 11-15, 1916, at Cleveland, Ohio, no. 15, 6 pp.

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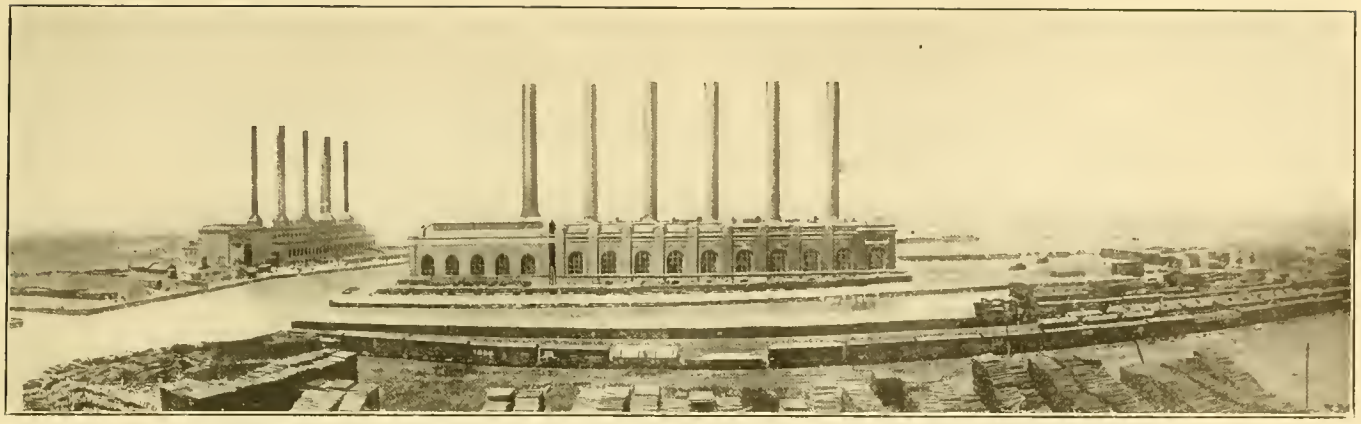

Fig. 1 Exterior View of Fisk and Quarry St. Stations, Chicago, Ill.

THE PROGRESS OF ECONOMIC POWER GENERATION AND DISTRIBUTION

By SAMUEL INSULL,[1] CHICAGO, ILL.

THE first part of this paper is devoted to the historical aspect of the generation and distribution of electrical energy, and traces the growth of the industry from the point of view of the apparatus used. This part is of special utility as a source of reference; it is referred to briefly in this abstract.

The second part deals with some of the economic problems in connection with the business, and is of current interest; it is here published in full.

GREAT MODERN GENERATING STATIONS

Fig. 1 gives an outside view of the Fisk and Quarry Street stations on the Chicago River. The large building in the center of the picture is the Fisk Street station and the building on the left is the Quarry Street station. The Fisk Street station was the first large steam-turbine station ever erected. Turbines of a few thousand kilowatts had been put into use by Parsons of England and Brown, Boveri & Co. of Switzerland, and one or two German manufacturers; but this was the first station built for steam turbines alone, and I think it was the first station built by an Edison company using alternating current as the basis of its generation.

The capacity of the Fisk Street station is 165,000 kw., or 247,000 h.p., and of the Quarry Street station is 84,000 kw., or 126,000 h.p. They are both run as one, under one organization, and together have a capacity of 249,000 kw., or 373,000 h.p. I presume that sometime in the next few years those two stations will represent a total of about 500,000 h.p.

To show the magnitude on which the business is conducted, these stations have been run at the highest possible load factor because the apparatus there, up to a short time ago, was the most economical that we had, 3,277,300 kw-hr. being generated in the combined plants in one day. That was on the 24th of December of last year. In the year 1915 the two plants generated 961,818,000 kw-hr., and the total energy generated to date by those two plants amounts to 5,814,162,000 kw-hr. These figures will give you some idea of the enormous production that electrical energy has achieved in the larger cities of the country.

GENERATING UNITS OF FISK STREET STATION

The view presented in Fig. 2 is a view of the first machines that were installed there, so far as their appearance is concerned. At the time we started to build the Fisk Street station we first ordered from the General Electric Company one 5,000-kw. machine. We had expected to put in fourteen machines—say 70,000 kw. We were rather impressed with the Curtis turbine as developed by the General Electric Company. They had an experimental machine of some 250 or 500 kw., and my friend Mr. Coffin, the president of the company, wanted me to give them an order for a machine capable of developing 1,000 kw. I told him that we already had a large number of reciprocating-engine units much larger, and to go to a machine of a smaller size simply because it was novel would be a step backward. He finally agreed to take the risk of building a 5,000-kw. machine if I would take the risk of installing it, the understanding being that if it would not work we were to return it, we to be out the cost of installation and the loss to our business and the General Electric Company to stand the cost of the turbine.

It is rather interesting to note here in New Haven that at that time Professor Breckenridge, who was then the head of the engineering department of our state university (Illinois), assisted us in testing the first units at the Fisk Street station. We put in three units. The first one ran as high as 7,800 kw., and the other two about the same—not because they were intended by the manufacturer to develop that amount of power, but because the necessities of our business compelled us to get all the power out of them that we could generate. Then we installed a fourth machine of larger capacity, of about 9,000 kw., and paid a premium because the machine exceeded the guarantee.

[1] President, Commonwealth Edison Company, Chicago, Ill.

Abstract of address, copyright by Samuel Insull, 1916, delivered at a joint meeting of the New Haven (Conn.) sections of the A.S.C.E., A.I.E.E., A.I.M.E. and Am.Soc.M.E. under the auspices of The American Society of Mechanical Engineers, April 5, 1916.

None of those four machines is shown in Fig. 2. The progress of the art was such that with practically the same boiler-room arrangements, a little larger grates, and a little higher stacks, we were able to operate 12,000-kw. units, so we scrapped the first four machines and installed 12,000-kw. units in their place. The view given is that of the later machines. I think that scrapping operation cost us upward of a million dollars, and I think it paid for itself in about three years owing to the advances made in turbine design.

LET THE SHOEMAKER STICK TO HIS LAST

It is rather interesting to note the difference in method of people who run the business of the manufacture of electrical energy as a business and the method pursued by people who run the manufacture of electrical energy as a side-show. One of the most up-to-date steam-railroad systems in the United States today is probably the New York Central line. I think they have two stations equipped with precisely the same kind of apparatus as that which we discarded several years ago.

What is the reason for that? Their business is to manufacture transportation. They might just as well be in the business of manufacturing coal as to manufacture electrical energy. It is a mere side-show with them. True, it has given them less trouble than anything else, but, so to speak, they are letting the water flow over the dam day after day in their electrical apparatus, because it is not their business to get highly efficient results in generating electrical energy.

The way railroad men make their balance sheet show up well is by finding out how to manufacture cheap transportation, whether of dead freight or live freight, and the way we central-station men make our money is by manufacturing cheap energy. I do not know of any better illustration, or any better case where we can (if I may be allowed to use slang) "hand one" to the steam-railroad company and quote the old adage that "a shoemaker had better stick to his last."

Several years ago there came out to Chicago a very distinguished engineering commission for the purpose of gathering information to be used in designing a large plant. This commission decided to duplicate what we had—not what we have—but what we had. And for fear they would not be able to run it they purloined one of our men to run it, and they are still running it. What they copied has been in the scrap heap for years. I think one of the machines which they copied is erected in the yard of the General Electric Company at Schenectady as a sort of relic of ancient history.

RUNNING INTO LARGE FIGURES

Fig. 3 is a view of one side of the boiler room of one of our stations. If we had a complete view of the room you would see that the chutes carrying coal down on each side give quite a Gothic appearance to the room. The number of boilers is five. The heating surface for each boiler is 12,200 sq. ft.; superheat, 200 deg. fahr.; steam pressure, 250 lb. per sq. in.; capacity in pounds of steam per hour for each boiler, 50,000 lb. For all five boilers 60,000 lb. of coal an hour is required.

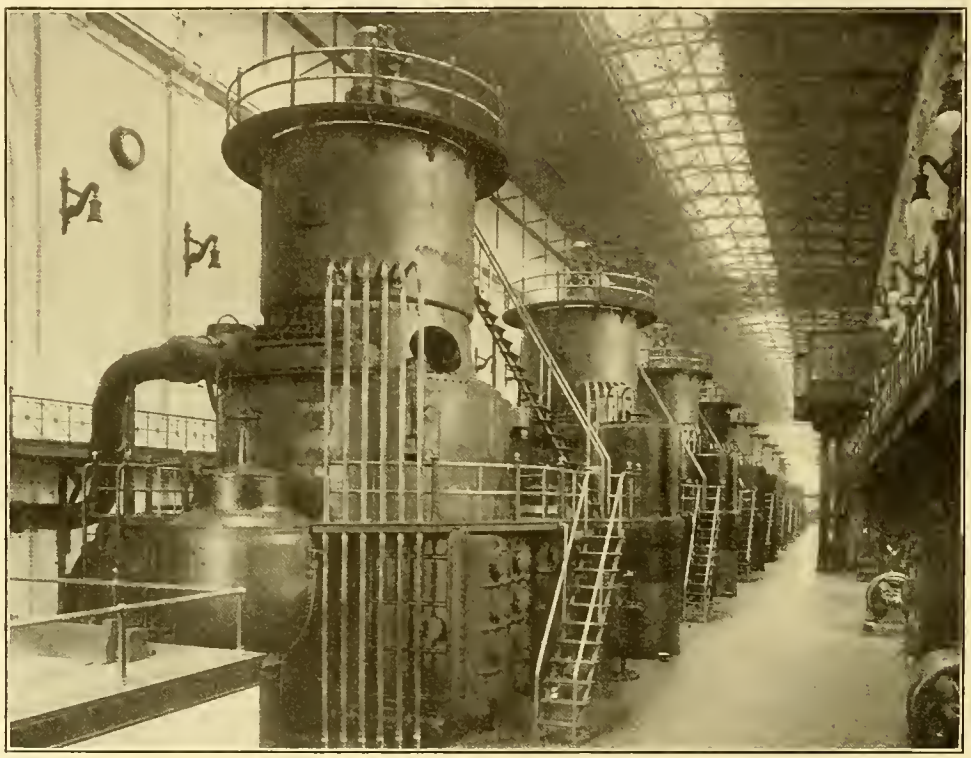

Fig. 2 Turbine Room, Fisk St. Station, Chicago, Ill.

A view of a turbo-generator erected in the Northwest station, Chicago, is given in Fig. 4. It is of 25-cycle, 9,000-volt, 30,000-kw. capacity; total weight, 590 tons; length over all, 60 ft.; width, 19 ft.; r.p.m., 1,500; peripheral speed of revolving field in ft. per min., 20,000. That class of apparatus has taken the place of the vertical turbine shown in previous views.

Our practice is to run a machine of that character practically all the time. We get the best results and the lowest repair costs if it runs continuously, provided it is shut down

a few hours a week to see that everything is in order. It is a class of machine which is being very largely used at this time and represents the most modern development.

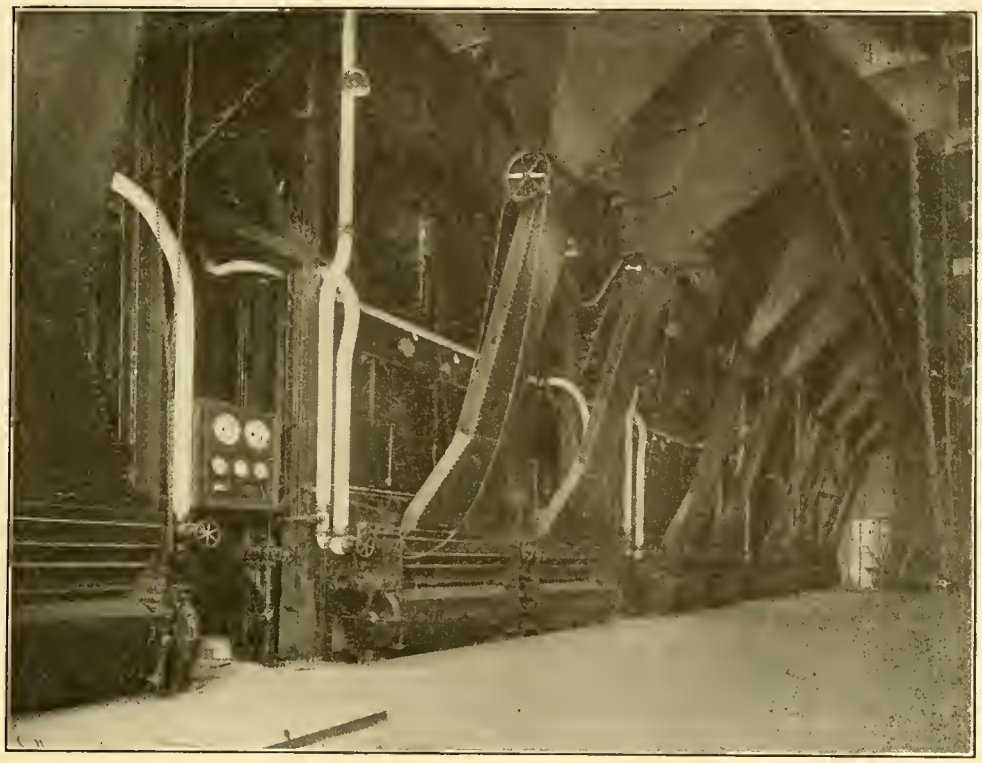

Fig. 3 Boilers Supplying 30,000-kw. Unit, Northwest Station, Chicago, Ill.

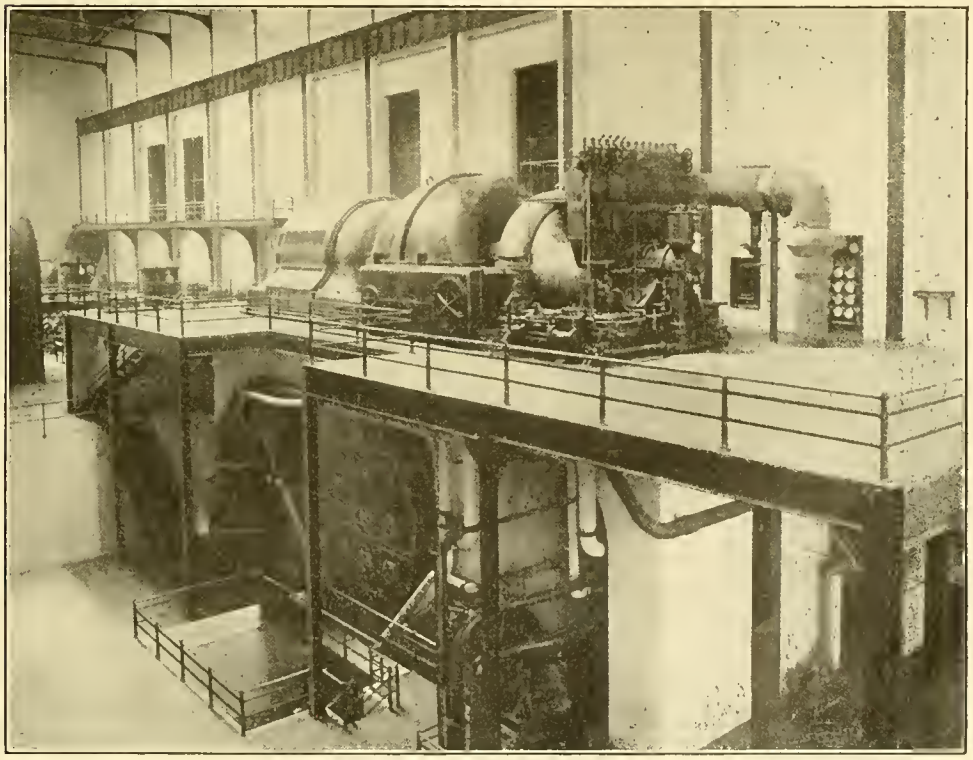

Fig. 4 30,000-kw. Turbo-Generator, Northwest Station, Chicago, Ill.

The diagram of Fig. 5 represents the capacity of generating units at various dates, and gives some idea of the progress in the massing of production of energy. In 1887, 160 kw.; 1902, 3,500 kw.; 1903, 5,000 kw.; 1915, 35,000 kw. That represents the progress that has been made. If there had been room on the diagram, we could have started out with the first direct-connected unit of 1881 of about fifty kilowatts.

I shall come back to this subject later on in the course of the address.

TAKING ADVANTAGE OF DIVERSITY OF DEMAND

A load diagram of the maximum day of the winter of 1915-1916 is given in Fig. 6. It shows the relative amounts of electrical energy supplied to street and elevated railways and for light and general power purposes in the city of Chicago. The light and power business took 147,300 kw. on the 29th of November, 1915, which was the day of the coincident maxima data. The railways took 190,600 kw. on the same day, a total for both of 337,900 kw. The non-coincident maxima for that winter came on the 22nd of December, 1915, in the light and power business when that business took 155,670 kw. The date of non-coincident maximum of the railway business came on January 6, 1916, when that business took 203,560 kw. So that we took care of the non-coincident maxima of the two branches of our business (359,230 kw.) with a total for the coincident maxima of 337,900 kw. This shows a diversity of

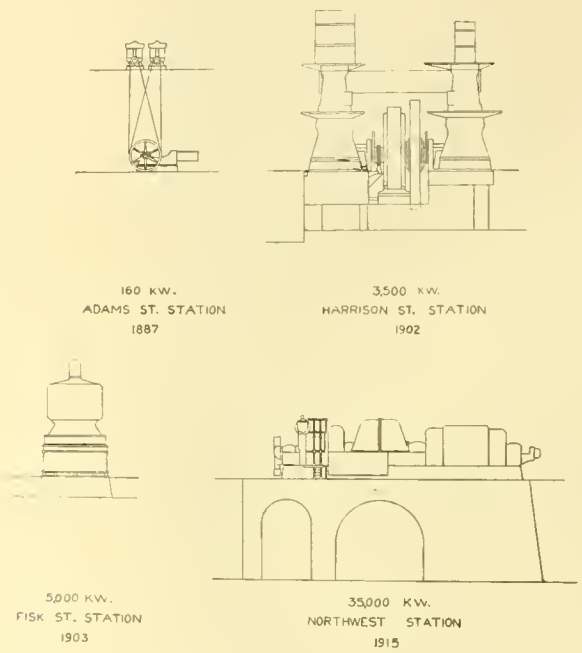

FIG. 5 RELATIVE SIZE AND CAPACITY OF GENERATING UNITS, CHICAGO, ILL.

21,330 kw. As I shall show you later on, one of the tendencies of the massing of production is to increase the diversity.

The drawing shown in Fig. 7 is the load diagram for the maximum day, and shows the Chicago curve for 1894 and one for a large city without the railway load prorated to the Chicago 1915 maximum curve for comparison. The annual load factor for Chicago in 1915 was greater than that of Chicago for 1894 by 68.5 per cent, and was greater than that of the large city in 1915, without the railway load, by 23 per cent.

I think on this load diagram you can find pretty good proof of the desirability of massing production and distribution. In 1894 the Chicago business showed a 25 per cent load factor. An eastern city having a great many advantages in the light and power business which we do not possess in Chicago, showed a 35 per cent load factor in 1915. Chicago, doing a wholesale and retail business combined, in 1915 showed a 43 per cent load factor. A reference to the diagram shows where the increase comes in.

Fig. 8 gives you a comparison of the summer and winter business of the energy supply to street and elevated railways. It shows that the winter demand is 35 per cent greater than that of the summer.

USEFULNESS OF ALTERNATING CURRENT

In the early days of this business of producing and distributing electrical energy, we were confined to very small

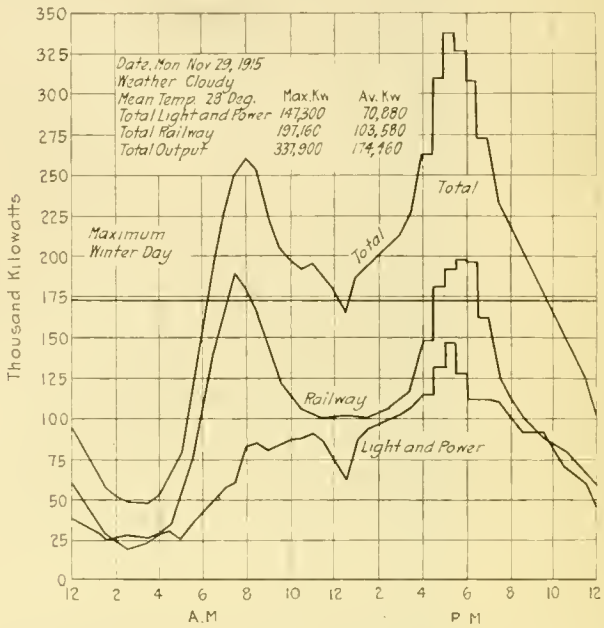

FIG. 6 LOAD DIAGRAM, MAXIMUM DAY, WINTER 1915 AND 1916, CHICAGO, ILL.

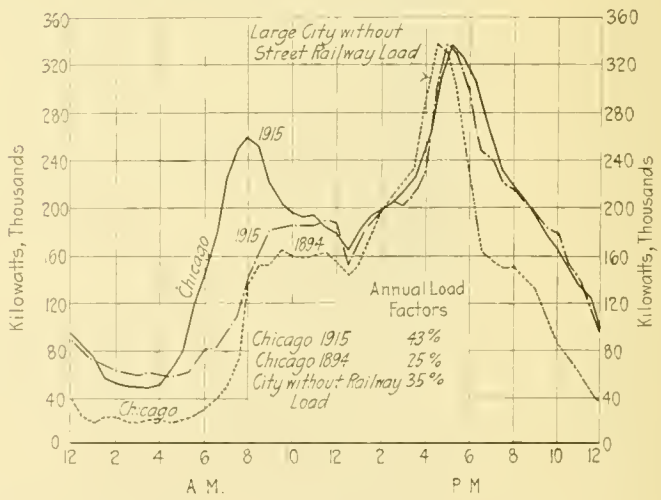

FIG. 7 LOAD DIAGRAMS FOR MAXIMUM DAY, CHICAGO, ILL.

areas—probably about 2,500 ft. in any direction from the generating plant. Unless we used expensive apparatus, such as boosters and very large feeders requiring a very heavy investment, it was difficult to get a direct-current system beyond 2,500 ft. in any direction, or say about a mile square.

Then the alternating-current system came along, and that did not fill the bill. There were disadvantages in the early apparatus. Owing to the smallness of the units, the cost of production was very high. We had made greater advances

really in the steam engineering and in the electrical engineering of the direct-current system than was made for a number of years by the alternating-current people. We people who had been very much wedded to direct-current production and distribution were casting around for means of economic transmission.

We were forced to the use of alternating-current feeders by the development of the marine type of engines with direct-connected dynamos, leading to the building of units running

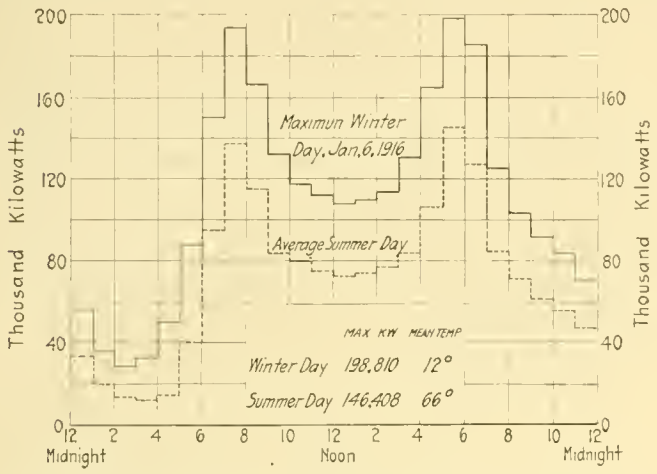

Fig. 8 Load Diagrams of Commonwealth Edison Company, Chicago, Ill., for Street and Elevated Railways

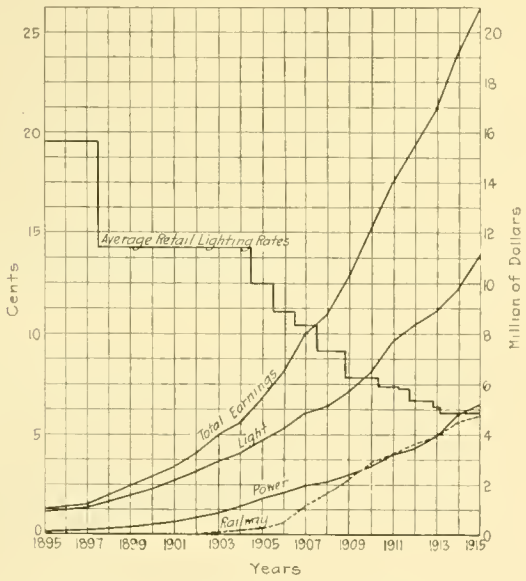

Fig. 9 Earnings from Sale of Electricity and Reductions in Lighting Rates, Chicago, Ill.

up to 3,000 and 4,000 and 5,000 kw. We were forced to take advantage of this system of transmission, many of us very unwillingly, because we at that time had great prejudices against the alternating-current system. We used to give it the name which is used with reference to some of the apparatus now used in the war, that is, "baby killer." And some of us used to point to the practice in several of the states of "electrocuting" criminals by the alternating current to show what a terrible thing the alternating current was. But as steam engineering progressed, as we got more economical units, we were forced to use the alternating-current system for generating and transmission purposes.

Improvements in the Apparatus

The apparatus was very uneconomical at the start. Some of us used rotary converters, some of us used motor-generators, but they were nearly all of them uneconomical at the start. The improvements in both classes of apparatus led to a very great extension of the use of the alternating current. But the thing above everything else that has led to the mass-

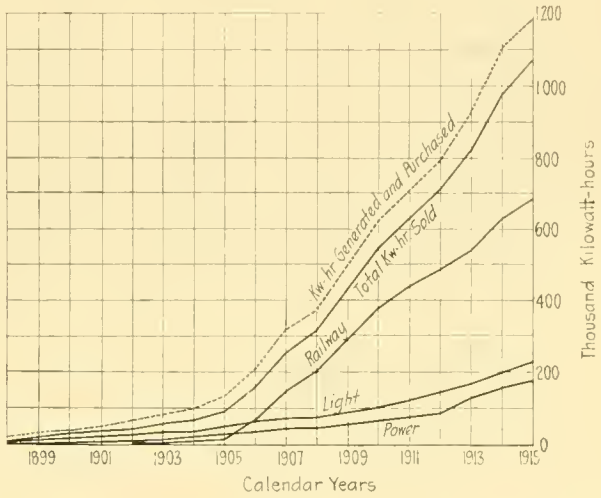

Fig. 10 Kilowatt-Hours Produced and Sold, Chicago, Ill.

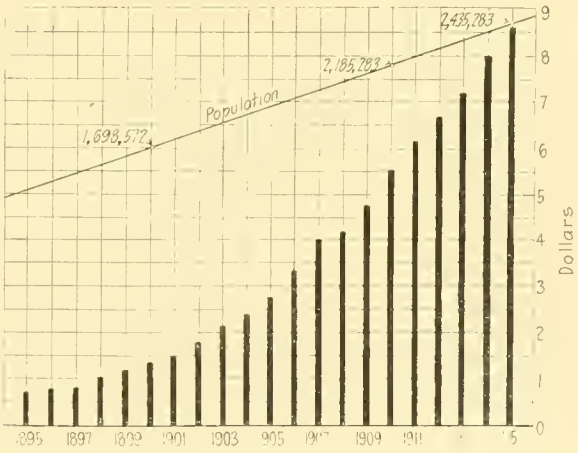

Fig. 11 Earnings from Sale of Electricity in Chicago, Ill., Per Capita, 1895 to 1915

ing of production of energy for all purposes is the introduction of the large steam turbine. With the reciprocating engine we could not get much above 4,000 or 5,000 h.p. There may have been a few units made of 5,000 kw., but very few indeed.

But when the large steam turbine was produced, with its great economy, both in its cost of installation and cost of operation, we were forced still further to take advantage of alternating-current generation and alternating-current primary distribution, so that today no one thinks of building a direct-current station for use where any large amount of energy is required over any extended area.

I think, next to the invention of the original direct-current distribution system and the original invention of the alternat-

ing-current system, that probably the thing that has had the greatest influence on the development of this great industry, which today is becoming not only state-wide but almost nation-wide in its character, is the development of the large steam turbine.

A NOTE OF WARNING AS TO SIZE OF UNITS

Probably there is no better time than this to sound a note of warning to those who are carrying the development of prime movers to very large sizes. To those of you who are familiar

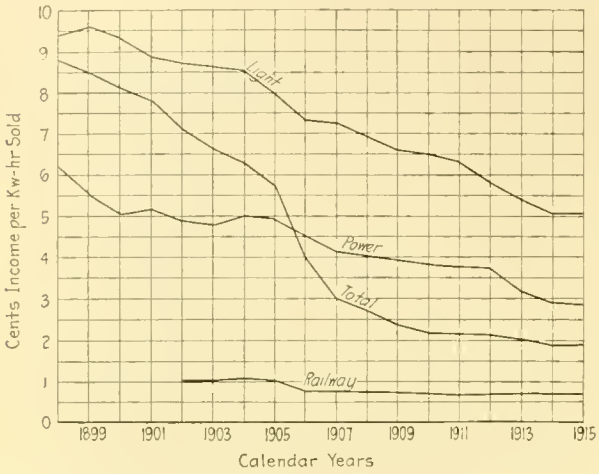

FIG. 12 INCOME PER KILOWATT-HOUR SOLD IN CHICAGO, ILL.

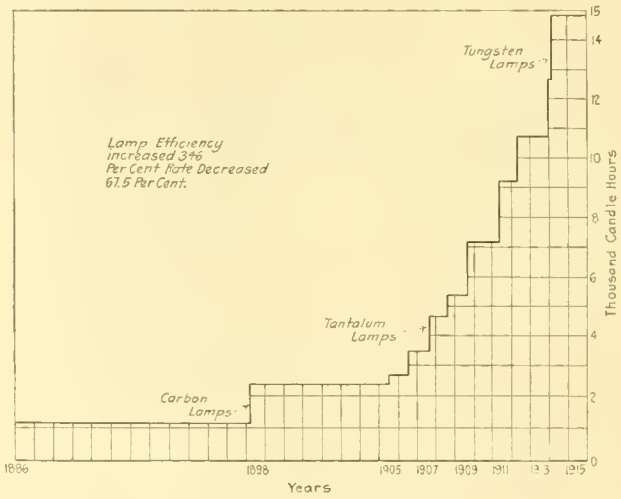

FIG. 13 AMOUNT OF ELECTRIC LIGHT ONE DOLLAR WOULD BUY IN CHICAGO, ILL., 1886 TO 1915

with the course that I have pursued myself in connection with the development of the enterprises under my control, it may seem rather unusual for me to sound a word of caution on size. But it does look to me as though a great many of the managers of the systems in different parts of the country are allowing their engineers to order turbines of a size out of all proportion to their requirements, and having no relation to the load which they have to deal with, and that if such a course is unwarrantably pursued it must inevitably lead to disaster in some of the great distribution systems of this country.

I heard the other day of a man who is installing a large turbine for more than 50 per cent of his load. There is absolutely no justification for such a course. I do not myself think that it is safe to order a unit for much more than say 10 to 12—and at the very extreme 15—per cent of the total demand on any one system. There are cases where it is not possible to confine oneself to that percentage; for instance, where turbines for new systems are being ordered. But I refer to cases where old systems are in existence, and there is not any justification for the very large turbines; and I would make the suggestion, particularly at this time when the cost of material is so great and when it is impossible to get the views of the best people on both sides of the Atlantic, that the operators of large systems would do well to call a halt in building larger sizes of turbines.

At the present time about 35,000 to 40,000 kw. is the largest size that can be obtained. I have heard of some orders being given for 50,000-kw. machines. I am rather sorry to hear it, because I think the buyers will regret it. Before we need the larger size we will need higher boiler pressure, which will first require expensive experiments in boiler construction, and we will need a great many changes in the details of apparatus used in connection with large turbine units; and I think that the progress of the next few years will be the better made if it is the slower made.

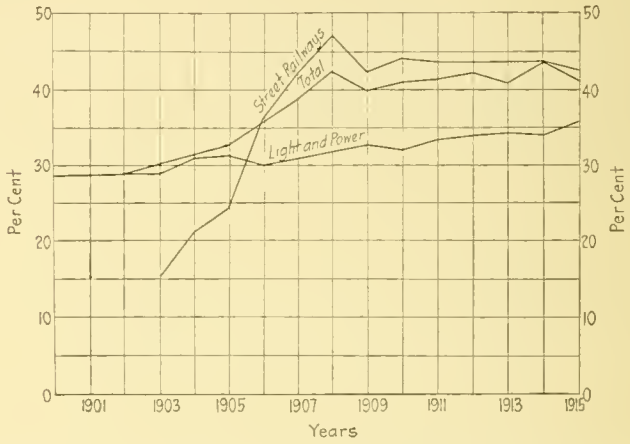

FIG. 14 ANNUAL LOAD FACTORS OF COMMONWEALTH EDISON COMPANY, CHICAGO, ILL.

I am sure that if those who are connected with any large system will follow up my suggestions as to the desirability of standing still a little while, they will find that in the course of the next few years they will be a great deal of money in pocket. I am giving this form to my views on the subject because I am generally credited with employing the largest apparatus that can be obtained.

THE ENGINEERING OF SELLING

Having true engineering of construction as a basis, we come to another side of the business; that is, the engineering of selling.

This diagram (Fig. 9) shows that, starting in 1896 with a gross business in Chicago of about $1,000,000, and increasing, year by year, we had in 1915 a total business of almost $21,000,000, divided as follows: Light, a little over $11,000,000; power, a little over $5,000,000; and the supply of energy for transportation purposes, a little below $5,000,000.

Fig. 10 is a chart of kilowatt-hours produced and sold. It is interesting to note how closely the output figures follow the figures of money. You will notice that the curves on this

drawing follow very closely the curves on the previous one (Fig. 9), so far as the total is concerned, but with a much sharper line so far as railways are concerned. The cause of this difference between the two curves, that is, the money curve and the output curve, is the fact that in the development of our business we have probably carried to a greater extent than the majority of electric-service corporations the wholesaling of energy for transportation.

Fig. 11 gives you an idea of the increase of the earnings from the sale of electricity per capita from the years 1895 to 1915 in the city of Chicago.

LOW PRICE OF ELECTRIC LIGHT AND POWER

The income per kilowatt-hour sold is given in Fig. 12. The income from light shows a steady drop per unit sold from 1898 to 1915, amounting to about 46 per cent in price per

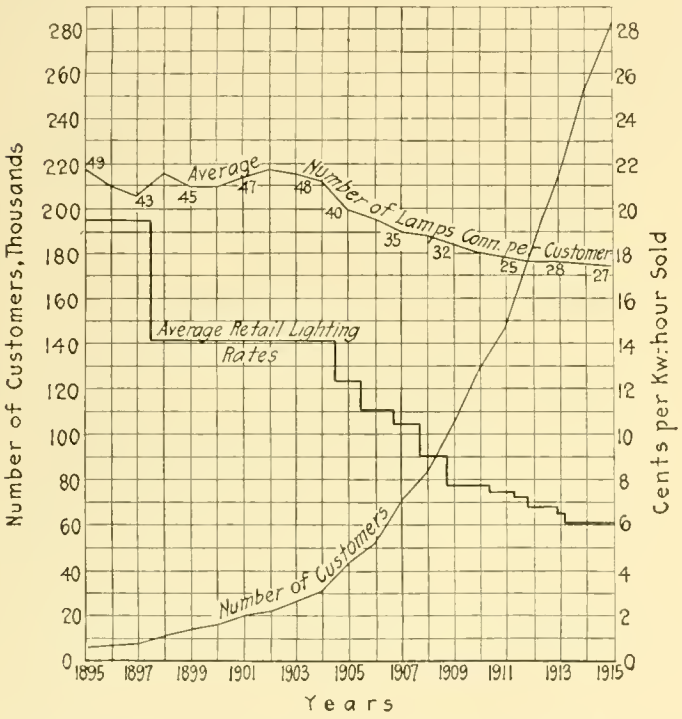

Fig. 15 Reduction in Lighting Rates, Average Lamps per Customer and Number of Customers, Commonwealth Edison Company, Chicago, Ill.

kilowatt-hour sold. The power income follows somewhat the same curve. It started at a lower price and necessarily ends at a lower price. The wholesaling of energy for transportation purposes runs along on a very steady line. In the first three years the price did not vary. As the business developed the price dropped in 1906, and that price continues practically up to the present time, and is on a basis lower than it is possible for the local transportation companies of Chicago to produce their energy themselves. The price per kilowatt-hour in 1915 was 16 per cent lower than in 1908. This difference is not apparent in the curve on account of the scale used.

Fig. 13 gives you an idea of the amount of electric light one dollar would buy in the years from 1886 to 1915. This chart shows graphically the great reduction in the cost of electric light to the average small user. The quantity that one dollar will purchase is now six times as large as it was ten years ago.

A chart of the annual load factors of the Commonwealth Edison Company (and its predecessors) for the last sixteen years is presented in Fig. 14. You will notice that the street-railway load factor went up and then dropped. It was at its highest for a few years just before one of the large street railways shut down its obsolete stations, which it had operated as "peak plants" only. This shutting down had also the result of earning it a very low price for the energy it purchased. The tendency of the railway load factor is to run even. The tendency of the light-and-power load factor is to improve. For 1915 the combined load factor was 42.5; the light and power 35.8, and the street-railway business by itself 41. The improvement in the two combined is owing to the diversity.

A diagram showing the reduction in lighting rates, the average lamps per customer and the number of customers is given in Fig. 15. The chart shows that as the rates for electricity have been reduced the number of customers has increased enormously and the average size of the customer's installation has grown smaller. Electric light, instead of being a luxury, as it formerly was, is now the cheapest illuminant.

WHAT BECOMES OF THE DOLLAR OF INCOME

Fig. 16 is an instructive chart showing what becomes of the dollar of income; and I venture to say that the figures given

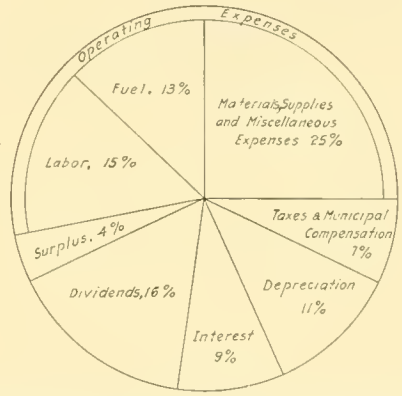

Fig. 16 The Dollar of Income and What Was Done with It in 1915, Commonwealth Edison Company, Chicago, Ill.

here are relatively about the same whether it is in a large city like Chicago or in a smaller city like New Haven.

While it is not my function to discuss political questions, one of the serious questions of the day is the view that a great many young men going out into life have regarding the large enterprises of the state. Their opinions are very largely based upon the statements of able writers who have great facility of expression but who are untrammeled by responsibility of position.

If you were to come out to Chicago, the long-haired talker, the long-haired reformer, would talk about the earnings derived from our investment in a way most unfriendly to the public-service corporation; he would tell you that the rate we charge is ten cents, whereas this is our maximum rate. But I want to tell you that of every dollar we receive, seven per cent of it goes back into either the municipal or the state treasury, and that, as a matter of fact, when our patrons are

paying us a dollar they are indirectly being taxed seven per cent of that dollar in the form of what amounts to double taxation.

ELEMENTS OF COST

If that long-haired reformer happens to be an advocate of municipal ownership, he will not tell you that no allowance is made by the municipal plant in this city or that city to compensate for the sum paid by the public corporation in the shape of taxes and compensation. Now take the size of these various sections (see Fig. 16). You will see here that that part of the capital which is obtained on a low-interest basis because it has a prior lien does not get very much more out of the business than the amount that has to be paid for the privilege of doing business; and bear in mind that the corporation does not pay for that privilege. Our customers pay for that privilege, as it is figured in the cost of energy.

We are a regulated monopoly, a partial monopoly, as a rule, but we are regulated, as our rate for energy is settled by a state commission, based upon our cost and a reasonable return on our property, and to that is added the taxes and municipal

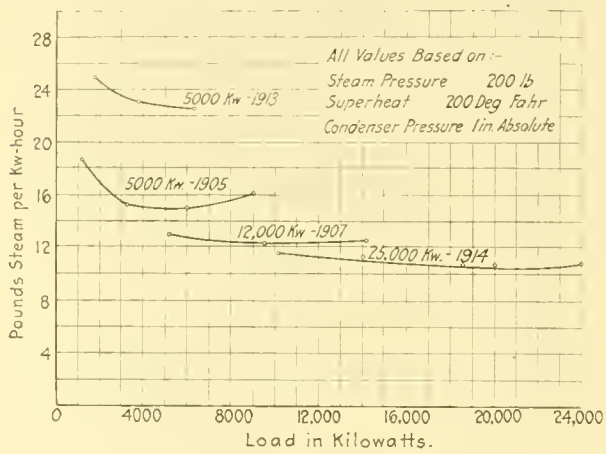

Fig. 17 Steam Economy Tests of Steam Turbines

compensation, so that the people who pay that are not our 2,500 stockholders, but our 250,000 customers.

The people who take the greater risk and who put their money into stock, into the junior securities of the company, only get a little over twice as much on the operation as the community gets for the right to do business. Those irresponsible heads of organizations who like all the privileges but none of the responsibilities of government always want to take care of labor; but out in Chicago all that they allow us to pay labor is about twice as much as our customers pay the community for our right to do business with them.

Fuel is supposed to be a very important portion in our cost. We consume thousands of tons of coal per day, and yet our total coal cost is less than double what our customers pay to the community for giving us the privilege to do business. And so on all the way round.

STEAM-TURBINE EFFICIENCY

An interesting chart in relation to the steam-economy tests of various turbines is shown in Fig. 17. These curves show that in 1903 the design of the steam turbines then available was such that the water rate was 22.5 lb. per kw-hr. The machines of that period had two wheels with four rows of buckets to each wheel. It was, therefore, necessary to expand the steam considerably in the first nozzles to get sufficient velocity so that the energy generated could be absorbed by the two wheels. This high velocity meant, of course, considerable friction loss.

In 1905 improvements in design reduced the water rate to 15 lb. per kw-hr. under the most economical load on the machine. In 1907 five wheels were used, there being two rows of buckets for each wheel. Consequently, the lower velocities from the nozzles reduced the friction losses, giving a water rate of about 12.3 lb. per kw-hr. Still further improvements

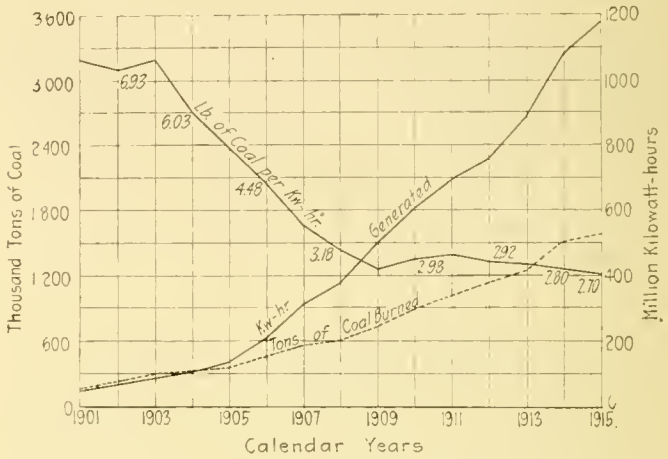

Fig. 18 "Conservation of Coal"

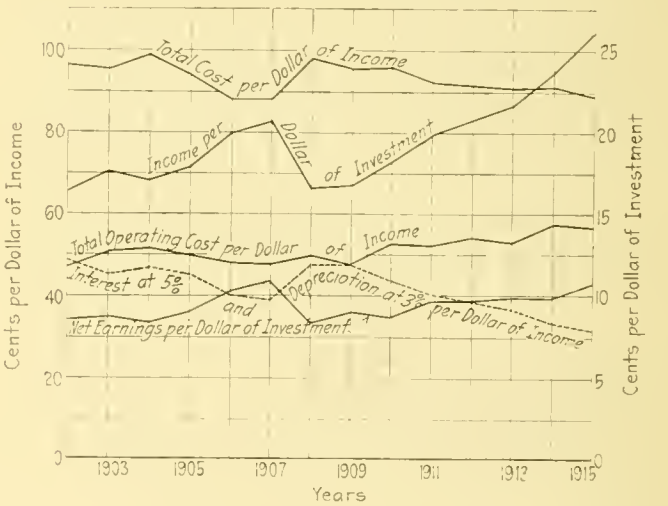

Fig. 19 Financial Chart No. 1, Commonwealth Edison Company, Chicago, Ill.

were made in the 1914 design. The number of wheels was increased to ten. With more correct bucket shapes, and with one row of buckets for each wheel, the water rate was still further reduced. The curve for this machine is not shown, as it coincides very nearly with the curve labeled "25,000 kw." in Fig. 17. This curve is for a turbine of the reaction type. The preceding remarks apply to machines of the impulse type. As its name implies, the reaction turbine employs the principle of reaction, its evolution being very similar to that of the impulse machine.

Those last curves are, I think, indicative of the progress which has been made in the efficiency of the steam turbine during a period of over eleven years.

CONSERVATION OF FUEL

Fig. 12 shows the other side of that same subject, that is, the conservation of fuel. Here is shown the drop in the pounds of coal per kilowatt-hour produced, starting at nearly seven pounds per kilowatt-hour and going down to 2.70 lb. Another curve shows the kilowatt-hours generated, and a third the tons of coal burned.

The diagram is indicative of what we have been able to do in the direction of conservation of coal. That results partly from the improvements in the prime movers, partly by the shutting down of small uneconomical stations, and the massing of production and distribution over very much wider areas.

I think that while a great many of our well-intentioned friends have been shouting about the conservation of natural resources, the steam-turbine inventors and the designing engineers of the great power companies using steam as a prime source of power have probably done more to conserve the natural resources of this country, in so far as fuel is concerned, than has been done by all the agitation that has taken place upon the general subject of conservation.

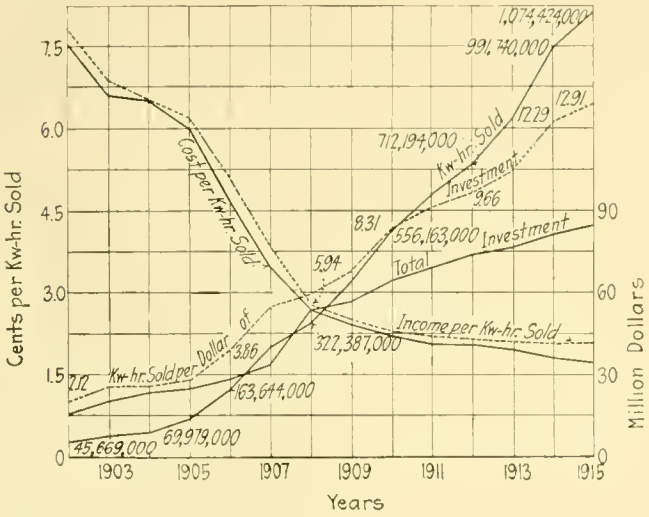

Fig. 20 Financial Chart No. 2, Commonwealth Edison Company, Chicago, Ill.

It is interesting to note that the saving in Chicago per unit for the fourteen years from 1900 to 1915 was equivalent to a saving for the year 1915 of 2,472,400 tons, or 58,000 carloads of coal per year, or fourteen loads of forty cars each per day.

FINANCIAL DATA AND STATISTICS

Fig. 19 gives you some financial figures—the total cost per dollar of income, the income per dollar of investment, the total operating cost per dollar of income, and the net earnings per dollar of investment.

Some more financial information in another way is presented in Fig. 20. This gives cost and income per kilowatt-hour sold. To the cost is added the necessary allowance for interest and depreciation. You will see how closely the cost and the income follow each other during a period of from 1902 to 1915. The kilowatt-hours sold per dollar of investment are also shown in Fig. 20. When we were doing but a small wholesale business we used to sell only two kilowatt-hours per dollar invested. Now we sell thirteen kilowatt-hours per dollar invested.

A very interesting diagram showing the diversity of large light-and-power customers is that of Fig. 21. It has always been assumed until this particular investigation was made that the maximum demand of manufacturers and large users came at about the same time, but Fig. 21 shows this is not the case.

POSSIBILITIES OF THE FUTURE

Now as to the possibilities of this class of business. You will have to excuse me for referring so much to Chicago, but I have more definite information regarding the city of Chicago than I have in regard to any other place. The light-and-power business of the Commonwealth Edison Company is approximately 338,000 kw.; that of isolated plants is 264,500 kw., and that of the steam railroads is 125,700 kw., making a total of 728,200 kw.

Our estimate is that at the present time we are doing about 46 per cent of the total possible business in the city of Chicago, and that if we had the entire possible business, instead

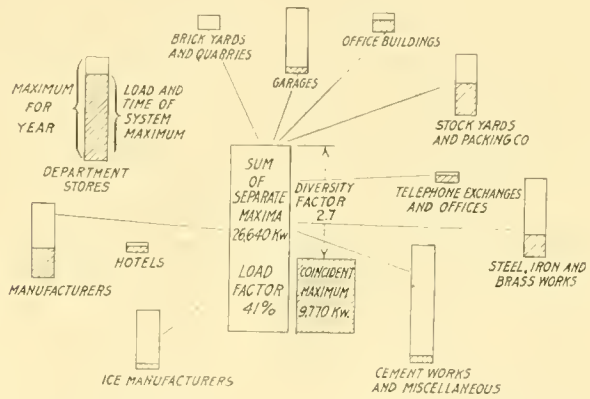

Fig. 21 Diversity of Large or Wholesale Light and Power Customers

of running at a load factor of 40 or 41 per cent, we would probably have a load factor on the entire system upwards of 50 to 60 per cent.

What does that mean? Broadly speaking, it means that the cost of carrying the necessary investment for a city of two millions and a half of people, that is, the interest cost and the depreciation cost of carrying the entire investment, if all the energy is produced under one organization, would be reduced approximately 33 1/3 per cent. That would indicate that at the present time where any form of energy is required —I do not care whether by steam or electricity or how it may be obtained—it is an economic waste for the individual spending the money to try to produce that energy in a small way, and that the true function of the large electric-light-and power companies of this country is to produce all the energy that is required in the community. In these days when so many of our operations between the cradle and the grave are being regulated I am somewhat inclined to think that the day will come when one of the regulating bodies will step in, insist on all energy being produced from central generating plants and tell the people who are guilty of economic waste that they must stop. Such regulating body will say that the country cannot afford to have them throwing away money, which indirectly must be sapping the country's wealth, as if

equipment is employed unnecessarily, if fuel is wastefully employed, if labor is wastefully employed, all those things must be harmful to the general wealth of the state.

BROAD ASPECT OF THE QUESTION

I firmly believe that the doctrine that it has been my privilege to preach for a good many years, and which I am glad to say is becoming more popular—that is to say, the massing of production, the massing of distribution, the selling of energy for all kinds of purposes on a very large scale from one system—I firmly believe that in advocating that course, while I am advocating a course that is very advantageous to the class of property that it is my privilege to have charge of, at the same time I am advocating a course that is very advantageous to the whole community and to the whole state.

To give you some idea of how these figures mount up I have had worked up the data derived from Census statistics on the same basis on which we have worked it out for the city of Chicago, and applied it to the whole country. Supposing we take all the settled areas of the United States wherever there is great density of population, practically everywhere this side of the Mississippi and practically everywhere the other side of the Rocky Mountains (all you have to leave out is the desert country and the purely agricultural country), and let us assume that all the work is done electrically. Let us assume that every part of the country where the density of the population justifies it, whether it is in a community or whether it is state-wide, or whether it occupies a larger area and goes beyond the confines of a state—let us assume the electricity supply business is all put under a series of central organizations, and what do we find?

GREAT SAVINGS THAT COULD BE EFFECTED

We find that it takes about 68,000,000 to 70,000,000 h.p. of non-coincident demand; that the coincident load would be about 47,000,000 h.p., and that the diversity would be upwards of 20,000,000 h.p. If you will capitalize the labor that would be saved; if you will figure the investment cost of the 20,000,000 of h.p. that would be saved; if you will figure out the value of the fuel that would not be used—the savings are staggering; and the possibilities that this business offers are almost beyond the dreams of the most enthusiastic figurer.

I happened to learn only a few weeks ago of a case in a city not very different from any other city and not a very large city, in a territory where the population is not so dense as it is in this Connecticut country, and where the amount of energy used is not as great. In the city itself the electrical interests, both for light and power and for transportation, are in one organization. Outside the city, in the surrounding territory, most of the light and power and transportation interests are in another organization. In the city the maximum load comes in the afternoon. In the surrounding territory the maximum load comes in the morning. In the city they, so to speak, allow the water to flow over the dam all day long except in the afternoon, and outside the city they allow it to flow over the dam all day long except in the morning.

If you will capitalize the saving in operation in just that one district, with a population relatively small, and add the saving in investment that would take place by combining the generation of energy in that small piece of territory of about 100 square miles, the saving will be between six and seven million dollars.

WHERE THE REAL DANGER LIES

Yet some persons would tell us that if that is allowed to be done it will produce a combination that may be dangerous to the state. It is not dangerous to the state to let the money go to waste, to waste its resources and its capital; but it is said to be dangerous to the state to allow an organization to double its size, even though that organization is regulated by a commission of the state appointed or approved by the state Legislature. I think that is the kind of danger to the state that I shall have to spend my days in advocating as long as I live; I think that it is to the highest possible advantage to the state, that it is a real contribution to the better management of the country's affairs. In closing I cannot do better than to tell the young men here who are expecting to make the class of business with which I am proud to be associated their life's work that I do not know of any business in this country in which there are greater possibilities, greater opportunities, for men not only to serve themselves but to serve their fellows. I know of no walk in life, public or private, in the industrial world, in which there are greater possibilities of national advantage and community advantage than in the business that I have tried to tell you something about this evening.

It is a question of some interest as to how far the continued combustion of mineral fuels will so alter the quality of the atmosphere we breathe as to lower the vitality of the human race as at present constituted. The total weight of the carbon in the coal, oil, gas and peat resources of the globe is estimated at something like 6,400,000,000 tons, requiring twelve times that weight of air for its complete combustion. A calculation shows that the weight of the atmosphere is nearly 150 times the weight of the air needed for the combustion in question, and that the weight of the resulting carbonic acid gas would be but 0.22 per cent of that of the atmosphere, or less than one-fifth the percentage allowed by the Mines Regulation Act. —Arnold Lupton in *The Iron and Coal Trades Review*, July 28, 1916.

According to Kelvin's law, maximum economy in electric transmission is obtained when the annual interest and depreciation charges equal the cost of the energy loss. This law, however, does not allow for additional capacity in lines to care for future growth in business nor for voltage regulation; hence it does not hold good in practice today, where experience shows that both of these provisions are necessary for the highest economy ultimately.—Geo. P. Roux, in *General Electric Review*, Oct., 1916.

An investigation of the markets of South America for construction materials and machinery is being undertaken by the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce. The investigation will cover construction materials, with especial attention to cementing materials, clay products, steel products, wrought iron, steel and cast iron pipes, valves and fittings and heating installations. With reference to construction machinery it will include power shovels, drills, derricks and hoisting apparatus, cableways, pumps, pile-driving machinery, mechanical mixers, floating equipment, road-making machinery, and construction tools.

THE SALES ENGINEER AND HIS RELATION TO PRODUCTION AND MACHINE DESIGN

By ARTHUR J. BAKER, CINCINNATI, O.

Member of the Society

THE title, Engineer, has already been subjected to so many prefixes, that one hesitates to add another to the already confusing number. There seems, however, hardly any other term than that of Sales Engineer which quite so well defines the activities of that growing class of engineers with whose influence on design and production it is proposed to deal.

As one views the progress of machine-tool design, one cannot help but feel that it has been largely left to the user of a machine to indicate the changes which would make the machine more particularly suitable for his class of work, and that the designer and maker of the machine have generally been the second party in such improvements. I do not, of course, here refer to detailed improvements, particularly in regard to the construction of the machine, but rather to those pronounced departures from type that may be said to mark the advances in the art; in other words, it would appear that the majority of the engineer-designers of most machine-tool factories have for many years been working on improvements of well-defined types of machines, and cannot have made that rigid investigation of the conditions which govern the use of such machines that would seem to be absolutely essential if ideal conditions are even to be aimed at.

There are, of course, very strong commercial reasons from the manufacturer's standpoint for standardizing the design of machine tools. There is further, from the user's viewpoint, that excellent reason relating to the ability of the average operator to handle, with the minimum amount of individual instruction, any machine of the class in which he claims proficiency. Probably in the last analysis this would also be regarded as a commercial reason, but it must also be taken into account in view of the apparent tendency toward the increased employment of unskilled help and the comparative difficulty of obtaining that *rara avis* which used to be known as an all-round machinist.

The user of a machine tool has of late either grown, or been educated, to demand of the machine-tool manufacturer a specific study of his (the user's) requirements. These studies have influenced the design of the manufacturer's product, and will influence it more markedly in the future. The "service" plan, which covers many trades, has developed into an important factor in machine-building organizations.

The function of the Sales Engineer, as stated by the author, is to study the requirements of the users of the machines made by his concern in order to discover what modifications of standard types and what auxiliaries in the way of jigs, fixtures, etc., are needed to effect an increase in production or decrease in installation cost, and to meet the competition from another type of tool as well as the peculiar conditions presented by novel machining problems.

The gradual development of the sales engineer from the old-time machine-tool demonstrator, and the beneficial effect of his services both to manufacturer and customer are dealt with at length in this paper, and several concrete illustrations of the methods employed are given.

The paper shows that the sales engineer has already had a positive influence on future design of machine tools, and that the knowledge his methods have brought out has been so utilized as to make it valuable for future research.

This condition has led to what I termed the Sales Engineer. His predecessor was the original demonstrator, who, it will be remembered, was and still is a man unusually skilled in the use of the machine which he demonstrates and who is sent out to break in the workmen and to assist the customer in obtaining high production from the newly installed tool.

These demonstrators in their visits to the different plants accumulated considerable experience in regard to the uses and weaknesses of their machines; and, following the natural onward tendency, they were in some cases replaced or augmented by engineers whose duties were not in any way connected with the demonstration or practical operation of the machine, but consisted rather in systematic observation of the uses to which the machine was put. These observing engineers, carrying back to the factory their authentic data, were able to influence materially new designs. They were still, however, concerned only with the standard type of machine and were only brought into contact with the customer's requirements after the machine was installed, and usually after some trouble had developed.

The original machine designer usually devoted himself so closely to his own particular machine that he was not thoroughly in touch with developments taking place in other classes of machines. Even today, in the great majority of cases, that condition prevails. The sales engineer, on the contrary, being brought directly and frequently in touch with the latest installations of such machines, immediately returns to the factory with advance information of the encroachments that the new type of machine is making on his own field. The designing department, lacking a detailed acquaintance with the latest usage to which machines are put, loses its proper perspective in regard to the relative time values of the different functions of the machine. The sales engineer, with any reasonably well-developed analytical faculty, can clearly see that a certain portion of the operation consumes more time than is really necessary, that the output is governed by this factor, and advises the home engineer of the need for improvement in this respect. Furthermore, continuous travels throughout the various shops must of necessity bring him into close contact with those home-made devices which are so often the basis of permanent improvements in standard design. It is idle to suppose for a moment that such improvements are found only in the larger shops, to which unfortunately the

Presented at a meeting of the Cincinnati Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, March 16, 1916.

visits of the sales engineer are usually confined. More often it will be found that the small shop, with its limited equipment, will have evolved some ingenious and interesting method of producing the desired results, where the larger and wealthier shop has been content to increase its quota of standard machines.

While the influence of the sales engineer on the design of his company's product cannot fail to be very marked, it may even be of more vital and material interest to the customer. The general adoption of this sales-engineering system immediately places at the disposal of the machine user a corps of highly trained engineers, whose collective abilities are likely to

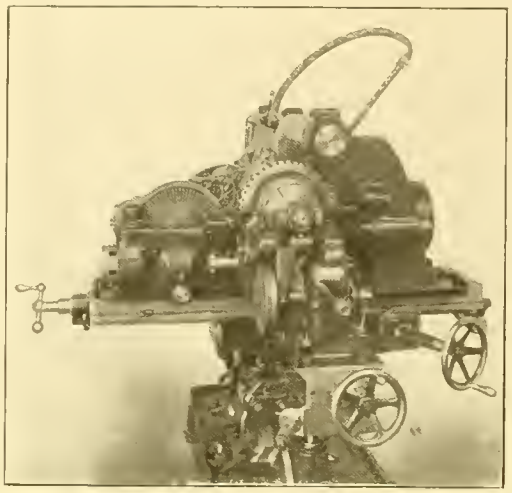

Fig. 1 Milling Machine with Special Equipment More Expensive than Machine Proper

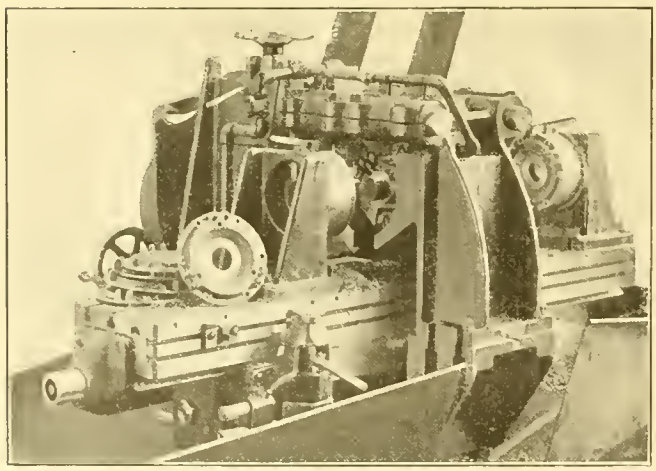

Fig. 2 A Departure from the Stereotyped Methods of Milling

greatly exceed those over which he would normally have control. Their advice and recommendations should lead to the scientific selection and installation of machines, resulting in a lessened installation outlay and a greatly increased production.

It must be apparent that the recommendations of the sales engineer cannot be made on the spur of the moment, but must receive a reasonably thorough preliminary study and investigation. In the company with which the writer is connected it has been the practice for the last half-dozen years to make comparatively elaborate time studies, for which considerable advance information is needed. This information must not only cover the end which it is desired to accomplish, but should also include a reasonable amount of data as to the earlier and existing methods. This is particularly essential because it has developed that the sales engineer, seeking continual outlet for his machines, will often invade a field that has been considered the exclusive property of some other type of machine. It is sufficiently obvious that there must be much debatable ground to be fought over by the competitive representatives of the engine lathe, the turret lathe, and the automatic machine, and again between the planer, shaper, and miller. The ideal conclusions drawn from such investigations can only follow a very full consideration of all of the factors connected with production, and not only, as is sometimes the case, with the number of pieces turned out per machine per day. For these reasons certain standard forms are used, on which is entered the following information, derived from the user of the machine:

1 The quantity per annum and, if possible, the size of the lots in which the work is put through the factory
2 The degree of finish required
3 The quality of material
4 The depth of cut
5 The machine on which the work is now being done
6 The time consumed
7 The wage rate paid
8 The burden or overhead charge (particularly if departmental burden is available)
9 The objections, if any, other than as to the time consumed, that may be made to the existing method. This latter may deal with the labor supply, the dependence upon certain materials, etc.

This report is supplemented either by a sketch of the piece, or preferably by the cutomer's blueprints. Samples for preliminary cutting tests are also obtained whenever possible. With all of this information a time study can now be made up, which will give in full detail the separate operations, the time taken for each part of the operation, the speed and feed necessary, and a sketch and description of the fixture and cutters to be used. To the total time required for the production of the unit piece must be added a certain "overhead" percentage, which will, of course, vary, and is a figure that can be easily determined and established as a standard. This information is then submitted to the customer, and in certain cases accompanied by a cost sheet comparing the suggested and existing methods. This sheet will specify the time per piece, including the above percentage, the total time per annum for the quantity of pieces required, the wage cost, and the burden, or overhead cost, showing the annual saving over the existing system. Such cost-comparison and estimate sheets are in themselves not necessarily final, but their great virtue is that they form a nucleus for specific analysis and recommendations on the part of the customer and his engineers. It is particularly important that such detailed information should be submitted, because the production of a given machine is very often entirely independent on the ability of that machine to carry through a certain cut; it is often entirely dependent upon the chucking time necessary, and, still again, frequently dependent upon the spacing of the feed marks or quality of finish. This latter may very well be a commercial requirement and entirely independent of the degree of accuracy.

We can assume that the time study shows conclusively that the production is mainly dependent upon the operator's chucking capacity. There are two ways in which this may be increased: either by the elimination of certain functions which he must perform in connection with the machine, or by chang-

ing and improving the holding arrangements for the work so as to reduce the chucking time proper.

In a great many cases the first method is the most feasible, since it is only reasonable to suppose that the fixture or work-holding device, designed especially for the job, is less likely to be deficient than the machine, which has been designed for more general utility. It is here that the twofold influence of the sales engineer on both design and production becomes pronounced. It is here brought home to him very strongly that the specific limitation of his machine, while originally of small importance, is now preventing a greater output. It must then suggest itself to him that some mechanical means must be found for overcoming the hand operation of the machine, and either of his own volition or through the home engineering department he will produce modifications of the machine to suit requirements. This may not take place immediately, or for the specific customer through whom the need for this improvement arose, but it is very evident that the continued facing of the same problem must ultimately lead to its solution.

A further important point in this connection is the influence that will be brought to bear on this matter by the customer himself, who will generally clear his mind of all details of the machine and reach the pertinent points that are connected with production. He is quite apt to compare the machine with some other entirely different machine which incorporates some feature of marked importance to his particular class of work. It would seem, for instance, that the day of the automatic power-return of the tables of small milling machines would have come much sooner had their users compared the miller with the planer in the way that should have been done. It would really not have been necessary to compare the miller with the planer, but to have compared it even with some of the larger planer-type milling machines, on which such apparatus is standard equipment. It would further seem that the flooded lubrication of milling cutters should have come sooner had the proper comparisons been made between the milling machine and the grinder, and parallel cases could doubtless be found throughout the whole machine-tool field. The customer, as a rule, either has not the time, or perhaps lacks the energy to bring such points strongly enough to the attention of the manufacturer, and it is hoped that through the efforts of the sales engineer more concerted action between user and maker will accrue.

There is another phase of the sales engineer's influence on production, and that is concerned with work-holding methods or fixtures. There are in many shops ingenious methods in force for achieving a desired end, which methods may be very well adapted not only to the same specific job but to others of a similar nature. Now these methods must come fully under the eye of the sales engineer, not only in his visits to the customer's shop, but in his comparisons of suggested with existing methods. The interchange of ideas thus brought about will be more far-reaching in its influence than if the comparison between methods and production be always limited to one type of machine, since, as is well known, the different types of machines have each tended to develop a different system and standards of holding appliances.

The foregoing roughly outlines the direction in which the sales engineer may be expected to influence production and design, and many other details upon which his influence may be felt will doubtless present themselves.

The accompanying illustrations show the particular influence that has been exercised on one type of machine tool, the milling machine, by such work as has been described. It will be noted that some of the improvements have been effected in the fixtures themselves, but in many cases the design of the machine has been entirely changed to meet manufacturing conditions.

Fig. 1 shows a rather interesting equipment, designed for the milling of turbine buckets, these being made up from bar stock of the proper section. It is necessary to mill a groove in this bar for steam passage, this groove having a cam section when viewed both along the longitudinal and transverse axis. The obvious question that presents itself on seeing this photograph is, just where and why the milling machine? The answer to that question would really be that the sale of the milling machine was an adjunct to the furnishing of the special equipment, since the latter is more expensive and more complicated than the machine proper.

When in operation, the only part of the machine proper that is moving is the spindle, which rotates, carrying the cutter. All of the movements of the work itself are self-contained in the fixture, which has a combination axial and radial cam movement, controlled by master cams with a compressed-air resistance chamber, the table, feed, cross feed, etc., of the machine being used only for the preliminary adjustments. This equipment points absolutely to the need of a special frame to

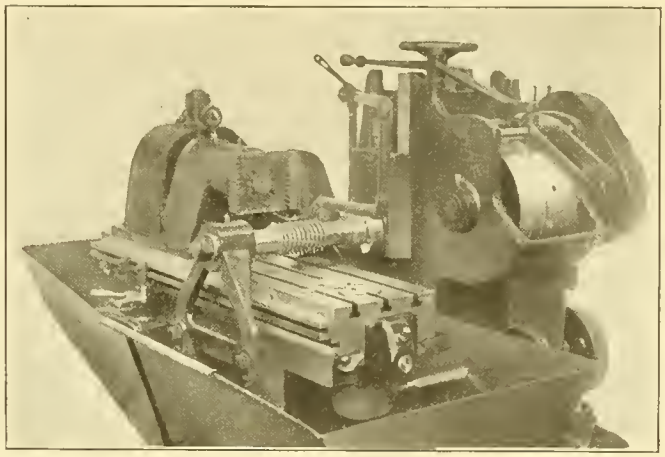

Fig. 3 One Operator and This Machine Produced More than Man and Boy with Standard Machine

take the place of the milling machine, which frame will contain a comparatively simple driving mechanism and a solid base, on which the fixture would have to be mounted. The cutter adjustments should all have been obtained through the vertical and axial raising of the spindle carrier, as in the Lincoln-pattern millers. Doubtless the succeeding machines that are installed for this purpose will be so made.

The second example, Fig. 2, shows a triple-spindle milling attachment fitted with an adaptation of the semi-automatic miller. Before this equipment was considered the work was handled in the stereotyped way, which consisted of one chucking, milling one set of bosses, indexing through 120 deg., milling the next set, indexing, milling the third set, and removing. With this equipment the three spindles mill all the surfaces at one passage, and the work itself is automatically clamped in place by means of the spring plunger shown in the center of the fixture. The table is provided with an automatic quick-forward movement, feeding movement, quick return to the fixture on the other side, and so on. The functions of the operator in this case are restricted to hooking the work onto the central locating stud and removing it when finished.

The example shown in Fig. 3 is interesting in that the conditions that had to be overcome before this equipment could

be installed were such as to make it hardly possible to effect a saving. The pieces that are milled with this apparatus are small tractor binder pins, having a half-round groove extending their full length, and which are slightly tapered on the outside. The old method for handling this work was to use a standard milling machine operated by a man who engaged the feed, returned the table and removed the work from the fixture. This man was aided by a boy, who drove the pins into the taper slots of a work holder while another holder was in the machine. The machine under such conditions was cutting most of the time, and the boy was loading the pieces into the work holder as rapidly as they are loaded today; but with the arrangement shown in Fig. 3 the production was considerably increased, and that with one operator only. The fixture is designed so that it automatically indexes, and the forward movement of the work to the cutter is taken at a high table traverse. The pins do not have to be driven firmly into the slots, since the action of the cutter itself tends to force them home to a bearing. They do not have to be removed from the fixture after the milling operation is completed, because the third stop in the indexing brings the finished pieces against a fixed ejector bracket which pushes them out of the holes. The operator loads into the upper horizontal slots, and he can also load in slots of the front vertical face should he fall a little short in his chucking of the full number held in the one side. It will be seen that with the exception of the twentieth part of a minute taken for indexing from one surface to another and a similar twentieth taken in returning we have cutters which operate all the time. There is no dwell and the operator's cycle is of the very simplest character possible. His functions are confined to putting the work loosely into the holder. He does not have to move it after cutting, and the only thing open for improvement in this connection would be the provision of a hopper feed, so that a bucketful of the pins could be thrown in indiscriminately, and the machine then become entirely automatic. This is the next step which will doubtless follow.

The foregoing illustrations are not intended as examples of perfected coördination between the customer and manufacturer. Some of them indeed are rather intended to show how far we have fallen short of the ideal, while still complying with existing commercial conditions. The purpose that they do fulfill, however, is to show that an attempt has been made to depart from standard practice where the need for such action was indicated by a study of the conditions. The resulting equipment, while not ideal from a designer's standpoint, in that it was obviously necessary to start with a foundation laid down for more general purposes, does nevertheless perform satisfactorily, and so justifies itself from the viewpoint of dollars and cents. More important than this, however, is the clearer light thrown upon the problem, the positive indication of the direction of future design, and the certainty that the combined knowledge of all concerned has been so utilized as to make it valuable for future research.

In many hydroelectric plants there is for some months of the year an excess of energy which is, to a large extent, not utilized. Use has been made of this excess by a Swiss company, for raising steam in the boilers of a reserve plant. Electric heating elements are placed on the grate bars of the furnaces, from which they are readily removable when it is desired to fire with coal. The three boilers of the company's Zurich station furnish 12,390 lb. of steam per day, with a consumption of 7392 kilowatt-hours, thus saving about 1650 lb. of coal.

The grain size in a metal may be measured by a method described by Z. Jeffries in a paper read recently before the Faraday Society. The method consists in counting the grains completely and partly included in the circular part of an image at standard magnification of the specimen; and by means of an empirical formula finding the number of whole grains in the area. The president, commenting on the method, mentioned that a 0.58 carbon steel contained 5540 grains per sq. in. when forged, and if forged and annealed, 4500. When the steel was water-quenched and reheated, the number rose to 330,000.

At a recent meeting of the British Association, in the section of mathematical and physical science, Dr. P. E. Shaw, of Nottingham University College, gave a brief account of the remarkable experiments which he has been conducting for several years in a vault of the Physics Department of the college with a Cavendish balance for the purpose of determining a possible temperature coefficient of gravitation. Such experiments require the most extraordinary care. For example, the readings of temperature are taken through an optical window by means of a telescope. One has to guard against electrostatic effects, magnetic effects, radiometric pressure, radiation pressure, convection, damping, stiffness and torsion of the wires, etc. An enormous amount of the work remains still to be done, notwithstanding the very large amount done already.

The average automobile brake is insufficiently powerful, requires too much effort to apply it, and requires too constant adjustment; its surfaces need too frequent renewal; it is harsh in action, affected by oil and dirt, and a prolific creator of rattles and squeaks. Any good engineer could design better brakes if he would only take the trouble, but it is quite usual to find that a man who will spend months calculating the stresses in almost every other part of his car will accept any sort of brakes without a thought. This is not confined to any one country: it is true of every place where motor cars are made, though least true of Italy, because Italian factories being all at the foot of the Alps, the need for exceptional brakes is forced upon the designers. Still, even the brakes of Italian cars are not always ideal, as the requisite power is often obtained at the expense of harshness.

In a letter recently addressed by the Aeronautical Society of America to the Secretaries of the Army and Navy, the Society, after careful consideration of the needs of this country in the matter of aerial defense, comes to the conclusion that from 8,000 to 10,000 heavier-than-air machines of various types are required. It arrives at the conclusion that our bill for effective defense of the country against foreign invasion in so far as it affects the most important branch of this defense, aviation, is as follows, depending upon whether a program of 8,000 to 10,000 ships is adopted:

Fighting and scout planes....	$120,000,000	to	$150,000,000
Dirigibles	30,000,000	to	40,000,000
Ships, etc., for planes.....	16,000,000	to	20,000,000
Ships, etc., for dirigibles.....	2,000,000		
Mother ships.....	6,000,000		
Training schools.....	40,000,000		
Total	$214,000,000	to	$250,000,000

ANNUAL MEETING PAPERS

Comprehensive Abstracts of Fourteen of the Papers to be Presented and Discussed at the Thirty-Seventh Annual Meeting of the Society, New York, December 5 to 8, 1916

THERE are printed below, and there will be concluded in the December issue of The Journal, comprehensive abstracts of the papers to be presented and discussed at the forthcoming thirty-seventh Annual Meeting of The American Society of Mechanical Engineers, to be held in the Engineering Societies Building, New York City, December 5 to 8, 1916.

These abridgements have been prepared with the collaboration of authors, and are therefore authoritative presentations of the subject-matter of the papers. In many cases the abstract comprises practically the entire paper, with the omission of only such sections as mathematical derivation of formulæ, minute descriptions of apparatus, and logs of tests.

Engineers—members of the Society and others—are invited to contribute discussion to these papers. Such discussion will be read at the meeting and be published in The Journal.

All the papers printed below are also being printed in unabridged form in pamphlet size, and members of the Society desiring a pamphlet copy of any particular paper may obtain it gratis upon application to the Secretary.

THE UTILIZATION OF WASTE HEAT FOR STEAM-GENERATING PURPOSES

By ARTHUR D. PRATT,[1] NEW YORK, N. Y.

Non-Member

The utilization of waste heat from various industrial processes for the generation of steam is not new. The advance within the last few years, however, in methods of utilizing such gases and in the results secured from their utilization has been so remarkable as to make of interest a comparison of former with present-day methods and results.

The design of waste-heat boilers has progressed to a point where it is today possible to successfully generate steam from gases whose temperatures[2] are as low as 950 to 1000 deg. fahr. It is but a few years since it was considered absolutely impracticable from a commercial standpoint to attempt to produce power from such gases, and it is in its ability to satisfactorily utilize these gases that the development of the modern waste-heat boiler has its most far-reaching effect.

The sole theory on which early waste-heat boiler installations were made has as its basis the non-interferences in the operation of the primary furnace. This meant, in practically all cases, that the draft at the exit of the primary furnace should in no way be impeded, and resulted in the installation of a given amount of heating surface arranged in such manner that the frictional resistance to the gases in their passage through the boiler should be a minimum. Presumably the object of such an arrangement was to enable a natural-draft stack of a practicable height to be used. As the result of minimizing this draft loss, such boilers as were installed were ordinarily entirely without baffles and the gases were given a straight passage through the boiler, though partially baffled boilers were used occasionally. High exit-gas temperatures were considered rather desirable than otherwise in order to assist the stack in giving the required drafts.

Boilers installed in this way were considered practicable

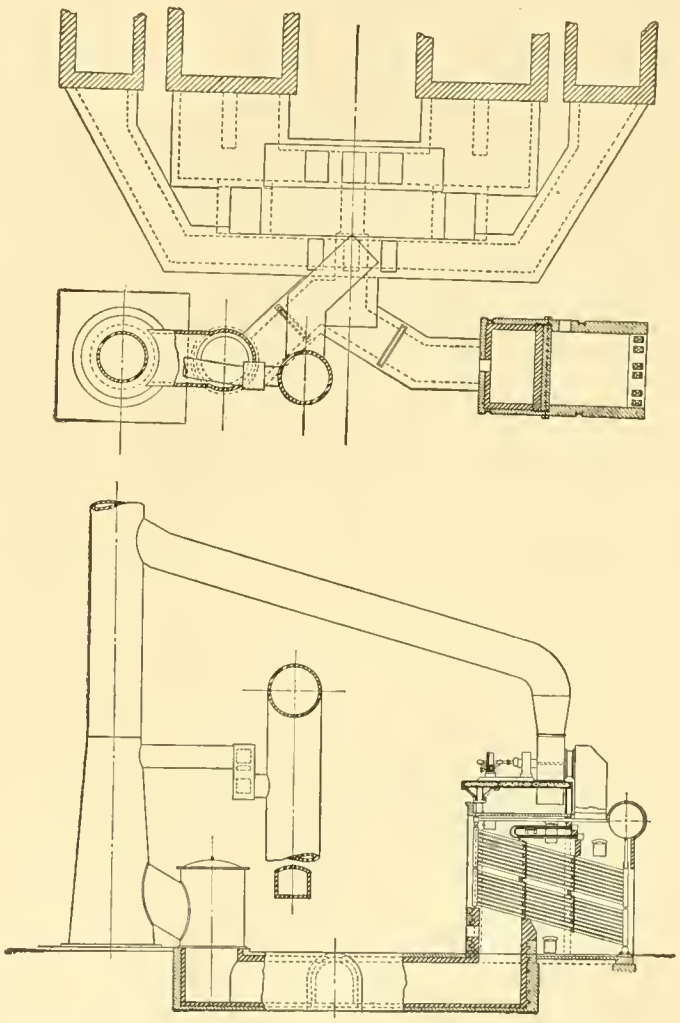

Fig. 1 Waste-Heat Boiler for Open-Hearth Furnace

only with gases whose temperatures approached those of coal-fired practice. The users accepted the steam generated as "something for nothing" and no particular endeavor was apparently made toward increased capacities.

Present-day waste-heat practice has come about with a more thorough understanding of the laws governing heat transfer and an appreciation of the function of gas velocity as affecting transfer rates. Without going into this aspect, it may be broadly stated that the rate of heat transfer is dependent upon

[1]Assistant to Advisory Engineer, The Babcock & Wilcox Co.

[2]All temperatures herein given are in deg. fahr.

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision

gas velocity and temperature difference between the gas and the absorbing surface. Experiments have shown that at even the highest velocities now used in waste-heat work the effect of increased temperature difference is small as compared with that of increased gas velocity.

In coal-fired boiler practice, the average temperature difference between gases and boiler surfaces is approximately 1150 deg. The heat-transfer rate corresponding to a boiler's rated capacity is about 3 B.t.u. per hr. per sq. ft. of surface per degree difference, or a heat absorption of 3450 B.t.u. per sq. ft. of surface per hour. In waste-heat work the temperature difference varies widely with the class of waste heat. With a gas temperature of say 1250 deg. entering a boiler, the average temperature difference between boiler surface and gas for a working pressure of 170 lb. per sq. in. will be about 500 deg. For such a temperature difference the transfer rate to

TABLE 1 RESULTS OF TESTS OF WASTE-HEAT BOILERS FOR OPEN-HEARTH FURNACES

Test Number	1[1]	2	3	4
Plant	Illinois Steel Co.	Indiana Steel Co.	Bethlehem Steel Co.	Lackawanna Steel Co.
Location	S. Chicago, Ill.	Gary, Ind.	S. Bethlehem, Pa.	Buffalo, N. Y.
Rated capacity of furnace, tons	65	75	80	[5]
Actual production, tons	72[2]	85	82.6	.. ..
Boiler	Stirling	Rust	B. & W	B. & W.
Heating surface, sq. ft.	4,000	4,880	5,232	5,407
Superheat, deg. fahr.	128	176	121	97
Gas weight, lb. per hour	73,000	83,434	75,271	78,947
Gas per hr. per sq. ft. htg. surf.	18.3	17.1	14 4	14 6
Temperatures:				
Gas entering boiler, deg. fahr.	1227	1155	1362	986
Gas leaving boiler, deg. fahr.	621	530	493	468
Drop in temp., deg. fahr.	606	625	869	518
Draft at boiler inlet, in.	.....	1.47	1.55	1.76
Draft at boiler damper, in	.....	3 95	3.29	3.63
Draft loss, in.	1.78	2 48	1 74	1 87
Gross h. p. developed	334.5	393	425 8	306
Per cent of rated capacity[6]	83 6	80.6	81.4	56.7
Boiler h. p. to fan	[3]	60[4]	24.3[3]	.....
Net horsepower	.....	386	401.5	.....
Approx. transfer rate (R)	5.08	6.92	4.77	5.12

[1] Average of ten tests. [2] Approximate. [3] Motor-driven fan. [4] 53 h.p. returned in feed-water heater. [5] Tilting furnace. [6] All ratings on basis of 10 sq. ft per h.p.

give an absorption per square foot of surface equal to that of the coal-fired boiler at rating, would have to be 6.9 B.t.u. per hr. per sq. ft. per degree difference. This rate is slightly higher than the rates corresponding to velocities that are as yet ordinarily used, but, with somewhat higher entering-gas temperatures, the absorption per square foot of surface is such as to enable a boiler's rated capacity to be developed without difficulty. With gas temperatures entering the boiler of 1800 to 2000 deg., which approach coal-fired practice, high overloads are being developed.

The gas velocities necessary to give what is now considered a desirable transfer rate lead to a frictional resistance through waste-heat boilers which makes the use of a natural-draft stack impracticable. Let us consider what is probably the extreme case insofar as draft conditions are concerned, namely, the open-hearth steel furnace. Common practice in this class of work is to use stacks 160 ft. high, which give a draft at their base of approximately 1.4 to 1.6 in., depending upon the gas temperatures. For the present purpose, assume that the draft loss through a modern waste-heat boiler installed with an open-hearth furnace is 2.0 in., a figure which approximately represents the practice of today. With a natural-draft stack, the draft at the checkers corresponding to the 1.4 to 1.6 in. given above is approximately 1.3 to 1.5 in., and this amount is necessary for the proper operation of the furnace. With a waste-heat boiler installed, then, the draft necessary at the exit of the boiler must be sufficient to overcome the resistance through the boiler, 2 in., that necessary to overcome resistance through the flues, say 0.75 in., and 1.5 in. necessary at the checkers, or a total of 4.25 in. It is to be remembered that with a waste-heat boiler installed, the temperature of the gases entering the stack, instead of being 1000 or 1200 deg., will be 450 or 500 deg., under which conditions a stack of 160 ft. instead of giving a draft of 1.4 to 1.8 in. at its base would give approximately 0.9 in., and to give the necessary 4.25 in. the stack height would have to be somewhat over 700 ft.

While, as stated, this is perhaps the extreme case, the same reasoning applies in practically all waste-heat work, and an induced-draft unit is now almost universally used with the modern design of waste-heat boiler. In certain classes of waste-heat work, such a fan not only furnishes the required draft suction, but is of a decided advantage in the operation of the primary furnace. This feature is discussed in the paper.

As may be inferred from the foregoing, the successful utilization of waste gases becomes more difficult with decreasing gas temperatures. It was in connection with regenerative furnaces and low-temperature gases that the principles of high gas velocity were first applied and the modern waste-heat boiler was developed. The success of the early installations in this particular class of work led to the application of this theory to all classes of waste-heat practice.

Waste-heat boilers of the modern design are in successful operation today with copper refining furnaces, cement kilns, open-hearth steel furnaces, beehive coke ovens, zinc refining furnaces and heating furnaces of various types, both regenerative and non-regenerative.

As stated, the waste-heat boiler of today was developed with low-temperature gases, and its largest field, until the present, has been with open-hearth steel furnaces. For this reason this class of waste-heat work is considered first. The following is an abstract of this consideration, and of the sections of the paper devoted respectively to cement kilns, copper furnaces, beehive coke ovens, heating furnaces and miscellaneous, including zinc furnaces, nickel refining furnaces, gas benches and oil stills.

OPEN-HEARTH STEEL FURNACES

Under this heading the paper describes in detail certain features of installation and operation, some of which refer specifically to open-hearth work and others to waste-heat work in general. These include location of boilers, connecting flues, air leakage, cleaning, dampers and explosions.

"The application of waste-heat work to open-hearth steel furnaces may be considered new. In this type of furnace we have the best and by far the most numerous examples of the regenerative furnace. From the very nature of the operation of such furnaces, gas temperatures passing to the stack are low, and the ability of the modern waste-heat boiler to utilize successfully these gases for the generation of steam is, without question, the best proof of the progress in the development of this particular class of boiler."

Four installations of waste-heat boilers for open-hearth furnaces are described—one of two Stirling boilers at the plant of the Illinois Steel Co., one of 28 Rust boilers at the Indiana Steel Co., one of Babcock and Wilcox boilers at the Bethlehem

Steel Co., and one of Babcock and Wilcox boilers at the Lackawanna Steel Co. Results of tests of these installations are compared in Table 1.

A typical successful layout of waste-heat boilers for this class of work is illustrated in Fig. 1. Approximate figures showing the great savings made possible by the installation of waste-heat boilers with open-hearth furnaces are included in the paper.

CEMENT KILNS

"The use of waste-heat boilers in the cement industry is not, strictly speaking, new. The number of installations, however, has been extremely small, and there appear to have been several reasons for the non-development of such boilers in this field."

Reference is made to several installations of waste-heat boilers with cement kilns, the first of which are typical of early waste-heat practice while the last is representative of the modern design of this class of boilers. Results of tests of these installations are given, from which the advantages of the modern waste-heat design are shown.

Factors of draft, cleaning and leakage are discussed in detail, and the possibilities of savings through the use of waste-heat boilers in this work are pointed out.

COPPER FURNACES

"The copper furnaces with which waste-heat boilers have been installed may be classed under two general heads: smelting furnaces (matte furnaces) and refining furnaces. Both classes are fundamentally the same in design, though for metallurgical reasons dimensions of the two classes and individual furnaces in the two classes are varied considerably."

Experiences of the Anaconda Copper Mining Company with Stirling boilers, of the Cananea Copper Co. with Stirling and Aultman and Taylor boilers installed with copper smelting furnaces are described, and also those of the Baltimore Smelting and Refining Co. with Stirling boilers utilizing the waste heat from copper refining furnaces. Other refining companies followed the Baltimore Co. in this practice, and the author is familiar with over 11,000 h.p. of boilers with refining furnaces alone.

As in the foregoing sections, results of tests are tabulated.

BEEHIVE COKE OVENS

"This class of waste heat is considered because of the very remarkable results being secured from modern waste-heat boilers utilizing gases from beehive ovens, and because of the possibilities of saving, due to this utilization, until such time as beehive ovens are replaced (with by-product ovens). Furthermore, there are available figures (given in the paper) from boiler installations made a number of years ago for this class of work, and from a comparison with the results today the great advance in the design of waste-heat boilers may be readily seen."

Even granting that beehive ovens will ultimately be replaced with by-product ovens, the author considers that, in numerous plants, an installation of waste-heat boilers would pay for itself many times before such a change could be made, and that it would be entirely possible, too, in these installations to design the boilers in such a manner that at the time of replacing the beehive ovens the boilers could be dismantled and reset either for burning coal or coke breeze, or to be fired with by-product coke-oven gas.

HEATING FURNACES

The early history of waste-heat boilers applied to heating furnaces is in reality the early history of the utilization of waste heat in general.

The early designs of boilers in most general use in this class of work are described and illustrated, this being followed with a description of the first waste-heat boilers of the strictly modern design and utilizing the theory of high gas velocity, these boilers being installed by the Bethlehem Steel Co. Results of three tests on this latter installation are tabulated.

MISCELLANEOUS

"While by far the greatest number of waste-heat boilers in service are in the industries outlined above, there are numerous installations in plants of different character."

In this miscellaneous class, while the number of installations in any single industry is small, reference is made to certain of these to give an idea of the wide and varied field for development in the use of waste heat.

THE TESTING OF HOUSE-HEATING BOILERS

By L. P. BRECKENRIDGE and D. B. PRENTICE,

NEW HAVEN, CONN.

Members of the Society

THIS paper discusses a standard method for testing house-heating boilers, which so far have not received the attention of the Power Test Committee of the Society. If all boilers are classified as either power or heating boilers, we define a house-heating boiler as one of the latter group designed to serve 2000 ft. of radiation or less. This is equivalent to a boiler of less than 14.5 h.p. Such a boiler is usually operated with little attention, infrequent firings, low rate of combustion, and automatic pressure regulation by damper control.

The satisfactory testing of house-heating boilers by a method which admits of fair comparison is important for three reasons:

a On account of the increasing cost of anthracite coal it is desirable to determine efficient types of heaters and the most efficient method of burning this fuel

b It is desirable to develop efficient types of furnaces for other fuels, such as bituminous coal and coke

c By means of standard tests it is desirable to establish a satisfactory rating system which will eliminate the uncertainty of the present manufacturers' ratings of house-heating boilers.

REQUIREMENTS IN TESTING HOUSE-HEATING BOILERS

The authors believe that a method of testing any apparatus to give results of value should meet two requirements:

For presentation at the Annual Meeting of the American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

a The apparatus should be tested with as many conditions as possible equivalent to those under which it normally operates (except for particular investigations under special conditions)

b Errors should be so far eliminated or reduced that results can be reproduced.

To meet the first requirement with a house-heating boiler it is necessary to operate at a moderate, reasonable pressure, controlled automatically, as would be the condition in an actual installation. It is proper to fire the fuel in rather heavy charges and to give attention to the boiler only at intervals of several hours. The fire should not be frequently shaken or poked. The temperature of the feed water should be comparable to the returns from a radiator system, and the boiler should be supplied with water continuously and uniformly. Perhaps the greatest essential is that the test should be started

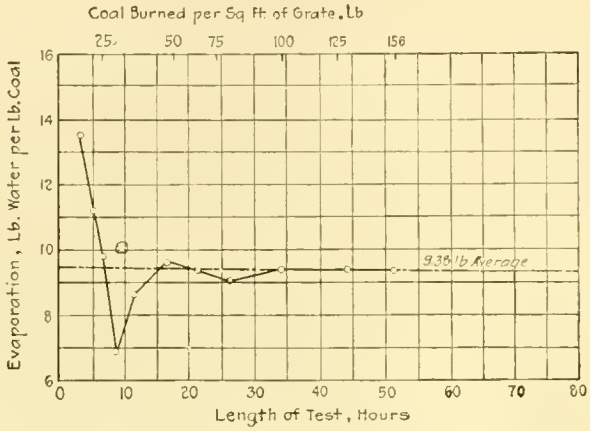

FIG. 1 SPECIAL TEST TO DETERMINE PROPER LENGTH OF HEATING-BOILER TESTS

under average running conditions, with the boiler and covering thoroughly heated to bring the radiation loss to equilibrium, and with a fire neither freshly kindled on bare grates nor clogged with ash; in brief, a good, thin, recently cleaned fire.

The elimination or modification of errors so that results can be verified by several tests presents some difficulties. The measurement of coal fired in the boiler is a matter of careful weighing. Determining how much coal has been burned is necessarily somewhat uncertain. The method of starting and stopping described later, the authors believe, decreases the error of measurement, yet makes the test under normal running conditions. The low rate of combustion in house boilers and the small amounts of fuel involved make long tests essential. It is necessary to burn at least 40 lb. of coal per sq. ft. of grate area, or to test for at least 12 hours, to secure results that can be approximately duplicated. The error in coal measurement is then distributed over an amount large enough to make it a small percentage of the total. That shorter tests are unreliable is shown by the diagrams of two special tests, Figs. 1 and 2. In these tests, from the start to any one of these endings may be considered a complete test. The evaporation per pound of coal has been calculated for the several periods from the start to the successive closing points, and these performance values are plotted against the elapsed time, that is, the durations of the corresponding periods. The heavy horizontal line represents the average evaporation for the longest period. The vertical distance of any point from this line is the error in the calculated rate of evaporation which would result from closing the test at that time. Very little gain in accuracy is secured by long tests.

CONTROL OF BOILER OUTPUT

The output of a boiler during a test may be controlled in one of several ways or it may be allowed to vary. The latter condition reproduces, strictly, house operation, where the heating load is uneven, depending on wind and weather. But testing on such a plan would be very unsatisfactory; for the duplication of a test would be a matter of chance, and innumerable experiments might be necessary to produce a performance curve for a fair range of output. Some control is desirable, preferably by a constant and accurate method. Condensation in radiators or piping, the amount of surface that is open to steam being regulated, is too variable. An orifice of some kind is a better control. However, the pressure in the boiler is not even, and the discharge of steam directly through a certain opening would not be uniform. An excellent arrangement seems to be to maintain a pressure of 2 lb. per sq. in. in a receiver by an automatic pressure-reducing valve, the boiler carrying 3 to 8 lb. The discharge from the receiver through a given area is then constant. The authors believe that a tapering needle valve is more satisfactory than a set of changeable orifices, as it facilitates varying the load during operation. A bank of valves of varying size, opening from the receiver, is another convenient and suitable method of control. The exhaust steam may be used to warm the feed water or it may be condensed and used again.

The method of feeding the water to the boiler is not important provided a steady, easily controlled flow is secured. The

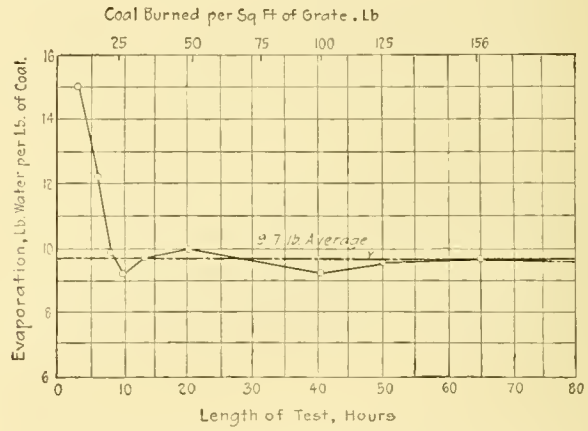

FIG. 2 SPECIAL TEST TO DETERMINE PROPER LENGTH OF HEATING-BOILER TESTS

measurement of boiler output may be made either before or after the water goes to the boiler. An extremely convenient method is to draw the water supply from a tank fitted with a long gage glass and scale. The level is quickly noted and no "weighing back" is necessary. The tank should be carefully calibrated, by weighing, over the entire range between the extreme levels reached. A duplex water-driven pump is a very convenient device for feeding the boiler wherever city water pressure is available.

METHOD OF STARTING TESTS OF HOUSE-HEATING BOILERS

The authors have found the following method for starting house-heating boiler tests very satisfactory. A preliminary fire is carried until the boiler is well heated and operating at the usual pressure, about 5 lb., and the load at which the test is to be made. When conditions are considered stable, the preliminary fire is allowed to burn down, the pressure begins

to fall, and the fire is shaken, which retards the pressure drop temporarily; but soon a pronounced fall is noticed. The fire is now thin, clean, burned-out, but still hot enough to kindle fresh fuel. When the pressure reaches a given point, perhaps 3 lb., the necessary measurements are made, including a careful determination of the thickness of the fuel bed, the first charge of weighed coal is fired, and the test is considered started. When the test is drawing to a close these same conditions are readily duplicated, and at a point, after shaking, when the pressure falls to 3 lb., the test is concluded. The ash should be shaken out until the thickness of the fuel bed is the same as at the start. The events outlined are characteristic, and a recording pressure gage pictures them very clearly. The accompanying diagram, Fig. 3, was copied from a pressure chart made during an actual test. The periods of falling pressure immediately before the beginning and ending of the test, as well as before each firing, are quite distinct.

PROPOSED UNIT OF CAPACITY FOR RADIATORS AND HEATING BOILERS

The capacity or commercial rating of a heating boiler has always been given in terms of the direct radiating surface which it would serve. The unit usually employed is the "foot of radiation," commonly understood to be that surface which will condense a quarter of a pound of steam per hour at 2 lb. pressure when in still air at 70 deg. fahr. Originally the foot of radiation meant a square foot of radiating surface, but improvements in design and arrangement enabled manufacturers to secure this condensation with less surface, and consequently less weight of iron. The result has been a variable and decreasing value in square inches for the "foot of radiation." In fact, the unit has become, as it should, dependent entirely on condensation of steam, which means a heat transfer, rather than on any particular area of metal.

If the unit is considered as a certain number of heat units it is applicable to boilers directly, as well as to radiation. There are many reasons why it would be convenient to have a capacity unit for heating boilers comparable to the capacity unit for power boilers, *i.e.*, the boiler horsepower. The authors propose, therefore, the following definition of a unit for stating the capacity of radiators and heating boilers:

The "foot of radiation" shall be a quarter of a pound of steam condensed from and at 212 deg. fahr. per hour.

This is equivalent to a heat transfer of 242.6 B.t.u. The condensation of a quarter of a pound of steam at 2 lb. pressure is equivalent to 241.5 B.t.u. There is, therefore, very little change in the heat equivalent of the unit. Although there is no direct connection between the unit as defined above and a square foot or any particular area of radiating surface, yet the authors favor the retention of the old name for the same reason that boiler horsepower was continued, although that unit bears no relation to the standard horsepower.

The advantages of the above definition of the "foot of radiation" are:

a The heating- and power-boiler capacity units are based on the same physical conditions.

b They are mutually convertible by the factor 138.

c Radiation is rated without reference to surface, so that efficient designs and arrangements are benefited.

d The unit is applicable to hot-water radiators and heaters by determining the heat transfer. (The result may be called "equivalent feet of radiation").

The authors recommend that radiator tests to determine rating be made with steam at 2 lb. pressure and in "still air" at 70 deg. fahr., and suggest that boilers under test be operated at from 3 to 8 lb. pressure.

PROPOSED HOUSE-HEATING BOILER CODE

[The paper proceeds to give the proposed individual code for house-heating boilers to be used in conjunction with the First Section (General Matters) of the Report of the Power Test Committee of the American Society of Mechanical Engineers. This code follows closely the A.S.M.E. boiler code of 1915, differing materially only in the paragraphs dealing with the duration of tests, the method of starting and stopping tests, and the calculation of results. These paragraphs are given below.]

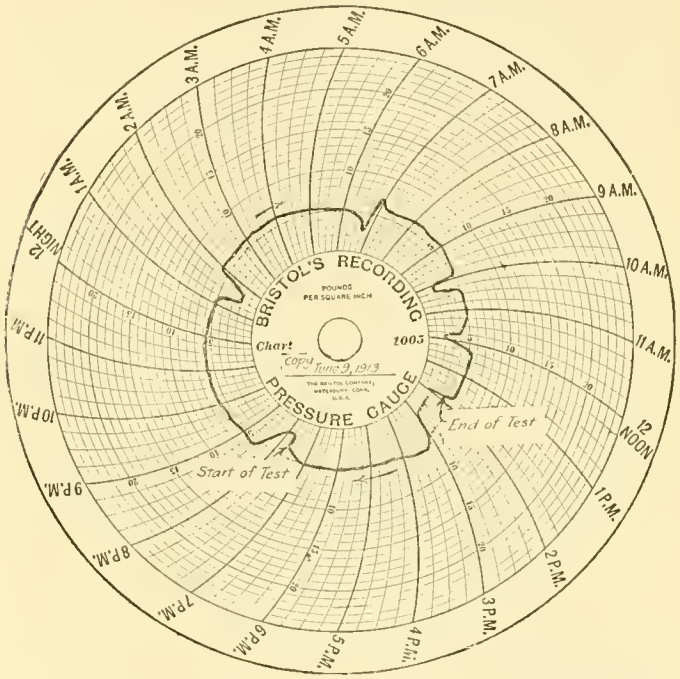

Fig. 3 Pressure Chart of Test of a House-Heating Boiler

DURATION

The duration of tests to determine the efficiency of a house-heating boiler should be at least 12 hours of continuous running, or such time as may be required to burn a total of 40 lb. of fuel per square foot of grate. The duration of tests which include periods of banked fires should not be less than 24 hours. The duration of tests to determine the maximum evaporative capacity of a boiler without determining the efficiency should not be less than 3 hours.

STARTING AND STOPPING

The conditions regarding the temperature of the furnace and boiler, the quantity and quality of the live fuel and ash on the grates, the water level, and the steam pressure, should be as nearly as possible the same at the end as at the beginning of the test.

To secure the desired equality of conditions the following method should be employed:

The furnace should be well heated by a preliminary run of at least an hour under all the conditions at which it is proposed to test. A suitable pressure for running the boiler while under test is from 5 to 8 lb. During this run the operation of the pressure-reducing valve and damper control should be tested, and the setting of the output-control valve should be verified. The fire should now be allowed to burn low, which will result in a falling pressure. When the pressure reaches a chosen point (3 lb. is recommended), the fire should be shaken clear of ash, the thickness of fuel bed noted, the water levels in boiler and feed tank recorded, together with steam pressure, draft, flue temperature and the other usual data. The first charge of weighed fuel should now be fired and the time recorded as the starting time for the test. The test should be ended when the fire has burned low and it is impossible to check the pressure fall by shaking, as at the start. When the pressure again reaches the chosen point the final readings should be made, the ash shaken out until the fire is the same thickness as at the start, and the time recorded as the stopping time. It is advisable to regulate the feed so that the water in the boiler is brought to the starting level and held there, toward the end of the test. All ash should be removed from the ashpit immediately after the fire is shaken down at the beginning of the test and again at the end. The second lot, with any that may have been drawn during the test, should be carefully weighed.

CALCULATION OF RESULTS

The method to be followed in expressing and calculating those results which are not self-evident or stated in detail in the Boiler Code, is as follows:

The capacity of the boiler in "feet of radiation" served is found by dividing by 242.6 the total heat absorbed per hour by the water in the boiler, expressed in British thermal units.

THE PROPORTIONING OF SURFACE CONDENSERS

By GEORGE A. ORROK, NEW YORK, N. Y.

Member of the Society

DURING the discussion of my paper on The Transmission of Heat in Surface Condensation,[1] I was asked to present formulæ covering the application of the results of my experiments to the design of surface-condensing apparatus. Since the appearance of the paper there have been a number of papers on allied subjects whose authors have approached the subject from a somewhat different standpoint, and the conclusions presented have been of varying character and usefulness in the design of surface-condensing apparatus. Only one author, Loeb,[2] has presented new experimental data which can be used for checking the heat-transfer constants, but considerable mathematical work has been done along the line of following out Jordan's deductions from Osborne-Reynolds's statement of the law of heat transfer.

I propose in this paper to discuss the state of the art of "heat transfer in surface condensation," and to establish design formulæ for use in proportioning condensing apparatus.

THE PROBABLE LAW OF TEMPERATURE RISE

The law of temperature rise of the water in a condenser tube is still unknown. My own tests led me to believe that this law departed somewhat from the logarithmic law as stated by Smith and Josse, but their results are sufficiently variant to allow for a slight modification. Loeb, however, has presented a set of tests with plotted curves, from which he deduces that the law is of the exponential form, with approximately 0.9 as the exponent. My plotting of his numbers places the exponent nearer 0.8, both of which are not far from my adopted figure of 0.875. These variations are not of prime importance for practical design, and indeed may be caused by the apparatus used in the making of the experiments; and I am still of the opinion that we may use $N = K\theta^{0.875}$ as the basis of our work, N being the total heat transfer per sq. ft. per hour in B.t.u., θ the temperature difference, and K a constant determined by experiment.

VISCOSITY NOT AN IMPORTANT FACTOR IN DESIGN

It has been stated in London Engineering (Jan., 1914) that the extreme variation in the results of heat-transfer experiments has been caused by a neglect of the variation due to the viscosity of the water, and quite an extended argument was given to show that some of these experiments were reconciled when the correction was applied. Wilson has carried this method to its logical conclusion in his paper, A Basis for Rational Design of Heat-Transfer Apparatus,[1] lately presented to the Society. Our work in the design of surface condensers, however, is mainly concerned with a very small variation in temperature, the upper limit of which is fixed by the vacuum carried at somewhere between 80 and 90 deg. fahr., while the lower limit in America is between 65 and 70 deg., and in Europe perhaps a few degrees lower—in all a variation of perhaps 20 deg. In the winter we can carry good vacuums with low heat transfer and our troubles are few, but the problem is the summer problem, and here the difference in viscosity is small. As a matter of fact, I believe Osborne-Reynolds's straight-line law does not apply where there is a change of state at either side of the metallic surface. Observers making use of this hypothesis have been frequently misled by the bunching of the results in the condenser range, with the consequent spreading of the results outside this range. This may be seen in Fig. 8 of Wilson's paper.

CRITICAL VELOCITIES NEED NOT BE CONSIDERED

There has been considerable comment on the effect of stream flow and turbulent flow on the heat transmission, and as there is a marked change in the friction characteristics between the two states of flow, the conclusion has been drawn that there will be a similar effect on the heat-transmission characteristics. Osborne-Reynolds investigated this subject and gave formulæ for the critical velocities. He finds two critical velocities, the lower, which we may call V_c, below which all motion is stream-line and if disturbed artificially will return to stream-line flow; and an upper critical velocity, V_a, above which all motion is turbulent. Between the two is a field in which stream-line motion may be maintained if no artificial causes upset it, or turbulency may be set up and will maintain itself when so started. He gives formulæ for these two velocities, which, following Parker, are

$$V_c = \frac{0.0388\,P}{D} \quad \text{and} \quad V_a = \frac{0.2458\,P}{D}$$

[1] Trans. Am.Soc.M.E., vol. 32, p. 1139.

[2] Jour. Am. Soc. Nav. Eng., May, 1915.

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[1] Trans. Am.Soc.M.E., vol. 37, p. 47.

where D is the internal diameter of the tube in feet and P is Poisseuille's ratio, *i.e.*, the ratio between the viscosity and density of the water. If the values of v = viscosity and δ = density be taken in C.G.S. units,

$$P = 56.2\,\frac{v}{\delta}\begin{cases} = 1.000 \text{ at } 0 \text{ deg. cent. (32 deg. fahr.)} \\ = 0.734 \text{ at } 10 \text{ deg. cent. (50 deg. fahr.)} \\ = 0.455 \text{ at } 30 \text{ deg. cent. (86 deg. fahr.)} \end{cases}$$

This agrees with Osborne-Reynolds's value, which is

$$P = \frac{1}{1 + 0.0336\,T + 0.000221\,T^2}$$

where T is the temperature in centigrade degrees (not the absolute temperature, as stated in Wilson's paper). The table of correction factors in Wilson's paper may be used as a table of P by multiplying the correction factors by 0.625, thus correcting the values to 32 deg. fahr. The critical velocities for a 1-in. No. 18 B. W. G. condenser tube will then be as follows, T being the mean temperature of the water:

T deg. fahr.	40	50	60	70	80	90	100	115	130	150
V_c....	0.50	0.422	0.362	0.318	0.278	0.25	0.224	0.192	0.166	0.14
V_a....	2.84	2.400	2.060	1.810	1.580	1.42	1.270	1.090	0.945	0.80

In condenser practice and in most of the apparatus for heat-transfer experiments it is nearly certain that the flow is turbulent above V_c. Velocities from 6 to 10 ft. per sec. are the common range in modern surface condensers, so that in every practical case the critical velocity need not be considered.

CONDITIONS DETERMINING THE VALUE OF THE COEFFICIENT K

Surface-condensing apparatus is never tested to the capacity of the surface to transfer heat, and Gibson and Bancel[1] have shown this in their characterizing the "active" and "inactive" zones in a surface condenser. The condenser must be designed for the maximum load that may be put on it when the entering water is at its maximum temperature, and additional surface must be installed as a factor of safety against dirty, oxidized tubes and the presence of undue amounts of air. The depression of the hot-well temperature below the vacuum temperature, a well-marked phenomenon in many condensers, may be eliminated by good design, and many tests by careful investigators have been reported in which the depression was zero. Certain designs of the dry-tube type may give hot-well temperatures somewhat higher than the average temperature in the condenser. The hot-well depression is especially marked where drowned lower tubes are used.

Neilson and others have objected to conclusion (*b*) in my 1910 paper[2] that the heat transmission is approximately proportional to the square root of the cooling-water velocity. Within the condenser range the experiments may perhaps be better represented by $KV_w^{0.6}$ instead of $KV_w^{0.5}$. Weir (Trans. I.E.S.S.), in his paper read Oct. 22, 1912, gives a curve for the relation of U to V_w for design purposes. The curve corresponds very closely to $U = 250\ V_w^{0.6}$, the maximum variation being less than 2 per cent. It is possible that a closer agreement might be secured by using more figures in the exponent, but such a procedure is hardly necessary, as probably we have already exceeded the accuracy of our experimental apparatus. The effect of air in reducing heat transmission has been shown in my 1912 paper,[1] and a term introducing the second power of the pressure ratios recommended to allow for it in design. This subject is still unsettled and will remain so until Smith's experiments are repeated on a proper scale, with known amounts of air present in the condenser. We may say that the term $(P_s/P_t)^2$ represents the reduction of heat transmission by air, with a possible variation of 10 per cent. The difficulty is in obtaining a figure for the amount of air present and its temperature. The use of the air bell enables the operating man to keep his leakage down to the minimum, and where water-jet air pumps are used the addition of the testing dry vacuum pump and air bell will usually pay for themselves in a very short time.

The attempt to find a better tube material than Admiralty brass has failed, and the standard tube today is a heat-treated Admiralty-mixture tube whose material coefficient is 0.98. This coefficient can now be neglected. A number of experiments with dirty and oxidized tubes have been made, but since it is possible to clean a tube by mechanical means and secure the original heat transmission, the cleanliness coefficient may be also neglected in design and only used in checking up a condenser test where allowance must be made for a dirty tube condition.[2]

Assuming that I had practically air-free steam in the experimental apparatus and clean tubes, the value of K is $U\theta^{0.125}/V_w^{0.6} = 470$. The value 630 given in my paper was arrived at by assuming an air pressure of about 0.065 in. of mercury. If the air-term influence be taken to the second power, $K = 570$. In both cases 90 per cent cleanliness and 0.98 for material were assumed.

We know that the results of single-tube experiments may be approached in real condensers, and the closer the approach when the condenser is supplied with sufficient steam the better the performance of the condenser. We know that they never can be approached with light loads or with colder water, because only so much heat is transferred as is present. This definitely prevents the use of Jordan's "mass flow" formulæ or the electric resistance simile. These hypotheses can only be true where no change of state takes place, and this condition is entirely foreign to heat transfer as met with in condenser practice.

We may now put down the following principles:

a The law of temperature rise in the tube is of the exponential form, with $0.875 = 7/8$ (0.9 or 0.8, perhaps) as the exponent.

b We may neglect viscosity for design purposes in America where the water temperature is 65 to 70 deg. fahr. and the vacuum 28 in. and over.

c We may also neglect critical velocity, since all condenser velocities are far above it.

d For velocities in condenser practice we may take K as varying as the 0.6 power of the velocity.

e The reduction in heat transmissive power due to air is very approximately covered by the use of a term $(P_s/P_t)^2$ as a reducing factor of K.

f For design work we may reduce the value of K once for all to account for the cleanliness of the tube and the material itself.

g The value of K will then be reduced to somewhere between 300 and 400 for design purposes, say 325 for average good working.

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[1] Trans. Am.Soc.M.E., vol. 37, p. 975.

[2] Trans. Am.Soc.M.E., vol. 32, p. 1135.

[1] Trans. Am.Soc.M.E., vol. 34, p. 713.

[2] Report of Com. on Prime Movers, Natl. Elec. Light Assn., 1916.

CONDENSER DESIGN

THE AUTHOR'S METHOD

Condenser specifications usually call for the condensation of a certain amount of steam per hour, W (lb.), and the maintenance of a vacuum referred to standard barometer or absolute pressure, P_v, with condensing water at a certain temperature, t_0. The quantity of condensing water, Q, the hot-well temperature, t_s, the power used by the auxiliaries and the steam consumption of the auxiliaries may be also specified, but the problem is reasonably determinate when W, P_v, and t_0 are known. It is important that the place of measurement of the vacuum P_v be specified, as there is a well-defined drop through most condensers, the vacuum being greatest at the air-pump suction, less in the condenser, and least at the prime-mover nozzle. This drop may amount in well-designed condensers to 0.2 in. of mercury. The specified vacuum should be measured at the prime-mover nozzle, and the designer, according to his judgment, will then allow 0.1 to 0.2 in. for the drop in the condenser.

The absolute pressure in the condenser will then be 29.92 — (vacuum + 0.2 in.) = P_v. The steam tables may now be consulted and t_s the temperature corresponding to the vacuum, λ = the total heat and q = the heat of the liquid be taken therefrom. The final temperature of the condensing water approaches t_s, and for close work may be $t_1 = t_s - 5°$. In ordinary practice, $t_1 = t_s - 7°$, or in some cases 8° or 10°. The ratio of condensing water to steam condensed, which is

$R = \dfrac{\lambda - q}{t_1 - t_0}$, may next be found. Many designers consider it close enough to use 1000 for $\lambda - q$, on account of the moisture in the exhaust steam, and some few use 968. I prefer to use $\lambda - q$ not on account of its accuracy but as a slight factor of safety. Q, the quantity of condensing water = WR in lb. per hour.

At this point the size and thickness of the condenser tubes as well as the water velocity must be chosen. Most of the large installations in Eastern United States use 1-in. tubes on account of bad water conditions, although it has been stated that smaller tubes are more efficient (*vide* Weighton, Neilson, and Weir). There are no definite experiments to decide this point, although from Loeb's work on ¾-in. tubes we may deduce a value of $K = 600$ against $K = 470$ for my experiments on a 1-in. tube. Nevertheless, it is doubtful if anything is saved by the use of anything smaller than ¾-in. when the pumping head is considered. 1¼-in. tubes have also been used, but the consensus of opinion seems to be that a 1-in. tube can be cleaned better, keeps in good condition longer, and can be made better than either smaller or larger tubes. Let us take 1-in. tubes, No. 18 B.W.G., as standard. The formulæ may readily be altered for other sizes of tubes when the constants are known.

With 1-in. tubes velocities from 7 to 10 ft. per sec. are now usual. We may take 8 ft. per sec, as the standard value for V_w.

The number of 1-in. tubes in one pass will be given by the formula

$$n = \frac{Q}{990\, V_w}.$$

The length of water travel (l), or the total tube length, may be found from

$$l = \frac{30.8\, Q}{325\, V_w^{0.6}\, n}\left[(t_s - t_0)^{0.125} - (t_s - t_1)^{0.125}\right]$$

and the total tube surface S from

$$S = 0.262\, nl$$

With 1-in. tubes from 40 to 80 will occupy 1 sq. ft. of tube-plate area, depending on the spacing and general design. The average will be about 60, making the cross-sectional area of the condenser (sq. ft.) equal to ($n \times$ number of passes) $\div$ 60. If there are two passes the length of the condenser will be $L = \frac{1}{2}l +$ depth of water boxes.

BEST TUBE LENGTHS AND TEMPERATURE RISES

The paper here gives the condenser formulæ proposed by Neilson in his paper read before the Institution of Engineers and Shipbuilders of Scotland, together with those published in Morrow's Steam Turbine Design, and in Bauer and Lasche's Marine Steam Turbines. These writers use the arithmetical mean for the mean temperature difference. Neilson says, "Equations for θ_m involving the use of hyperbolic logarithms are not to be recommended for condenser design," the reason being that the steam-air mixture in the condenser is not homogeneous. Weighton, upon whose experiments Morrow's work is largely founded, did not consider θ at all in his paper. Many other authorities follow this rule also, and I must acknowledge this position to be correct providing that equal increments in the temperature rise of the water in the condenser tube accompany equal increments of length. The tests of Smith and Josse as well as my own have definitely proved that this is not so. Thermometers placed in the water boxes of any two- or three-pass condenser will also show this fact very plainly.

Now for each curve of temperature rise except the arithmetic there is a definite relation of l/d which is best for any given condition. Under the arithmetical law any values of d, n, and l which will give the necessary surface should be equally efficient, and 10 tubes 100 ft. long should work as well as 1000 tubes 1 ft. long from the heat-transfer standpoint.

The differences between the logarithmic law and the exponential with an exponent between 0.9 and 0.8 are quite small, but the length of the tube required by the formulæ is considerably shorter using the logarithmic formula. These length formulæ may be derived from the expressions for S given in the fourth column of the table on p. 1152, vol. 32, Trans. Am.Soc.M.E.

Taking the steam temperature t_s at 90 deg., the entrance water temperature t_0 at 70 deg., and the discharge at 80 deg., with a water velocity of 8 ft. per sec. and 1-in. tubes, I figure the best tube lengths and temperature rises as follows:

	Tube Length, Ft.	Rise in Deg. Fahr.
Arithmetical Law	23.2	0.4310 deg. per ft. of tube
Logarithmic Law	24.0	0.4918 deg. in first foot
Exponential Law (exponent = 0.875)	26.8	0.5624 deg. in first foot

It is to be hoped that some investigator will definitely settle this question on which so much in condenser design depends.

The paper gives a logarithmic chart for the ready determination of such fractional and decimal powers of numbers as are called for by the formulæ given.

WATER FOR STEAM BOILERS—ITS SIGNIFICANCE AND TREATMENT

By ARTHUR C. SCOTT, DALLAS, TEX.
Member of the Society, and
J. R. BAILEY,[1] AUSTIN, TEXAS
Non-Member

In recent years the value of a critical analysis of production costs and operating efficiencies has become prominent in the business of manufacturing, and since water is necessary for the operation of nearly every industrial establishment, its *quality* is receiving more attention than formerly. The plant owner is rapidly modifying his views heretofore concerned only with the available quantity, because of the important factor in the operating cost due to the use of water unsuited to the service required. This is especially significant in steam making.

No general source of water supply, whether lakes or ponds of surface water, rivers, or wells of varying depth, is free from impurities obtained either from filtration through the earth or from the air, or from both.

Water from lakes or large reservoirs is ordinarily most satisfactory for boilers, since it is chiefly rain water and surface drainage, and the suspended matter has had opportunity to settle. Under conditions of a long drought, however, as the reservoir capacity is reduced, the organic matter from algal growth and other sources may have an appreciable effect upon the quality of the water.

River water is more or less variable in character, depending upon the location and extent of the watershed or drainage basin and upon the rainfall. Slow-moving rivers may carry a large amount of mud, some of which settles out readily, while the red or yellow mud will generally remain in suspension a long time unless some coagulant like sulphate of alumina is used. A river frequently picks up considerable organic matter, which by decomposition forms organic acids that corrode boiler metal. The character of the drainage area of a river will affect the character and content of dissolved mineral matter in the water, and this will vary more or less with the season of the year and may vary from day to day part of the time.

Well water varies in quality with the location and depth of well and with the rainfall. Water from deep-well sources is usually low in organic matter but contains mineral constituents dissolved by the water in passing through the earth.

BOILER FAILURES AND LOSSES DUE TO SCALE

Reports show an increased number of dangerous defects in boilers from year to year due to scale, corrosion, priming, etc. Aside from the dangerous condition of a "scaly" boiler, scale also means fuel waste, ranging according to the thickness from 2 per cent for 1/64 in. thickness, to 90 per cent for ¾ in. as a general average.

Other troubles through scale are clogged feed pipes and water- and steam-gage connections, and valves prevented from completely closing.

WATER-SOFTENING PROCESSES

The common methods of reducing scale troubles are:

a two types of cold processes for the actual softening of water: the intermittent originating with Clark in 1841 and the continuous invented about 1867
b the hot process
c live-steam purifiers
d boiler compounds

For very large plants where several hundred thousand gallons per day are used, a considerable expenditure is justified for tanks and mechanical equipment for the cold process of purification, which is fundamentally a treatment of the water with proper amounts of milk of lime and soda ash. These cold processes perform their chief service in softening water for locomotives and in large plants where water is used in considerable quantities in connection with jet or barometric condensers, or where it must be softened for other purposes than boiler feed alone.

The hot process is particularly desirable for plants where exhaust steam is available. Purification of the water is partly obtained by heating to the approximate boiling point, but sufficient soda ash is added to satisfy the alkaline earth sulphates and chlorides and any acid present. The essentials are heat and soda, and the whole scheme is virtually embraced in the ordinary operation of an open-type feed-water heater, with the introduction of soda ash into the hot water.

Live-steam purifiers are useful as partial purifiers, but are always subject to boiler pressure, waste some heat, must be placed higher than the boiler level, and frequently give trouble from water hammer.

Boiler compounds are more or less palliative in their action and produce results by (*a*) acting as chemical reagents combining with the scale-forming impurities, breaking them up and precipitating them as sludge; (*b*) acting mechanically on the precipitated scale-forming matter and entrapping it as it is precipitated from solution before it has formed a hard, adherent scale. Examples of materials in use under (*a*) are soda ash, caustic soda, trisodium phosphate, sodium fluoride, and compounds of tannin; and under (*b*) gelatinous or starchy materials, such as ground bones, hoofs, horns, slippery elm, and potatoes.

Boiler compounds are to be recommended for use only in small plants whose capacity will hardly justify arrangements to purify the water before it enters the boiler. The steam boiler should be used primarily for generating and storing steam energy, not as a precipitating tank. If it must be used partly as the latter, it is most economical to have the feed water analyzed, and the character and amount of chemical reagents determined to effect the necessary purification. These reagents, of definite strength and known amount properly proportioned for the conditions, should be pumped in with the feed water as it passes into the boiler.

BLOWING OFF BOILERS

The main factors in ordinary boiler-water purification are heat, soda ash and blowing off, with possible filtration when this can be arranged, as is sometimes done with the hot process. The blowing off is important. It should be done under low pressure to be effective in carrying out the sludge and to reduce the boiler stresses coincident with rapid blowing under high pressure. If it must be done under high pressure, the

[1]Professor of Organic Chemistry, University of Texas.

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valves should only be "cracked"; otherwise only a small part of the sediment will be carried out, because the vortex or whirlpool formed draws down clear water, leaving the main body of the sludge intact.

Undoubtedly some of the troubles recorded as due to scale-forming water are really attributable to the disregard of proper methods of blowing off, and to the pumping in of cold water, thereby overstraining the boiler material.

KEROSENE FOR SCALE TROUBLES

The success of kerosene oil in removing and preventing scale is undoubtedly due to mechanical action alone. To be effective the oil should be put in after the boiler is emptied and washed, and the boiler should be refilled slowly from the bottom. It is useless to pump the kerosene in with the feed water, for it may tend to form a non-conducting film over the heating surfaces that will introduce an element of danger.

BOILER TROUBLES CAUSED BY CORROSION

The trouble due to corrosion of sheets, tubes, stays, etc., is in some cases more acute than ever occurs with scale. Carbonic acid gas, occluded oxygen, and sodium and magnesium chlorides are the most frequent offenders, and the chlorides are so difficult to remove that the cost is practically prohibitive.

Corrosion due to the chloride ingredients is particularly destructive to steel boiler tubes, hot-water piping, and brass-seated valves. Galvanized steel pipe is not immune, because any defect in the zinc coating permits local galvanic action, with consequent rapid destruction of the zinc coating. Water with as much as 500 parts to a million of these chlorides, especially when hot, is destructive to steel pipe and fittings.

Waters are frequently both scale-forming and corrosive; usually a water having a corrosive tendency will be more or less scale-forming. Caustic or carbonate alkalies or caustic lime act as neutralizing agents for corrosive ingredients, but must be carefully handled or the scale-forming matter will be increased. Their use should be confined to treatment of the water outside the boiler if possible.

BOILER TROUBLES DUE TO FOAMING OR PRIMING

Boiler troubles due to foaming or priming apparently depend largely upon the concentration of alkali salts in the water, although silt, organic matter, loosened scale, lubricating oil, character of load and design of boiler all have an appreciable bearing upon this phenomenon.

Surface blowing is a remedy where it can be applied, and usually the proper use of the main blow-off will reduce the concentration of salts in the boiler.

There are many natural waters of sufficient alkali content to produce immediate foaming whenever the pressure at the surface of the water in the boiler is relieved by the sudden and large use of steam. As there is no chemical treatment that will precipitate alkalies from solution, such waters are to be rejected for boiler use.

WATER TREATMENT

CHEMICAL PROCEDURE IN WATER SOFTENING

Excepting waters containing hydrogen sulphide, all natural waters contain the same ingredients. The analytical chemist makes the same determinations in the same way on every sample of water which he investigates, unless the water contains hydrogen sulphide. He determines silica, iron oxide, and alumina, together with the following important basic and acid ions:

Basic Ions (B)	*Acid Ions (A)*
Potassium and Sodium	Chlorine
Magnesium	Carbonic acid
Calcium	Sulphuric acid

Were it possible to make all the determinations without experimental error, the basic ions (B) would be found present in just the right amount to combine with the acid ions (A), forming "salts." Chemists universally regard the ions as the form in which salts exist in solution, but engineers are more accustomed to water analyses expressed in the form of salts. When so given the nature and amount of chemical treatment necessary for softening water are very clearly shown.

In the discussion of boiler waters it is well to divide the salts present into (1) the alkali salts, that is, the salts of potassium and sodium, and (2) the calcium and magnesium salts. The alkali salts do not crystallize out under the conditions attained in the boiler, and therefore cannot produce scale. Apart from the small amount of silica, oxide of iron, and alumina, the scale formed in boilers is due entirely to calcium and magnesium salts. These are commonly spoken of as constituting the hardness of water, and it is customary to divide hardness into two kinds—temporary and permanent.

HARDNESS IN WATER AND ITS REDUCTION

The combined bicarbonates of magnesium and calcium constitute temporary hardness, while the other salts of magnesium and calcium constitute permanent hardness. Temporary hardness can always be expected in river, spring, and well waters, but a great many waters do not possess permanent hardness. Waters with less than 8 grains per gallon of scale-forming material are considered very good; 8 to 15 grains good; 15 to 20 fair; 20 to 30 poor; 30 to 40 bad, and over 40 very bad. Scale due principally to temporary hardness will deposit as a loose sludge, readily blown off. Where the ratio of permanent to temporary hardness exceeds 1 to 4, the scale will be hard, cement-like, and very adhesive to boiler metal.

Water treatment, or softening, removes the greater part of the calcium and magnesium. The bicarbonates are removed practically altogether, but of the sulphates and chlorides the calcium and magnesium are removed and the SO_4 and Cl left in the water. As an equilibrium must exist between the basic and acid ions, other basic ions must be substituted by adding soda ash.

When water is softened outside the boiler and the sludge removed by sedimentation and filtration before the water enters the feed-water heater, the chemicals used in the treatment are either lime alone, or lime and soda ash. If the lime and magnesium are present as temporary hardness alone, that is, as bicarbonates with the sulphates of these bases absent, lime suffices for the chemical treatment. If either the magnesium or both the magnesium and calcium are present in other salts, the lime treatment must be supplemented by soda-ash treatment. No chemicals other than lime and soda ash are used under ordinary conditions in water softening. There are others that would do the work more efficiently, but their cost precludes their use.

The paper here gives the chemical calculations entering into water softening, including those for the reactions and the quantities of the reagents necessary for softening a given water.

CHEMICAL CONTROL IN WATER SOFTENING

No matter what the patent features of a water-softening system may be, it is impossible to regulate automatically the feed of chemicals to compensate fluctuations in the scaling ingredients of the water. The best results can be obtained only by controlling with chemical tests the successive batches of water treated. They require the use of standard acid in connection with two indicators, phenol-phthalein and methyl orange with the use of a standard soap solution.

The paper here gives a list of apparatus needed and directions for performing tests for hardness, causticity and alkalinity. The operator in a softening plant very soon learns how to make use of the knowledge obtained from these tests in producing a satisfactory boiler-feed water.

CORROSION AND FOAMING

Pitting and corrosion in boilers are frequently due to magnesium chloride and less often to calcium chloride. Either of these salts is very pernicious in that on hydrolysis it produces free hydrochloric acid. This action is, however, in large measure counteracted when the temporary hardness runs high. Waters high in nitrates are always highly corrosive. Large amounts of sodium chloride also tend to make waters corrosive. Some waters very low in mineral content produce corrosion, especially at the feed-water intake, owing to a large amount of dissolved oxygen and free carbonic acid. Peaty waters are harmful to boilers by reason of the vegetable acids which they contain. Waters containing a free mineral acid are particularly harmful.

Waters which contain large amounts of alkali salts, especially sodium carbonate and sodium chloride, have a tendency to foam. Suspended matter of any kind increases the foaming tendency. Waters low in mineral content but high in organic matter, though perfectly clear, may also be troublesome. Sodium salts, in most cases sodium sulphate, are augmented in the softening process. Some waters are so high in initial alkali salts that they will not stand a further addition from the soda ash used as softener without producing serious foaming. In such cases barium hydroxide can be used as a substitute for soda ash, although it is expensive. All barium salts that are soluble are poisonous.

From what has been said relative to the effect of large amounts of alkali salts on waters, it is evident that one good result to be obtained from chemical control in water softening is the prevention of an overfeed of soda ash, as any large excess of this chemical will produce a foaming water. The only methods of combating foaming waters appear to lie in frequent blowing off and washing out the boilers, and along lines of improved boiler construction.

THE IMPACT TUBE

By SANFORD A. MOSS, LYNN, MASS.

Member of the Society

THE impact tube as a part of the pitot tube is well known as a means for measuring flow of fluids. When used as a separate instrument, however, it is much more valuable, and has not received the attention it deserves. This paper deals with application of the impact tube to a number of purposes not generally known, particularly relating to compressible fluids. The paper is based on laboratory work of the Steam Turbine Department of the Lynn works of the General Electric Co., Richard H. Rice, Mem.Am.Soc.M.E., chief engineer.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

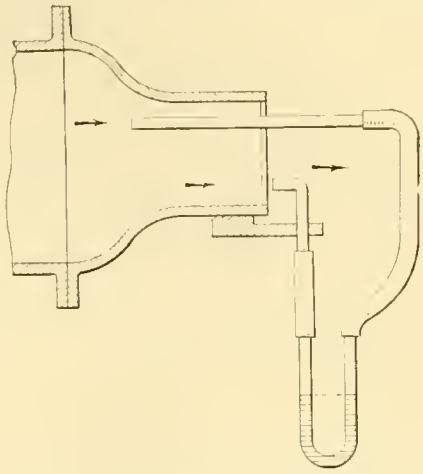


FIG. 1 CONSTANCY OF IMPACT PRESSURE OF AN ORIFICE

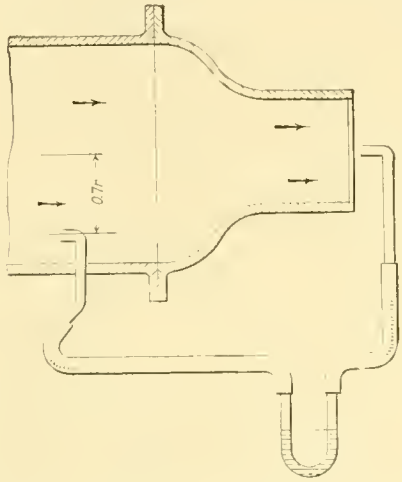


FIG. 2 EQUALITY OF IMPACT PRESSURE IN PIPE AND JET

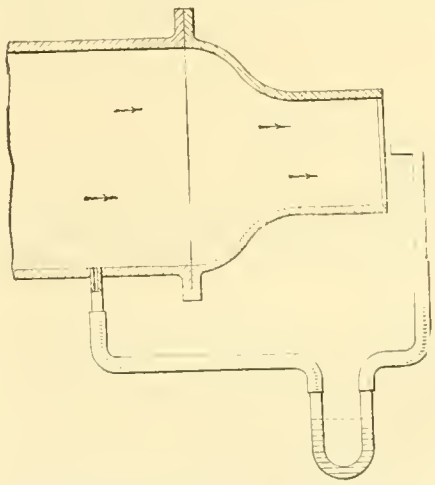


FIG. 3 VELOCITY HEAD SHOWN BY DIFFERENCE BETWEEN PIPE STATIC AND JET IMPACT PRESSURES

LAW OF THE IMPACT TUBE

The law of the relation between velocity and the differential pressure (difference between the readings of an impact opening and a true static opening) is well known for incompressible fluids or where the compressibility effect is negligible, such as

air and steam at comparatively low velocities. This law is usually given in the form $V = \sqrt{(2\,gh)}$, where V is the velocity in feet per second, and h is the height, in feet, of a column of the fluid in question having a pressure equal to the differential pressure.

The impact tube is not restricted to use where the above formula applies, however. Very high velocities with compressible fluids can be measured accurately if the complete law is used. This law is that *the impact tube perfectly converts velocity into pressure.* That is to say, the velocity of the fluid in front of the impact tube is exactly that which would be produced by theoretical adiabatic flow from a region where the absolute pressure is that shown by the impact tube, to a region where the absolute pressure is the static pressure. We may, therefore, use the theoretical thermodynamic formulæ for adiabatic flow through orifices, deduced with the assumption that the initial velocity in the pipe preceding the orifice is practically zero. This law holds for steam, air and all gases, as well as for liquids.

The flow of a gas thus computed is somewhat different than if computed from $V = \sqrt{(2gh)}$. This difference is negligible if the differential pressure is a small fraction of the absolute static pressure. The error is appreciable with air with a pressure of 1 lb. per sq. in. above atmosphere, with velocities of about 50 ft. per sec., and becomes more and more serious as velocity increases.

The law of the impact tube follows directly from the general law that *impact pressure is constant at all points as we proceed up the stream along an orifice fed by a very large pipe.* It has been known for some time that this law holds for liquids. It may be extended to the case of high velocities and compressible fluids. Demonstration of this law is readily made with apparatus shown in Fig. 1. A stationary impact tube is clamped at a convenient point in the jet from a convergent orifice preceded by a large pipe. An impact tube, moved by hand, is arranged to be pushed up inside of the orifice. Differential pressure between the two tubes is shown by a water U-tube. It will be found that the differential pressure is zero. The law is certainly accurate to within about ¼ of 1 per cent of the orifice impact pressure, and probably is absolutely accurate.

INITIAL VELOCITY HEAD

The apparatus above mentioned shows, when the pipe preceding the orifice is more than about three times the orifice diameter, that the jet issuing from the orifice into the atmosphere has a constant impact pressure, and hence a constant velocity, at all points over its area except very close to the edges.

The velocity in a long straight pipe preceding an orifice is not constant but is proportional to the ordinates of an ellipse, being a maximum in the center and gradually decreasing toward the sides of the pipe. When this pipe velocity is not negligible compared with the spouting velocity, the experiment of Fig. 1 shows that the static pressure in the pipe preceding the orifice plus the average velocity head at this point is equal to the impact pressure in the jet issuing from the orifice. The sum of the initial static pressure and the average velocity head is given by an impact tube in the pipe preceding the orifice placed at such a radius as to give the average velocity head. If the pipe preceding the orifice is quite large, the point where the velocity head has the average value is at about 0.7 of the radius. Hence, a water U-tube arranged as in Fig. 2 reads zero. For the same reason, the water U-tube in the experiment of Fig. 3 reads the average velocity head in the pipe preceding the orifice.

CONVERGENT-DIVERGENT ORIFICES AND VELOCITIES GREATER THAN VELOCITY OF SOUND

For a compressible fluid where the final pressure is greater than about half the initial pressure, an orifice must be wholly convergent just as for incompressible fluids. In such cases, the velocity of the jet issuing from the orifice is less than the velocity of sound. The above impact-tube laws, as well as all of the work with impact tubes here discussed, apply only to such cases. With a gas, when the final pressure is less than about half the initial pressure, the orifice must be first convergent and then divergent. The writer has not carefully investigated impact tubes under these conditions. There is an indication that they do not convert velocity into pressure with 100 per cent efficiency. It can be said, however, that with a final pressure less than half the initial pressure, and with a wholly convergent nozzle (a shape which does not give full theoretical velocity), the impact pressure in the jet close to the end of the orifice is equal to the initial pressure. In this case, it is known that the static pressure of the jet is about 52 per cent of the initial pressure for air, and 58 per cent for steam, regardless of the pressure of the region into which the jet discharges, and that the jet velocity is the velocity of sound. The jet itself forms stream lines, creating an extension of the orifice, and representing a divergent portion where pressure decreases to the pressure of the surrounding region and where velocity increases from velocity of sound to a somewhat greater value, which is less, however, than the value that may be obtained by using a properly shaped orifice.

ADVANTAGES OF THE IMPACT TUBE OVER THE PITOT TUBE

The writer believes there is no reason for using the common form of pitot tube. This is a double-walled tube consisting of an impact tube pointed upstream surrounded by a chamber with openings for determining the static pressure. It has been known for years that the impact portion of this tube gives reliable results, regardless of its shape. On the other hand, the static holes give very indefinite results and the shape and sizes of all of the parts have influence on the static readings. Measurements made by use of a plain impact tube in conjunction with a static hole in the pipe wall will give results that are identical with those obtained by using an accurate form of pitot tube.

Parallel flow in a pipe is only possible when the static pressure is absolutely the same at all parts of a section perdendicular to the stream. Therefore, if there is variation in the static pressure the stream angles will be such that even an accurate form of pitot tube will give erroneous results. The pitot tube, therefore, offers no advantage over the combination of an impact tube and a static hole in the pipe wall. On the other hand, it is much easier to make a reliable static hole in the pipe wall than it is to make a reliable static hole in the pitot tube. The usual trouble with pitot tube static openings is that they give too low a reading for static pressure. This increases the small difference reading between impact and static sides and indicates a quantity larger than actually exists.

DEDUCTION OF THE IMPACT TUBE LAW FOR GASES

A gas in a closed envelope consists of a number of molecules darting hither and thither at high velocities, and a gas flowing in a pipe consists of molecules with velocities such that the average velocity downstream has a definite value, the velocities across the stream cancelling so that the average is zero. Hence, if gas is flowing from a large vessel through a properly shaped orifice into a region of lower pressure, the molecules in the jet issuing from the orifice are really in the same condition as those in the vessel, except that there is a general net velocity which we call the velocity of the jet. The net velocity is at once destroyed, however, if anything is inserted in the jet, so that the molecules immediately in front of the impact tube in a discharge jet are in exactly the same condition as those in the large vessel from which the gas issues. Hence, the impact tube in the jet must measure the same pressure as would a static hole in the pipe wall of the large vessel.

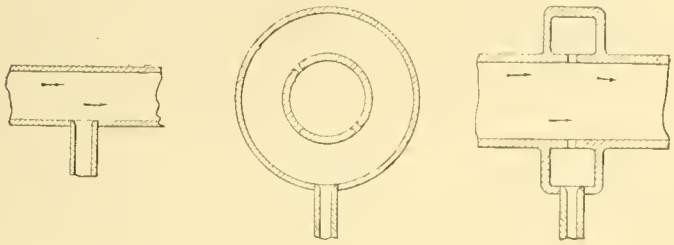


Fig. 4 Fig. 5

Fig. 4 Single Static Hole in Pipe Wall
Fig. 5 Ring of Static Holes in Pipe Wall

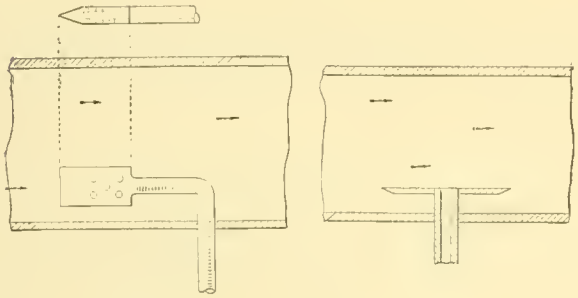


Fig. 6 Fig. 7

Fig. 6 Static Pressure Boat
Fig. 7 Static Pressure by Side Gage

IMPACT TEMPERATURE

A similar situation occurs if a thermometer is placed in a high-velocity jet in an attempt to measure its temperature. The molecules surrounding the thermometer are immediately restored to the same condition as those in the large vessel from which they originally proceeded. Hence, as can be demonstrated by experiment, a thermometer inserted in a high-velocity jet issuing from an orifice will give nearly the same reading as a thermometer in the large vessel from which the jet discharged.

A gas discharged from an orifice, from the ordinary point of view, has a very low temperature, resulting from adiabatic expansion. Actually, however, this temperature is only relative to a thermometer moving with the velocity of the jet. The individual molecules have the same average kinetic energy and hence the same temperature as they originally had.

Temperature measurements have been made and published which show temperatures in a high-velocity jet of air much above the theoretical adiabatic temperature of the jet. It was alleged that these experiments showed that the velocity of such a jet was not really the theoretical velocity due to adiabatic expansion, and that it was not possible to expand a gas in a nozzle so as to obtain such a velocity. This conclusion is incorrect, however, and with a properly shaped orifice or nozzle, nearly the full theoretical velocity due to adiabatic expansion can be attained with air or any gas, just as with steam in a steam turbine. If the energy is extracted from the jet by a turbine wheel or the like, the exhaust will show low temperature. If, however, no energy is extracted but if the thermometer is inserted directly in the high-velocity jet, nearly initial temperature will be shown.

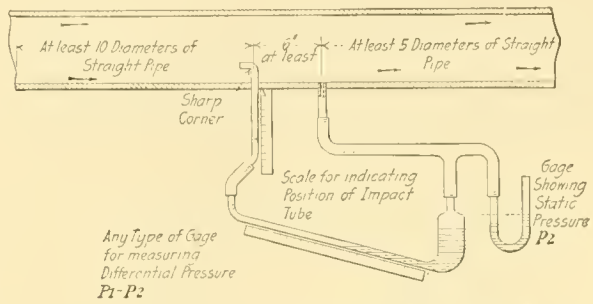


Fig. 8 Impact Tube and Hole in Pipe Wall for Measuring Pipe Flow

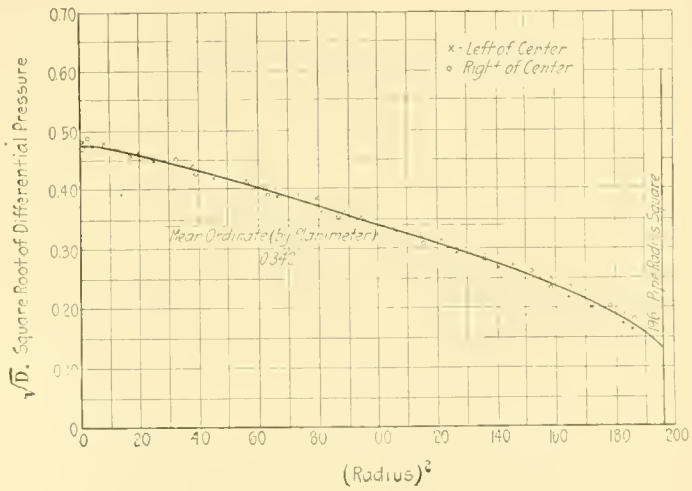


Fig. 9 Curve of Pipe Flow Test by Impact Tube Traverse

The mean ordinate of a smooth curve through the points, as found by a planimeter, gives the square root of the impact pressure difference, √D, which is to be inserted in the formulae.

In the Bradley and Hale experiments on temperature of air after great expansion,[1] thermometers directly in the high-velocity jet showed a lower temperature than those a little further away where the velocity had been destroyed. This is probably due to the fact that the orifice which was demanded by the pressure ratios involved should have been first converging and then diverging.

IMPACT TUBE ARRANGEMENT

The exact shape of the impact tube is not important. It is only necessary that there be a pipe or tube facing squarely

[1] Physical Review, 1909, v. 29, p. 258

upstream in a jet undisturbed except by the impact-tube end. The impact-tube end, therefore, should have a straight portion parallel to the jet about 10 times the length of the impact-tube opening, before the tube bends away from the jet. The open end of the tube should be slightly rounded on both inner and outer edges and should be smooth. For ordinary work, the tube is ¼ in. to 1 in. in diameter. For work with small pipes, and for special exploration work, the tube may be of any size. The writer has obtained satisfactory results with tubes as small as $^1/_{32}$ in. outside diameter.

The impact tube must face squarely downstream. There is no necessity for exact measurement in this connection, however, and estimation by eye is accurate enough.

STATIC HOLES IN A PIPE WALL

Figs. 4, 5, 6 and 7 show different methods of obtaining static pressure. Fig. 4 shows how actual pressure is obtained by means of a hole in the pipe wall. The inner surface of the

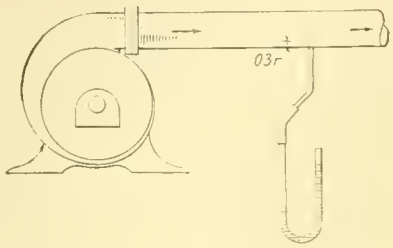


Fig. 10 Impact Tube Giving Total Pressure Rise with Atmospheric Inlet Pressure

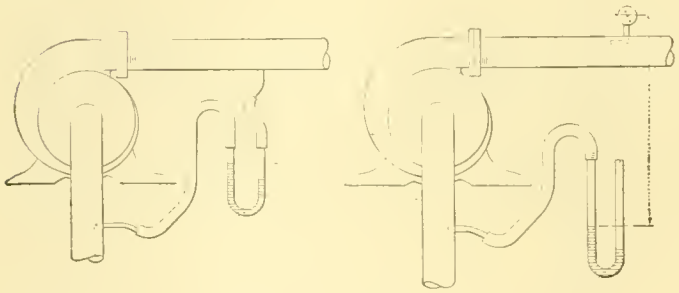


Fig. 11 Impact Tubes Giving Total Pressure Difference Between Inlet and Discharge Pipes

pipe adjacent to the hole must be smooth. The hole must be at right angles to the surface and there must be no burrs. The inner corners should be rounded with a radius 1/10 to 1/50 of the diameter of the hole. Fig. 6 shows a number of static holes. This form is in very common use and it is supposed that any variation in static pressure is averaged. It is questionable whether any advantage is obtained, however, from the multiplication of holes.

For any of these types, the pressure holes must be of good size. They should be at least ¼ in. in diameter and preferably ½ to 1 in. to avoid a drop of pressure which might occur with a small hole and a minute leak. One of the disadvantages of the common form of pitot tube is that the static holes are often so minute that the pipes to the pressure-measuring instrument must be extraordinarily tight to secure accuracy. On the other hand, if a large hole is used in the pipe wall or the equivalent, as in Figs. 4, 5, 6 and 7, and if the impact tube is made of good size with the opening ¼ to 1 in. diameter, a slight leak will not have very serious effect.

TIGHTNESS OF PIPING

It is desirable to use large pipes for connecting the static and impact tubes with the measuring instrument. Standard ¼- or ⅛-in. piping should never be used for such purposes unless the connecting lines are very short. When the piping is of any great length, ½-in. pipe or even 1-in. pipe should be used, because it is much easier to make the larger-size pipe tight, and because even a small leak will not cause much of a pressure drop. It is to be noted that the differential pressure measured is usually quite small, so that even a slight error in either pressure will cause an appreciable error in the differential.

The paper here gives methods of test for tightness of piping applying to pitot and impact tubes, flow-meter work, venturimeter work, etc.

IMPACT TUBE AND HOLE IN THE PIPE WALL FOR MEASURING PIPE FLOW

The apparatus is to be arranged as shown in Fig. 8. However, instead of the single static hole as shown, other means

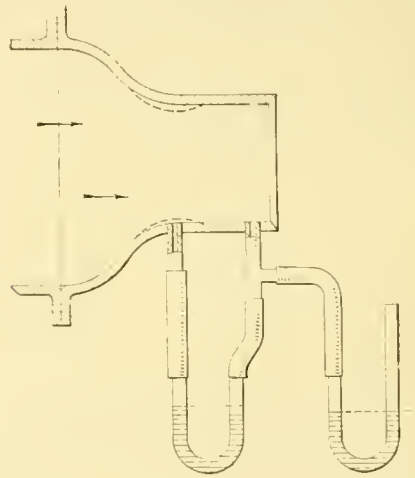


Fig. 12 Apparatus to Show Contraction at End of Convergent Portion of an Orifice

of securing static pressure can be used, as shown in Figs. 5, 6 or 7. If methods of Figs. 6 or 7 are used, the impact tube must be placed at such a distance from the static tube that neither instrument will disturb the flow past the other.

There are numerous well-known forms of the differential gage which may be used.

If any of the tests give flows large enough to show a differential pressure of 1 in. or more of water vertical, it is desirable to connect up a vertical water U-tube in parallel with the differential gage.

The impact tube should be pushed clear across the pipe, readings being taken at both sides with the tube in contact with the pipe wall, and at a number of points between. One method is to space the positions at distances proportional to the square of the radius. Then the arithmetic mean gives a number properly weighted for the various areas involved.

The writer has found it satisfactory to measure the actual radius with each setting, spacing settings somewhat more

closely at the edges than at the center. The various readings are then plotted as shown in Fig. 9, readings on both sides of the center being plotted together. The square of the radius is plotted against the square root of the differential pressure. The mean ordinate of such a curve gives the mean square root of the differential, properly averaged for use in the formulæ given in the paper. The static pressure is also to be measured independently. The computation work is slightly simpler if this is taken rather than impact pressure.

IMPACT TUBE FOR MEASURING PIPE PRESSURE

When a fluid, either liquid or gas, is flowing in a pipe, it is frequently desirable, for general purposes, to use the impact pressure rather than the static pressure. An example of this is pressure in a pipe preceding a venturi meter or other form of orifice in a pipe line. The ordinary formulæ involve this pressure as well as the pressure at the throat or orifice end, and include a very troublesome corrective term for the initial velocity at the point where the initial static pressure is measured. If, however, this initial pressure is measured by use of an impact tube, the velocity head at this point is automatically added to the static pressure and a net pressure obtained, equal to the pressure which would have been obtained if the pipe preceding the orifice had been large enough to render the velocity head in it negligible. The formulæ for this case (given in paper) are very much simpler than those usually given, in which the initial velocity has to be taken into account. Of course, if there is any foreign matter in the stream, it is likely to clog the impact tube, in which case this arrangement can not be used. In such a case, initial pressure must be measured by means of a hole in the pipe wall, and the ordinary formulæ which take account of initial velocity must be used.

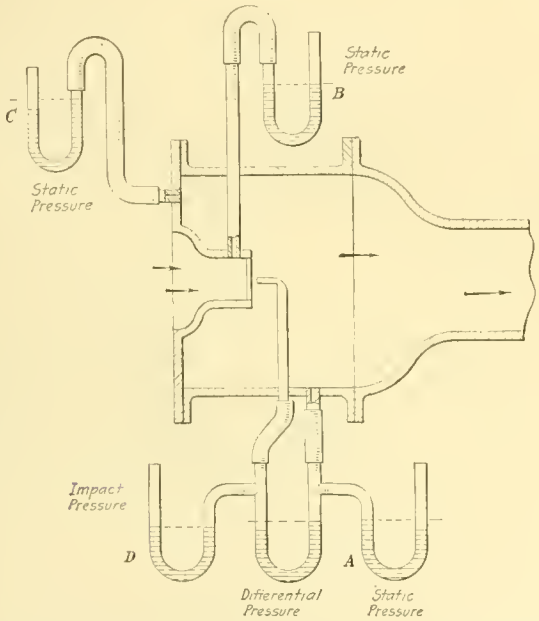


Fig. 13 Orifice Discharging into an Enclosed Region

The static pressure of region into which jet discharges must be taken in a number of places, such as *A*, *B* and *C*, and seen to be exactly the same.
If the orifice is supplied from the atmosphere, the impact pressure *D* will be zero.

Another case in which it is convenient to measure the impact pressure is in finding the total pressure rise produced by a centrifugal pump or centrifugal compressor. If the discharge pipe of such a machine is very large, the velocity head in it is negligible, and the pressure produced is the static pressure. If, however, the pipe is small enough to give an appreciable velocity head, as is often the case with fan blowers and centrifugal compressors producing a pressure of 2 or 3 lb. per sq. in., the energy actually put into the air by the machine is completely shown by the impact pressure. It is really correct to compute the efficiency of the machine on the basis of impact pressure. The arrangement is shown in Fig. 10. A similar arrangement can be used in the case of centrifugal pumps. If the inlet and discharge pipes are both of the same size, impact tubes give the same difference as static holes. If, however, the inlet pipe is larger than the discharge pipe, as is often the case, impact tubes in both pipes automatically take account of the difference in velocity heads. The difference in the pipe pressures as shown by the impact tubes, plus the head equal to the vertical height differences, gives the total work done by the pump. The arrangement is shown in Fig. 11. These remarks do not apply to the case of pulsating flow, as with a reciprocating machine.

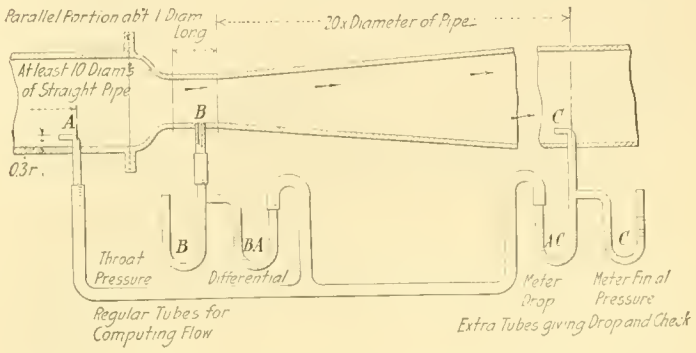


Fig. 14 Venturi Meter with Impact Tube and Extra Tubes for Experimental Purposes

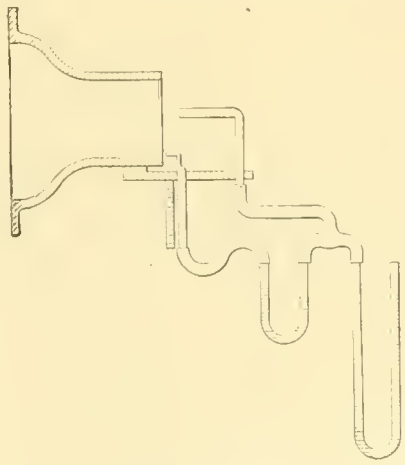


Fig. 15 Orifice Calibration by Traverse of an Exploring Impact Tube

In all cases, the impact-tube center should be about 0.3 of the pipe radius from the pipe wall.

As an additional advantage in the use of the impact pressure rather than the static pressure, it should be noted that the pressure is obtained more accurately. The tapping of a pressure hole in the pipe wall is very uncertain and it is often easier, particularly in the case of field tests, to insert an impact tube which is certain to give correct pressure, than it is to take the necessary precautions to make sure that a hole in the pipe wall is free from burrs and projections.

SHAPE OF ORIFICES FOR MEASURING FLOW OF FLUIDS

The "orifice" frequently discussed in this article is a smoothly formed, convergent passage. Such an orifice is used at the entrance of a venturi meter, or for measurement of fluid discharged into the atmosphere, as discussed later. The exact shape by means of which the convergent portion is secured is not very important. The writer prefers the general shape shown in Fig. 18, formed by circular arcs. A cone with straight sides, however, is probably equally satisfactory, if the angle is gentle and if there is a smooth circular arc connecting with a straight portion at the end of the orifice.

It is highly essential that there be a parallel portion at the end of the convergent portion, of sufficient length properly to size the jet. At the end of the convergent portion there may be a contraction of the jet, due to the fact that the orifice is not shaped to avoid contraction. The existence of such an effect can never be known except by an actual experiment, as indicated in Fig. 12. If, however, we have an orifice of the shape of Fig. 18, or a venturi meter with the shape of Fig. 14, the parallel portion insures that the jet whose measurement is sought has the exact diameter of this parallel portion.

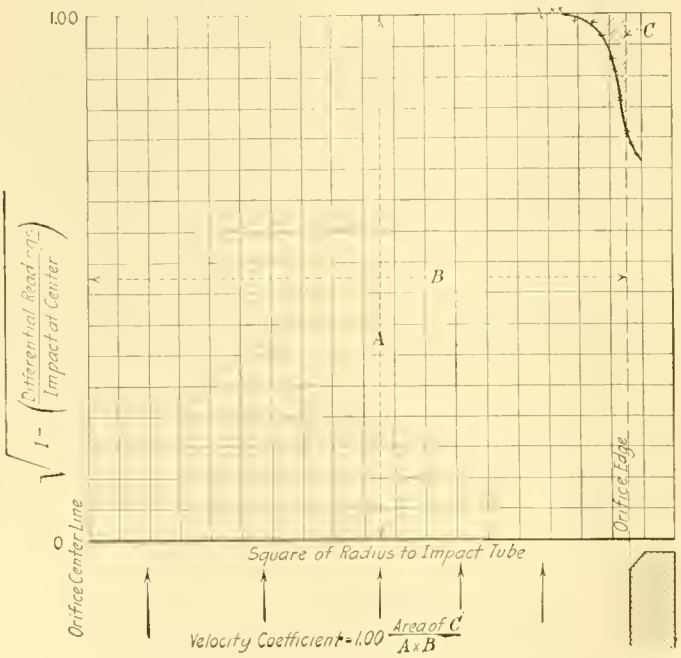


Fig. 16 Curve of Orifice Calibration by Impact Tube Traverse

The length of such a parallel portion should be from half diameter to diameter of the parallel portion. Greater length might introduce appreciable friction drop.

A minor point, of practical importance, is the chamfering of the outer end of an orifice. This prevents the edge from being burred or dented during handling and so preserves the diameter of the parallel portion everywhere. The parallel portion must, of course, be carefully machined so as to be exactly parallel and round.

VENTURI METER WITH IMPACT TUBE

The general arrangement is shown in Fig. 14. The use of such an impact tube avoids the computation work necessary to take account of the initial velocity head and the necessity for care in drilling a static hole.

Fig. 14 also shows some additional readings which the writer has found convenient in the case of venturi meters used for experimental testing. The readings will check as follows, if all pipes are tight and the apparatus properly set up. (See Fig. 14.)

If B and C are above atmosphere, the difference between B and AC will equal the difference between C and BA.

If B is below atmosphere and C above, the sum of B and AC will equal the difference between C and BA.

If B and C are below atmosphere, the sum of B and AC will equal the sum of C and BA.

PRESSURE OF A JET DISCHARGING FROM AN ORIFICE INTO THE ATMOSPHERE

The only case discussed in this paper is that in which the final pressure is greater than about half the initial pressure, so

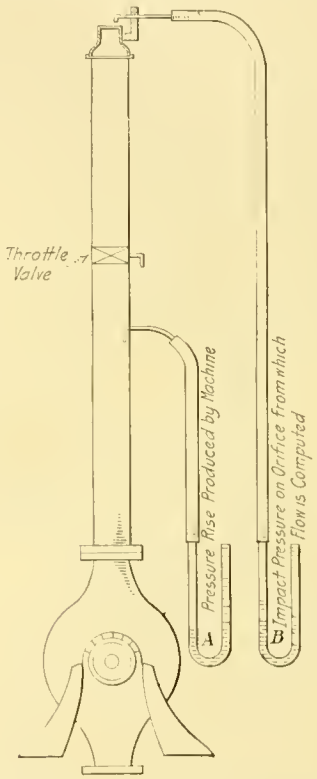


Fig. 17 Measurement of Quantity of Flow by Means of Orifice and Impact Tube

that the theoretical orifice is wholly convergent. In such a case, *the static pressure of the jet discharged from an orifice is exactly equal to the pressure of the region into which it discharges.* This law applies primarily to the discharge of an orifice into the atmosphere. However, it also applies to discharge of an orifice into an enclosed region, such as is shown in Fig. 14, provided there is ample room all around the orifice for a free discharge of jet and no restrictions such as would be likely to cause a venturi-meter effect. The static pressure of the region into which a jet discharges must be measured in a number of places, such as A, B and C, Fig. 13, and seen to be exactly the same. If the orifice is supplied directly from the atmosphere, the impact pressure, D, will be zero. The accuracy of the above law is really the basis of all the impact-tube work here discussed. So far as known, the law has never received any valid criticism.

If the orifice has a parallel portion of appreciable length at the end, the streams of the jet, as they discharge into the atmosphere, necessarily proceed in straight lines. This can also be seen by watching the jet discharging from a water or wet-steam orifice of the proper shape, or by feeling the surface of an air jet. The jet preserves a solid parallel column for quite a distance. If, now, a stream at the edge of the jet and a stream in the interior of the jet are proceeding in parallel directions, there can be no possibility of pressure difference between them. If there were any pressure difference, the flow would be in curved lines. A stream at the edge of the jet, proceeding in a straight line, is obviously at the pressure of the region. Hence, the same pressure exists throughout the cross-section of the jet.

The paper here describes an interesting experiment giving additional verification of the above point.

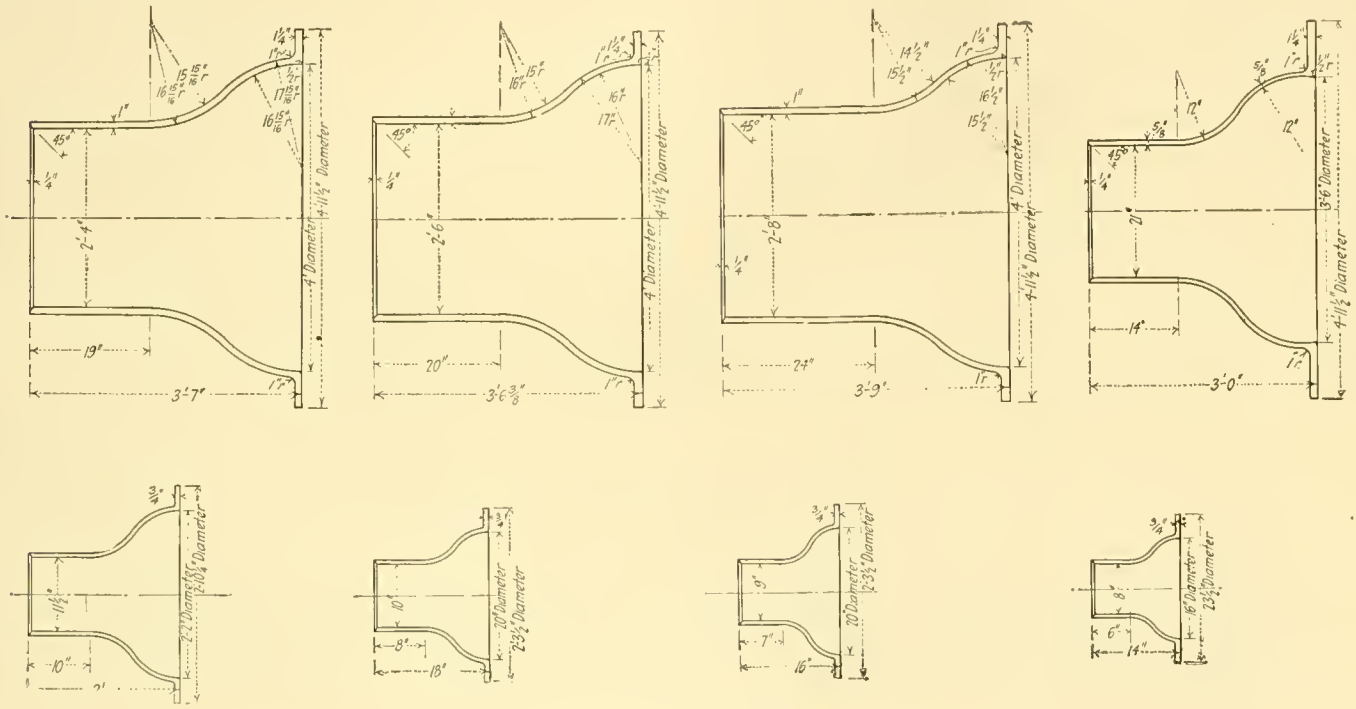


Fig. 18 Dimensions of Some Measuring Orifices

Orifice Calibration by Means of Impact Tubes

Many calibrations of orifices discharging high-velocity jets of air have been made by the writer with the apparatus of Fig. 15. This consists of a stationary impact tube placed in the center of the jet, slightly beyond the plane of the orifice end, and a very small movable impact tube which can make a traverse across the edge of the jet covering a space of ¼ to ½ in. The differential pressure between the two tubes is read by means of a vertical water U-tube, or some more delicate instrument, as circumstances warrant. The impact pressure is constant everywhere in the jet, except for a narrow ring around the edge which is traversed by the small impact tube. An impact tube about 1/32 in. outside diameter has been used with a 4-in. orifice, traversing a space of about ¼ in., and proportionally with larger orifices. The results are plotted in Fig. 16. The ratio of the area of the small corner C to the area AB, of the large rectangle, gives the velocity loss. By subtracting this from unity, the velocity coefficient of the orifice is obtained. Many such tests indicate a velocity coefficient of about 0.99. These experiments have been accurate to within ½ of a per cent, so that the coefficient may be somewhere between 0.985 and 0.995. It seems probable that the larger the orifice the greater the coefficient.

It should be noted that this method *gives an accurate calibration of any orifice without measurement of flow by means of tanks, weirs, gas holders, etc.*

Calibration with water orifices and the same general system were made by John R. Freeman, Mem.Am.Soc.M.E., and are described in the Transactions of the American Society of Civil Engineers.[1]

Exploration of Irregular Jets

The same general methods have been used by the writer to find velocities of various types of jets, such as those from the nozzles and stationary buckets of steam turbines.

Measurement of Discharge of High-Pressure Air by Means of an Orifice and Impact Tube

The general arrangement is shown in Fig. 17. The discharge pipe of the machine which is being measured is connected up with a considerable length of straight pipe to the orifice. It is usually desirable to have a throttle valve in the pipe so that various amounts of flow giving various loads on the machine can be measured by means of a single orifice. It is necessary that there be at least 10 diameters of straight pipe between the throttle valve and the orifice. If it is desired to measure the discharge pressure produced by the machine, it is necessary, in addition, to have about 10 diameters of straight pipe between the machine itself and the throttle valve. An impact tube inserted in this pipe gives the net pressure rise which the machine under test produces, while the impact tube on the orifice gives the volume or quantity passing through. The orifice should be selected by the use of formulæ given in the paper.

[1] No. 426, v. 21, Nov., 1889; No. 479, v. 24, June, 1891; and v. 13, p. 382.

The impact tube is to be stationary and in the center of the jet, slightly outside the plane of the orifice end. The tube is in plain view throughout the test so that it can always be seen to be properly in line and free from obstructions. This is one of the advantages of this method.

The general method here described has been used on centrifugal pumps and fire streams. It is just as convenient with high-velocity jets of air or other gases.

The flow is to be computed by formulæ given in the paper.

The parallel portion at the end of the orifice should have a diameter at least one-third of the diameter of the straight pipe preceding the orifice. The orifice, of course, may be smaller than one-third pipe diameter without any effect. It is probable that the coefficient does not differ greatly from 0.99, even if the orifice is but one-half of pipe diameter. In all such cases, the effect of the varying velocity at different radii in the pipe is not transmitted through the orifice, and the discharge jet has the same velocity at all points, except at a narrow band close to the edge. For cases where the orifice diameter is greater than about one-half pipe diameter, it is probable that the variation of pipe velocity has some effect on the discharge jet.

The impact tube, as here discussed, can only be used with continuous flow, such as is given by centrifugal machinery. Pulsating flow, such as is given by reciprocating machinery, can not be integrated by the impact tube.

In order to compute the quantity or flow, it is also necessary to know the temperature in the pipe preceding the jet. This must be secured by the insertion of a thermometer through the pipe wall. However, as already pointed out, a practically identical reading will be given by a thermometer inserted in the jet outside the orifice. In all cases, for accurate work, the bare bulb of the thermometer should be in the jet, and wells or metal casings should be avoided.

The above methods have been used for measurement of many million cubic feet of air discharged by various types and sizes of fan blowers and centrifugal air compressors in the Lynn Works of the General Electric Co., since 1904. Fig. 18 shows some of the orifices which have been used.

ADVANTAGES OF THE ORIFICE METHOD

If a machine whose flow is to be measured can be arranged so that its discharge can be wasted, the use of an orifice in the discharge pipe is the only method of flow measurement which should be considered. The reason is that nearly the entire pressure rise produced by the machine can be utilized in causing discharge through the orifice. This gives a reading of such magnitude that accurate observations can be made. For instance, if the machine being tested gives an air pressure of 15 lb. per sq. in., the reading from which the flow is computed will be about 30 in. of mercury. If the machine gives an air pressure of about 1 lb. per sq. in., the reading will be 27 in. of water. Such magnitudes are easily measured and do not require the use of inclined gages, hook gages, or other means of getting small differentials.

The use of the impact tube gives the advantages of simplicity of formula in connection with initial velocity head, and ease of proper arrangement, over the use of a static hole in the pipe wall preceding the orifice.

VALUATION PAPERS

THE Valuation Session of the Annual Meeting will be devoted to a discussion of engineers' ideas of principles and methods in the valuation of industrial properties. The Committee on Meetings hopes that the information brought out will form a valuable supplement to the large amount of material already available on the subject of economic theories of values and their application to public utilities.

PRODUCTIVE CAPACITY A MEASURE OF VALUE OF AN INDUSTRIAL PROPERTY

By H. L. GANTT, NEW YORK, N. Y.

Member of the Society

SOME months ago a professor of political economy in one of our most conservative universities admitted to me that the economists had been obliged to modify many of their views since the outbreak of the European war. My comment was, that the professors of political economy were not the only people who had been obliged to modify their economic and industrial views.

The war has taught everybody something. Military methods have undergone radical changes, but industrial methods are undergoing changes which promise to be even more radical than the military developments have been.

If there is any one thing which has been made clear by the war it is that the most important asset which either a man or nation can have is the ABILITY TO DO THINGS. Our industrial and economical developments have in the past been largely based on the theory that the most important quality a man can possess is his *ability to buy things;* but the war has distinctly shown that this quality is secondary to the *ability to do things.* The recognition of this fact is having a most far-reaching effect, for it makes clear that the real assets of a nation are properly equipped industries and men trained to operate them efficiently. The money which has been spent on an industrial property, whether it has been spent wisely or unwisely, and the amount of money needed to reproduce it are both secondary in importance to the *ability of that plant to accomplish the object for which it was constructed,* and hence cannot be given the first place in determining the value of the property.

Inasmuch as every industrial plant is built to produce some article of commerce at a cost which will enable it to compete with other producers, the value of a plant as a producing unit must depend upon its ability to accomplish the object for which it was created.

To determine the value of an industrial property, therefore, we must be able to know with accuracy the cost at which it

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. Advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

can produce its product, and the amount it can produce. To compare two factories on this basis, their cost systems must be alike; for, if there is a lack of agreement as to methods of cost accounting, there will necessarily be a lack of agreement as to the estimated value of the properties. There are many methods of cost accounting; but there are only two leading theories as to what cost consists of. They are:

First, that the cost of an article must include all of the expense incurred in producing it, whether such expense actually contributed to the desired end or not.

Second, that the cost of an article should include only those expenses actually needed for its production, and any other expenses incurred by the producers for any reason whatever must be charged to some other account.

The first theory would charge the expense of maintaining in idleness that portion of a plant which was not in use to the cost of the product made in that portion of the plant which was in operation; while the second theory would demand that such expense be a deduction from profits. When plants are operated at their full capacity, both theories give the same cost. When, however, they are operated at less than their full capacity, the expense of carrying the idle machinery is, under the first theory, included in the cost of the product, making the cost greater; while under the second theory, this expense of idle machinery is carried in a separate account and deducted from the profits, leaving the cost constant. It is most interesting to note that, *when costs are figured on the second basis, great activity immediately ensues to determine why machinery is idle, and to see what can be done to put it in operation.* It is realized at once that this machinery had better be operated, even if no profits are obtained from its operation and only the expense, or even part of the expense, of maintaining that machinery is earned.

Fig. 1 illustrates this subject most clearly, and is an indication of the efficiency of the management as contrasted with that of the workmen, about which we hear so much. It is interesting to note that charts of this nature, which are being made monthly in several large plants, have already had a very educational influence on the managers of those plants. They show that idle machinery which cannot be used should be disposed of, and the money received, and the space occupied, put to some useful purpose.

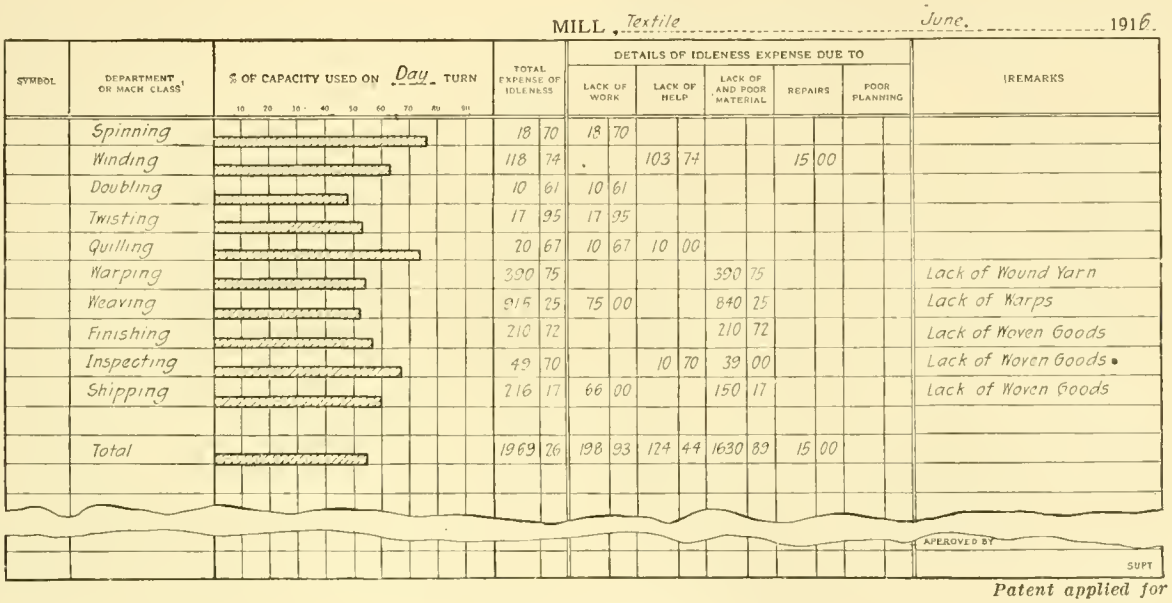
A little consideration of the method of getting the data on this chart will make its value more apparent. It is a logical outgrowth of the paper I read at the Buffalo meeting on The Relation Between Production and Costs,[1] and is based on the fact that simple ownership of a machine costs money, inasmuch as it takes away from available assets. For instance, if we buy a machine for $1000 we lose the interest on that $1000, say at 5 per cent per year, then we have taxes on that machine at 2 per cent and insurance of 1 per cent. Further, the machine probably depreciates at a rate of 20 per cent per year, and we must pay $50 or more per year for the rent of the space it occupies. All these expenses, together $330, go on whether we use the machine or not. Thus, the simple fact of our having bought this machine and kept it takes from our available assets approximately one dollar per day.

If now the cause for idleness is ascertained each day we can find the expense of each cause of idleness as shown on the chart. That part which is due to lack of orders points out that our selling policy is wrong, or that the plant is larger than it should be—in other words, that somebody in building the plant has overestimated the demand. It is clear, however, that no conclusion should be based on the figures for one month, but on the results for a series of months during which the problem has been carefully studied. If a mistake has been made in building too large a plant, an effort should be made to determine the proper disposal, or utilization, of the excess in order that the expense of idleness may be taken care of, even if no profit can be made.

The next column shows the expense due to a lack of help, which means that we must investigate the labor policy.

The next column, showing the expense due to lack of, or poor, material, is an indication of the efficiency of the purchasing policy and storekeeping system. The next column reflects the repair and maintenance department.

If in any case the expense of idleness is greater than can be attributed to all of these causes together, it must go in the last column as poor planning.



Patent applied for

Fig. 1 Idleness Expense Chart

[1] Trans. Am.Soc.M.E. vol. 37, p. 109.

We can hardly claim that such a chart gives us a *measure* of the efficiency with which the above functions are performed, but it certainly does give us an *indication* of that efficiency.

In several cases, the first of such charts gotten out resulted in the scrapping of machinery which had been idle for years. The space thus saved was used for a purpose for which the superintendent had felt he needed a new building.

In another case it resulted in the renting of temporarily idle machinery at a rate which went far toward covering the expense of carrying that machinery.

Under the first system of cost accounting the facts brought out by this method are not available, and the increased cost that a reduced output must bear is a great source of confusion to the salesman. The newer system, with its constant cost, shows that non-producing machinery is a handicap to the industry of a company, just as workmen who do not serve some useful purpose in a plant, or industry, are a handicap to that plant or industry. *Similarly, plants or people, therefore, who do not serve some useful purpose to a community are a handicap to that community, for idle plants represent idle capital, and idle people are not producers, but consumers only.* The warring nations have recognized these facts, and put both idle plants and idle people to work wherever possible.

The statements so far made concern principally the operation of industrial plants and the production of articles of commerce; but they are none the less true concerning the construction of industrial plants.

We may ask the same question about construction that we ask about operation; for instance, should the cost of a railroad include all the money spent by the people engaged in building it, or should it include only such money as contributed to the building of the road? As an illustration, is the cost of a piece of road which was built and then abandoned for a superior route a part of the cost of the railroad built, or is it an expense due to improper judgment on the part of the builders?

I am not discussing the question as to whether the public should be called upon to pay interest on the money uselessly spent through improper judgment, but I do think that *in all construction it should be possible to separate those expenses which contributed to the desired result from those which did not so contribute.* A comparison of these amounts will give a measure of the efficiency of the builders. On this knowledge proper action can ultimately be taken.

Still another factor enters into the value of a "going plant." We all have known cases where the same plant operated under one manager was a failure, and under another a very decided success. The value of a going plant, therefore, consists of two elements, namely, the value of the physical real estate and equipment, and the value of the organization operating it. In considering the value of an organization we should realize that it lies not so much in the personality of the managers or leaders (who may die or go elsewhere) as in the permanent results of their *training and methods, which should go on with the business,* and are therefore an asset and not an accident.

We have the authority of no less a person than Andrew Carnegie, Hon.Mem.Am.Soc.M.E., for the statement that his organizations were of more value to him than his plants. Before we can determine exactly the value of a going plant, therefore, we must find some means of measuring the value of the organization which operates it, for this is an integral factor in the valuation of an industrial property, which is just as real as the more tangible brick and mortar of which buildings are composed.

Our charts showing the expense of idleness give us at least a rough indication of this value, for they show the expense of inefficient management.

If the above premises are correct, the following factors are important elements in determining the value of an industrial property:

The cost of the product
The capacity of the plant
The portion of the plant operated, and
The expense of maintenance of the idle portion.

ACCURATE APPRAISALS BY SHORT METHODS

By JOHN G. MORSE,[1] BOSTON, MASS.

Non-Member

As the Factory Mutual Companies developed their methods of making plans and inspections and their tests of fire-preventing appliances, to the complete forms in use today, so also did they develop the making of insurance appraisals. At present these consist of inventories in as much detail as necessary to determine accurate values, while a system has been adopted for obtaining a reasonable estimate of all the minor items without going into elaborate detail. These appraisals are made without cost to the assured and have been appreciated to such an extent that they are constantly used as a basis for bookkeeping and cost systems, for mergers and other business uses.

In explaining this method by which a large manufacturing plant can be accurately appraised in a short time and with a comparatively small amount of work, I shall endeavor to show how useless it is to waste time on more laborious detail. No appraisal can be made without incorporating many figures that are based simply on estimate. It is, therefore, needless to carry the detail in any direction where it will not add to the accuracy of the final result.

Disregarding new factories, where records of actual cost are easily available, let us consider an older plant and particularly one where no records of cost have been preserved. A building may be measured so carefully that the exact amount of each material is known. The market price of each material may be obtained. Yet the amount of waste must be estimated and the amount for labor and all contingent expenses must be estimated.

The inventory of machinery may be made to the last trifling detail, yet the exact value can be obtained only for standard machines. Every special machine, as well as the cost for erecting every machine, must be estimated. Constant changes in market values always affect the accuracy of the result, but, aside from that, the amount of depreciation on both buildings and machinery must be estimated (or largely guessed at) before the actual present value is found.

A METHOD OF APPROXIMATION

The method developed by the appraisal department of the Factory Mutual Companies is based entirely on the theory that if the larger factories are carefully appraised, the less important items may be estimated in groups.

[1]Appraiser, Insp. Dept., Assoc. Factory Mutual Fire Ins. Cos.

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

The property to be appraised is divided into two parts—buildings and machinery. The buildings are considered as empty structures, and anything that can be removed without altering the building is classed under machinery. In insurance appraisals, foundations and other underground work are ignored, but the method would be practically the same were they included. Machinery is divided into machines proper, shafting, belting, piping, electric wiring and furniture and miscellaneous apparatus. Special small tools, dies, patterns, drawings, molds, lasts and any objects of similar nature that exist in large quantities in the plant under consideration, are treated independently. The subject "miscellaneous apparatus" covers all objects of minor value not easily classified under any of the other heads.

The price values used for buildings and all the subdivisions of machinery are based on *replacing new at today's market* (regardless of original cost), and these price values are then depreciated as judgment dictates.

BUILDINGS

In appraising we use the square foot of floor area as a basis. Many architects and engineers use a factor based on the cubic foot of contents, but it is floor area that gives manufacturing facility, and the figures thus obtained are also useful in other parts of the appraisal, as will be shown later. As a groundwork we use the tables prepared by Charles T. Main, Mem. Am.Soc.M.E. These must, of course, be changed for different heights of stud, degrees of finish, thickness of walls, etc., and also for constant fluctuations in the market value of labor and materials. As new factors are obtained for reinforced concrete and other modern forms of construction, the tables form a guide for consistency as lengths and widths vary.

It is in appraising buildings that the uselessness of extended detail is strikingly apparent. Suppose two identical buildings are constructed, one by the highest bidder and one by the lowest. They may be more than ten thousand dollars apart. Is the actual cost of either a fair appraisal figure? An estimate based on the square foot of floor area that showed a figure halfway between the extremes would give a much more reasonable value. Indeed, Mr. Main states that several contractors have told him that they use his tables as a check before submitting bids.

The actual cost of foundations is far more unsafe to use for appraisal purposes. A building resting on extremely expensive foundations in quicksand is worth no more than a duplicate building resting on a ledge. A fair estimate for the cost of sufficient foundations in average ground would be a better figure to use for either when appraising an industrial property. With appraisals of public service corporations conditions are different, but that comparison is not to be discussed here.

MACHINES

It is our custom to make a complete inventory of all fixed machines, not only producing machines but those used for power and for maintenance. This inventory also includes all elevators and cranes. There is no hard and fast rule, but the practice is to list everything (exclusive of furniture, small tools, etc.) that has enough value to be worth considering separately. In making this inventory, the shortest description that will identify a machine is used. As an example, for a cotton spinning frame, "one ring frame 256 sp. 3″ met. bds. sep." means a ring frame with 256 spindles 3-in. gage, with metallic thread boards and separators. "One engine lathe 14 × 6 comp. taper" means an engine lathe with 14-in. swing, 6-ft. bed over all, screw cutting, without special gearing, with compound rest and taper attachment. Other special features that materially affect the cost are, of course, noted. In each case the above brief notes are all that are necessary to determine the value of the machine in question. By adhering to this method the fixed machines in a large factory can be inventoried in a much shorter time than would be deemed sufficient by one not acquainted with the work.

Having completed the inventory, it is a simple matter to appraise standard machines either directly from price lists or from data compiled from individual quotations and actual costs obtained when making other appraisals. Of course, all such prices are given in confidence and are used without the source of the information being divulged. In the same way machines built on order or by the owner can be appraised as data on similar machines accumulate. Allowance is made in all cases for the cost of freight, cartage and labor of erection. It should be understood that no prices are fixed arbitrarily by the appraiser. On the contrary, the figures are discussed with the owner or manager and as much assistance as possible obtained from their records.

APPROXIMATION ON MINOR ITEMS

The appraisal of buildings and machines forms the most important part of the work, both in time consumed and in results obtained. It would, therefore, be inconsistent to devote a greater amount of effort to the smaller part of the value. It is here that accurate "short cut" methods have been developed in the appraisal department of the Factory Mutuals.

Shafting. By figuring in detail representative lines of shafting, with couplings, hangers and pulleys included, various factors per lineal foot erected have been obtained. Experience soon teaches which factor to apply when examining lines of shafting in actual use. Opportunities are repeatedly presenting themselves to compare the results obtained with those of a detailed appraisal, and the accuracy of the approximate method is confirmed.

Belting. The most satisfactory method by which belting may be rapidly inventoried is to measure the main belts by eye. The machine belts can then be classified in groups, as similar machines will require about the same amount of belting. Individual motor drives are lessening the amount of belting in a modern factory, and where the machines are scattered and the belts vary greatly, it is usually easier to list them by using eye measurement than to attempt to apply any shorter method.

Piping. A detailed inventory of piping and pipe fittings would require an amount of time out of all proportion to that devoted to the remainder of the work. To obtain a "short cut" method has not been easy, due to the great variety in the material to be considered, much of which is hidden. The different uses to which the piping is put enable the appraiser to divide the subject into classes and these classes can be treated by different methods.

Automatic sprinkler piping can be appraised at a price per sprinkler head or, by what amounts to the same thing, by a price per square foot of sprinkled floor area. This applies to the piping inside the buildings only.

Steam heating, where consistent throughout the plant, can also be appraised on a floor area basis. Where the amount

of steam heat varies a price per lineal foot of coil or per radiator can be easily ascertained. The heating pipe in dry rooms, lumber dry kilns, paper dry lofts, etc., can be treated similarly.

Gas lighting can be appraised at a price per light. Where a building has gas lights at frequent intervals, a factor per square foot of floor area can easily be estimated.

The piping used for manufacturing purposes presents the greatest difficulty. The steam and water pipe in a steam power plant will vary little from a standard figure per horsepower of boiler rating. For long runs of covered steam pipe through rooms where there are few or no outlets, a price per lineal foot can be used.

In plants where there is a great quantity of piping, particularly in bleacheries and paper mills, small factors cross-checked by large factors can be used. These factors are obtained from time to time when actual costs in a new plant are available. In all cases the large factor for steam is based on the horsepower rating of the boiler plant. In a bleachery the large factor for water is based on the number of kiers; in pulp and paper mills, for water and stock piping, on the number of pulp grinders, digesters, wet machines and paper machines, as the case may be. The small factors in all cases are varied with the pieces of apparatus. By using both methods in estimating a plant a sufficiently accurate total can be obtained. With factories making dyes, chemicals, soaps, etc., the same method can be employed.

Air piping, though quite extensive in modern machine shops, never amounts to more than a very small fraction of the value of the plant. The runs of pipe are easily followed and a factor per lineal foot or per machine supplied can be ascertained.

Fuel-oil and gas or gasoline piping is of still less importance from a value standpoint and can be easily estimated in a manner similar to that used with air piping.

Furniture and Apparatus. In every plant there is a large amount of equipment (exclusive of small tools, dies, etc., which will be considered later) that cannot be classified under the head of machines and yet does not belong to any special class. This equipment is covered under the very elastic term "furniture and apparatus." All furniture, benches, racks, trucks and scales come under this heading. In a textile mill all bobbins, spools, etc., in a metal-working plant all boxes, trays and cans, indeed, every miscellaneous article that cannot be included under any other definite title, can be covered under this.

To list all of these items in detail would be arduous. Many would be destroyed and new ones added before the list could be completed. The value, however, would be insignificant when compared with the total value of the plant. It is not difficult, however, to obtain a fairly accurate estimate.

In a cotton mill a factor per spindle can be used, and in a woolen mill a factor per set of cards. In any textile mill, however, it is possible to obtain from the different foremen the approximate number of bobbins, spools, roving cans, filling boxes and trucks, while the appraiser can easily estimate, room by room, the value of what other miscellaneous apparatus there is. In a metal-working plant the benches and racks can be appraised by a factor per lineal foot; the number of tote boxes, cans and trucks can be obtained from the foremen, and the other miscellany can be estimated as above. A similar method can be applied to any plant. Office furniture can be appraised, without listing, by using judgment.

Small Tools and Dies. All machine shops contain an equipment of small tools and all metal-working plants an equipment of dies. The proportion that the value of these bears to the value of the whole varies greatly with the class of work. In many concerns fairly accurate records are kept of the cost of such small tools and dies. Experience has shown that factors per producing machine can be used that will give a fairly accurate appraisal. Where a closer estimate is needed, the tool and die storerooms can be examined and fairly representative shelves or drawers can be appraised to obtain a factor or factors to be used for the remainder.

Patterns and Drawings. Depreciation plays an important part in finally determining the value of patterns and drawings. To obtain the new value of patterns it may be possible to study the pattern-shop pay roll for a given period and add a proper amount of overhead expense. So many patterns are obtained from outside, however, that the most satisfactory method is to examine the shelves in the pattern storage, classify them into a few groups and estimate a price per square foot of shelf area for each group.

With drawings the pay roll, plus overhead expense covering the entire time since the drawings began to accumulate, gives the most accurate basis. For replacing cost the present rates of pay should be used, but a deduction should be made for time spent in experimental work in either case. A good cross-check is to obtain from the head draftsman the total number of drawings, divided into several groups for size and cost.

Molds, Lasts, etc. Molds, used both for hard and soft rubber and in several other classes of manufacture, are usually carried on accurate inventory by the owner, but if not, they can be appraised by methods similar to those used for small tools and dies. Lasts in shoe factories, copper shells in print works, print rolls in wallpaper factories and dandy rolls in paper mills are almost invariably carried on inventory. In the rare cases where not so listed they can be easily counted, divided into classes and an average price to be used for each class readily obtained.

Miscellaneous. The above-mentioned subjects are the ones most commonly found. Occasionally the appraiser visits a manufacturing establishment which is out of the ordinary and special auxiliary apparatus is found in large quantity. By using some of the methods described for appraising small tools, patterns, etc., the value of these extras can be obtained.

Stocks and Supplies. In making insurance valuations the Factory Mutual appraisal department almost invariably relies on the inventories of the assured to obtain the value of stock and supplies. In rare instances, however, where such are not obtainable, a rough average obtained from previous appraisals of similar plants can be used.

ROUGH APPROXIMATION

The methods described above enable the appraiser to make an accurate estimate of the value of buildings and machinery in a much shorter time than would be used were all items listed in detail. To obtain quickly an approximate valuation a comparison can be made with other appraisals on a basis of the square foot of floor area or of the number of producing machines. In specific instances the comparison can be made per spindle, per set of cards, per kier or per paper machine.

DEPRECIATION

There is a wide difference of opinion as to the amount of depreciation that should be allowed on buildings and various classes of machinery and as to the method of caring for such

depreciation in the book accounts. Indeed, another argument in favor of the "short cut" method of making valuations is the fact that two competent appraisers would show more difference in the value of a plant on account of varying opinions as to the amount of depreciation to be allowed than in errors made in estimating the new value.

Depreciation for Insurance. A building that houses a going concern or a machine that is turning out a salable product deserves less depreciation from an insurance standpoint than from any other. It is the intention of the Factory Mutual Insurance Companies to deduct for depreciation what judgment shows is deserved for actual wear and tear and for obsolescence. The methods used in estimating this depreciation vary with buildings and with different kinds of machinery. In some cases a sliding scale can be applied and in others an average figure.

Depreciation of Buildings. A building badly out of repair naturally deserves fairly heavy depreciation. A building in good repair, but so antiquated in size and shape that it is manifestly unsuited for the uses to which it is being put, also deserves a reasonably heavy deduction. When, however, a building is of such dimensions that it perfectly answers its purpose, has remained plumb and is constantly kept in repair, actual age has little influence on judgment. It is considered that about five per cent of the new value is enough. In other words, buildings are not depreciated a certain per cent a year, but have a flat amount deducted on account of condition and not on account of age.

Depreciation of Machinery. Machines vary greatly both in the manner in which they wear out and in the rapidity with which they go out of date. In rare cases where a machine has been practically superseded in the market by one that will cost much less, it is better to use for a new value the cost of the less expensive machine rather than show an excessive depreciation. As a rule, the amount deducted applies chiefly to wear.

With machines that need repairs at all points from time to time, a day arrives after a period of years when it is better to throw them out altogether and replace with new rather than continue to repair them. Practically all textile machines come in this class, as do engines and other power-plant machines, and also some machine tools, wood-working and paper-working machines. To all of that nature a depreciation table is applied, allowing 2, 2½, 3, 4 or 5 per cent a year, deducted from the net and not from the gross. If a machine is entirely rebuilt it is usually considered to be worth at that time within five per cent of new value, and the table is applied for succeeding years. In either case, the probable average life is ascertained and the table that best fits is used, but seldom is the depreciation carried to a point beyond fifty per cent.

There are many kinds of machines where the main portion, sometimes as much as eighty per cent of the total value, remains for years with practically no wear. The small moving parts, however, wear so rapidly that they are constantly being replaced. This is true of a great variety of machine tools, metal-, wood- and paper-working machines. With these it is considered that the wearing parts are always in a state of fifty per cent depreciation, and the amount deducted is half of the percentage the value of the wearing parts bears to the total value of the machine. This method also applies to rolling mills, rubber mills and calenders where the frames and gearing remain intact for years and the rolls constantly wear down and are replaced.

There is another class where neither the depreciation table nor the definite average described above can be used. This includes most of the machinery in paper mills, bleacheries and dye works where wet processes are used. These machines wear rapidly and are frequently rebuilt. Paper machines in particular are composed of a train of parts, and from time to time different sections are either rebuilt or removed entirely and replaced. The depreciation in such cases depends upon the condition at the time of the appraisal and is not influenced by the age of what remains of the original machine.

Depreciation of Shafting, etc. It is quite apparent that to obtain the age of shafting, belting, piping, etc., would nearly always be impossible, so that general figures for depreciation are safest. Shafting shows such slight wear that depreciation is seldom recognized. It is becoming the custom, however, to show either a slight deduction or else purposely record the new value at a conservative figure when on account of poor arrangement an amount in excess of what is needed is in use.

Main belts wear slowly, while machine belts will always average 50 per cent wear, so that, as a rule, the total amount of belting is depreciated 33⅓ per cent.

Piping will last for years, except where exposed to acid fumes. Pipe covering and valves show wear, but piping as a whole is seldom depreciated more than ten per cent.

The miscellaneous equipment classed under the head of "furniture and apparatus" is made up of objects most of which are constantly wearing out. The amount is, therefore, usually depreciated from twenty to fifty per cent.

Small tools, dies, print rolls and electrotypes wear out, but they are affected to a great extent by obsolescence. Patterns, drawings, molds and lasts are subject to depreciation for the latter reason only. In determining the amount to be deducted from the new value of any of these the appraiser must ascertain what proportion of the equipment is indispensable or practically new.

APPRAISAL COMPANIES

Having explained the method by which an accurate appraisal can be made, expending the minimum amount of time, the writer may well refer briefly to the method of making an appraisal by laborious, painstaking detail, best illustrated by the work of the appraisal companies. The finely prepared volumes are found to contain a list of substantially everything on the premises. They are overburdened with extended descriptions of buildings and machinery, far more than is necessary to determine value and decidedly confusing to the searcher for individual items. The usual proportion of the total value recorded is based on estimate only, and invariably there are errors large enough to counterbalance whole pages of minor items so carefully noted. The law of averages usually balances these errors, so that the final result is approximately correct, but no more so than that of an appraisal made by the shorter method already described.

CONCLUSION

This so-called approximate or "short cut" method of making appraisals has been employed by the Factory Mutuals for years and foundations and other uninsurable properties are omitted, while the depreciation charged off is for insurance purposes only. It should be emphasized that the figures thus obtained are not intended for other uses, though safe enough for proportioning a cost system. But the method described can be employed in making an appraisal for any purpose.

RAILROAD PAPERS

THE Sub-Committee on Railroads has been fortunate this year in securing for presentation and discussion at the Annual Meeting papers of interest both to locomotive engineers and to passenger-car men. The session in charge of this committee will therefore be of wide interest.

MECHANICAL DESIGN OF ELECTRIC LOCOMOTIVES

By A. F. BATCHELDER, SCHENECTADY, N. Y.

Member of the Society

IMPORTANT features in the mechanical design of electric locomotives are, in the order of their importance:

1 Safety of operation
2 Adaptability to service conditions
3 Reliability in service
4 Convenience of arrangement as affecting safety and efficiency of operation
5 Power efficiency (affected by mechanical design)
6 Service time factor (ratio, time available for service to total time)
7 Cost of maintenance of permanent way
8 Cost of maintenance of locomotives
9 First cost.

SAFETY OF OPERATION

The steam locomotive has been developed to such a state of perfection that it can operate at near 80 m.p.h. with perfect safety; but no one would think of operating at this speed backwards. With the coming of the electric locomotive, the railroad operator is not content with single-end operation, but must have a locomotive that will operate equally well in either direction. This does not impose any serious difficulties in the design of locomotives for speeds under 50 m.p.h., but for higher speeds it requires very careful consideration of running-gear details, to obtain the most satisfactory results as to tracking and effect on rails and roadbed.

The steam locomotive has what now seem to be natural characteristics to allow high-speed operation in one direction. These characteristics are low center of gravity at the front end carried on the center pin of a 2-axle guiding truck tending to prevent rolling over and having but little effect on the guiding, and high center of gravity at the rear end with inside journal bearings allowing the locomotive to roll and increasing the time element, which thus reduces and distributes the lateral pressure against the rail over a longer distance and increases the vertical pressure on the rail, thus holding the locomotive more firmly in place. These same characteristics can be obtained in electric locomotives by the sacrifice of double-end operation.

The advantages gained in operating the electric locomotive in either direction are so important that means should be provided for satisfactory double-end operation. One way of doing this is by using a 4-wheel guiding truck at each end of the locomotive. With the use of the extra truck, however, the importance of a high center of gravity largely disappears. The lateral pressure against the rail at the rear end now appears at the truck flanges rather than at the flanges of the driving wheels, and the high center of gravity no longer provides the same increased vertical pressure on the outer rail at the point of the maximum lateral pressure. The lateral stresses from guiding the main frame being taken at the center pin of the two guiding trucks, the additional vertical pressure on the outer rail is dependent upon the height of these center pins rather than upon the height of the center of gravity of the main frame above the wheel hubs, thus leaving less advantage to be derived from a high center of gravity.

The paper shows that while the swivel truck is desirable as a guiding agent at the front end, it is not so desirable at the rear end, and means must be provided to prevent oscillation of the truck and to accomplish the same results as the high center of gravity in a single-end locomotive. For this it is necessary to reduce the momentum effect and to reproduce the equivalent of the time-element factor and of increase of vertical pressure on the outer rail that is characteristic of the high-center-of-gravity single-end locomotive.

The momentum effect can be reduced by introducing resistance against swiveling, thus restricting the truck from oscillating from one side to the other of the track. The amount of this resistance is determined by the allowable amount that can safely be applied to the truck when leading. To reproduce the time-element factor, lateral movement can be given to the truck center pin by any of the several methods for giving lateral movement to the leading truck center pins on locomotives. However, the writer has obtained the best results with the method that is the nearest to constant pressure and dead beat, as it also tends to prevent oscillating.

To increase the vertical pressure on the outer rail, the center bearing of the truck can be made wide, thus allowing the vertical component of the lateral pressure at the center of gravity to be transferred through the bearing to the wheel, or, with the narrow center bearing, the height may be made such that the lateral pressure at that point will result in an increased vertical component independent of the height of the center of gravity.

It is the writer's opinion that the double-end locomotive, while its characteristics are different, can be designed for high speed with safety equal to the single-end locomotive, and this regardless of the height of the center of gravity.

ADAPTABILITY TO SERVICE CONDITIONS

The electric locomotive, besides being required to operate in either direction, is often also required to be adapted for operating high-speed passenger trains and heavy low-speed freight trains over main-line tracks, to negotiate sharp curves, and to be easy on light track and bridge structures.

With locomotives having geared motors, the requirement of operating the passenger and freight trains can often be met by changing the gearing to obtain the proper speed and drawbar pull.

The running gear can be made with trucks of short wheel base and coupled together, the number of trucks depending upon the required weight of the locomotive for its maximum drawbar pull, and also on the allowable weight per axle.

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With such a design curves of very short radius can be operated over, and the weight per axle can be such as to allow operation over light structures.

RELIABILITY IN SERVICE

When the design is such that it is safe to operate at the required speeds and is proper for the curves and other service requirements, and liberal factor of safety is provided for the parts subjected to strain, reliability in service affected by the mechanical part of the locomotive depends mainly upon the bearings, their lubrication, and the method of power transmission from the motors to the drivers. It is necessary therefore to provide effective lubrication and as few bearings and as simple driving mechanism as the design of the motors will allow.

CONVENIENCE OF ARRANGEMENT AS AFFECTING SAFETY AND EFFICIENCY OF OPERATION

After providing all the safety appliances recommended by the Interstate Commerce Commission, it is important to arrange for the most convenient location of the operator to allow him an unobstructed view of the track and signals, to place within his easy reach the air-brake valve and locomotive-signal-device handles, as well as the reverse and power-controller handles, keeping in mind the importance of making them so free from complication that the operator will require the least amount of thought to manipulate any of the devices and be left free to respond to signals and look out for emergencies.

The arrangement for housing the electrical apparatus and its position in the cab must be governed largely by its design, but it is important to arrange it so that its operating parts are accessible and easy to inspect, and at the same time are protected against persons coming in contact with any live parts.

POWER EFFICIENCY

The power efficiency as affected by mechanical design is governed largely by the type of traction motors. It is apparent that the gearless motor mounted directly on the axle allows the design of maximum efficiency on account of its few bearings and absence of gearing and moving parts. The gearless motor mounted on a quill and driving through springs to the wheels may be considered second in its possibilities for high-efficiency design, it having additional bearings and a greater number of moving parts. The single-reduction geared motor with its additional bearings and gear losses can be given third place in efficiency design; the single-reduction geared motor driving through gears and side rods to the wheels may be placed fourth, and the gearless motor driving through side rods and jackshaft to the wheels fifth.

SERVICE TIME FACTOR

The service time factor is dependent upon the ability of the locomotive to operate under all service conditions and without undue strains, which requires a liberal design of its wearing parts. In addition to this it depends on the simplicity of design of the locomotive and the ease with which its parts can be inspected, adjusted, repaired, or replaced.

COST OF MAINTENANCE OF PERMANENT WAY

The cost of maintenance of permanent way can be increased or reduced by the design of the locomotive. The lowest cost is obtained when the locomotive meets its service requirements without undue strains, when the rotating parts are balanced, the weights per axle are suitable for the structures, a suitable equalizing system provided to maintain the proper weight distribution, and provision made to protect against flange wear.

COST OF MAINTENANCE OF LOCOMOTIVES

The cost of maintenance of the locomotive is dependent upon safety of operation, adaptability to service conditions, reliability, convenience of arrangement, and the same items that enter into its service time factor. It is also governed by the same conditions as affect the maintenance of permanent way.

The care with which the material is selected, the quality of workmanship, ease with which the parts can be inspected, adjusted, repaired or replaced, and simplicity of design govern maintenance cost.

FIRST COST

This will depend largely upon the design chosen, but its importance, except at the time of purchase, becomes of little moment when taking into consideration the eight foregoing features. With two locomotives designed for the same service, the cost of the difference in efficiency and locomotive maintenance alone for one year may, when capitalized, amounts to a considerable proportion of the first cost of one of the locomotives.

Too much importance cannot be given to developing to the utmost the mechanical part of the electric locomotive. From the present outlook, the locomotive for high-speed passenger service with gearless motor with armature mounted directly on the axle, and the locomotive for freight and switching service with single-reduction geared motor mounted on and geared to the axle, lend themselves best to simple design and low cost of maintenance.

In making these comments the writer does not criticize the work of any other designer. The conclusions he has reached are drawn from experience with his own designs of the various types referred to.

CLASP BRAKES FOR HEAVY PASSENGER EQUIPMENT CARS

By T. L. BURTON[1], ST. LOUIS, MO.

Non-Member

THE first requirements of a power brake are to stop the vehicle to which it is applied in the shortest possible distance, consistent with maximum rail adhesion, during emer-

[1] Equipment Department, The New York Central Railroad.

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gency braking, and in the minimum distance, consistent with accuracy and smoothness, during service braking, all of which is largely dependent upon the type of equipment employed, the manner in which it may be operated and the braking ratio (percentage of brake power) that can be successfully used.

The braking requirements for present-day heavy steel passenger-car equipment can best be appreciated by a careful analysis of the records of a number of passenger-train brake tests with the earlier light wooden cars and the heavy steel equipment of today, and for those who care to make such an analysis the paper which was presented by S. W. Dudley at the February, 1914, meeting of the Society is unqualifiedly recommended. For ready reference, however, it might be interesting to state that in 1902 an exhaustive series of brake tests were made on the Pennsylvania Railroad, under the supervision of A. W. Gibbs, with trains consisting of one locomotive and comparatively light wooden cars, in which stops were made from a speed of 60 m.p.h. with emergency-brake applications in approximately 1000 ft.

In 1903 similar tests were made on the Central Railroad of New Jersey, under the writer's supervision, in which passenger trains consisting of what was then considered modern equipment were stopped from a speed of 60 m.p.h. in an average distance of 970 ft.

Early in 1905 another series of tests was made on the Pennsylvania Railroad with equipment similar in weight and construction to that used in the 1902 and 1903 tests, with substantially the same results.

The emergency braking ratio in the Pennsylvania Railroad and the Central Railroad of New Jersey tests did not exceed 125 per cent of the car weight, and a reducing mechanism was employed for automatically reducing the braking ratio during the stops, so that the mean effective ratio was approximately 100 per cent.

Based upon results obtained in the three brake tests just referred to, a distance of 1000 ft. was considered a desirable theoretical emergency stop from a speed of 60 m.p.h. for a passenger train having the ordinary "high-speed brake."

In the fall of 1905, closely following the second test of the Pennsylvania Railroad, similar tests were made on the New York Central Railroad, under the supervision of C. H. Quereau. The locomotive and cars used in this test weighed, however, considerably more than the ones used in previous tests, and the emergency stops from 60 m.p.h. were over 1200 ft., in cases where the air-brake equipment and braking ratio were substantially the same as had formerly produced approximately 1000-ft. stops with lighter equipment.

Results of the New York Central test immediately established the fact that as the weights of the individual vehicles of which the train was composed increased, the braking ratio would have to be increased if the length of the stop was to be no greater than was formerly made with lighter equipment, and to meet the requirements of the heavier locomotives and cars the air-brake manufacturers immediately developed an air-brake equipment with which could be had a higher braking ratio than was obtainable in previous tests with lighter locomotives and cars.

In 1908 another exhaustive series of tests was made on the Southern Pacific Railroad with still heavier locomotives and cars, in which it was found that a distance of over 1300 ft. was required for stopping the heavier trains from a speed of 60 m.p.h. with no greater emergency braking ratio than was formerly required for making a 1000-ft. stop with the ligher equipment.

In 1909, R. B. Kendig, Mem.Am.Soc.M.E., conducted still another brake test on the Lake Shore & Michigan Southern Railroad with trains consisting of locomotives and cars closely approximating present-day equipment in weight, for which was required an emergency braking ratio of 180 to 200 per cent of the car weight for producing approximately a 1200-ft. stop from a speed of 60 m.p.h. These tests demonstrated to the entire satisfaction of all who participated in them that the emergency braking ratio for heavy steel cars would have to be not less than 180 per cent of the car weight if the emergency stops were to be made in no greater distance than formerly required for the lighter cars.[1]

Realizing that 180 to 200 per cent braking power applied to one side of a car wheel would probably produce ill effects on journals, brasses, trucks, etc., the writer had made a careful and thorough analysis of the force action on car journals as effected by high-braking forces. These analyses show conclusively the undesirability of applying to one side of the wheel a braking ratio of sufficient magnitude for stopping the modern heavy steel equipment in no greater distance than formerly required for stopping the lighter wooden equipment. A summary of these analyses is given in the text of the paper and in illustrations.

In the light of these analyses, it is the writer's opinion that a suitable design and make of clasp brake should be used on modern steel passenger equipment, the advantages of which are, briefly stated, as follows:

SAFETY

a In case of danger, requiring an emergency brake application, a much shorter stop can be made with the clasp brake than with a single-shoe brake, other conditions except those affected by the brake gear being the same in both cases.

b If properly designed, manufactured and installed, there is no occasion to disconnect any part of the clasp-brake rigring between shopping of cars. The probability of the brake becoming inoperative through a failure to properly replace cotters when disconnecting the brake with the car in transit and the loss of brake pins resulting therefrom is reduced to a minimum.

c A thin brake shoe or the loss of a brake shoe does not in all cases necessitate cutting out a brake to save the brake beam.

d If the clasp brake is properly designed, manufactured and applied to the car it will be practically impossible to adjust the rigging so as to impair its efficiency or interfere in any way with its proper operation.

e The axles and truck frames, in addition to performing their usual functions, become safety hangers for the major portion of the brake rigging, thus reducing to a minimum the possibility of derailment that might be caused by brake rigring dropping on the track in case of failure of the truck brake gear.

f While the possibility of disconnected brake parts dropping on the track is greatly reduced in comparison with the single-shoe type of brake gear, the danger is further reduced on account of the clasp-brake parts being much lighter than those of the single-shoe type.

[1] It is not the intention to show by the above references to brake tests the distance in which trains may be stopped in service. In conducting brake tests variations in equipment by which stopping distances are effected are necessarily reduced to a minimum, otherwise the results would not be comparative. The stopping distances referred to should, therefore, be used only as a basis of comparison for different equipments, and it should not be assumed that such stops would be reproduced in actual train service. On the contrary, it may safely be assumed that the stops with service trains should be much longer than test records show.

ROUGH VS. SMOOTH TRAIN HANDLING, ACCURACY IN MAKING STOPS, ETC.

g Many modern passenger trains are, on account of the inherent shortcomings of the "single-shoe" type of brake, extremely difficult to handle smoothly. Careful investigation of the complaints of roughly handled passenger trains indicate that most of these troubles are due largely to non-uniform braking power and the *time in which it is developed,* as a result of improper piston travel.

In service braking at low speeds, whether for the purpose of stopping from such speeds or for completing stops from high speed, such as making a *second brake application* as the stopping point is approached, the brake power should be light and the retardation resulting therefrom must be developed slowly, or simultaneously on all cars, if smooth handling is to be insured. Smooth service stops from all speeds are also contingent upon the flexibility of the brakes.

The seriousness of slack-action shocks is greater than in former years on account of the greater average weight of cars and increased length of trains, and the chances for producing them are much greater with the single-shoe brake than was formerly the case with lighter cars and shorter trains.

Contrasting the desired rate at which the braking power should be developed at low speed, making service or emergency stops from high speed in a minimum distance necessitates developing a high nominal braking power, and in addition thereto it must be developed rapidly.

The rate at which both service and emergency braking power are developed is largely dependent upon piston travel, and with a view to producing the best results under all conditions, the automatic brake is built on the principle of maintaining, as near as practicable, 8 in. of piston travel at all times and under all conditions. As an example, if, during service braking at low train speeds, the piston travel resulting from a 10-lb. brake-pipe reduction is only 5 in. instead of 8 in. (with some brake riggings it is 5 in. or less), the braking power will be fully 100 per cent greater than with the predetermined standard piston travel of 8 in.; and with the shorter travel a 10- or 15-lb. reduction will practically equalize the auxiliary reservoir and brake cylinder pressure, thereby materially reducing the flexibility of the brake. While the vibration of the car may cause the 5-in. piston travel to increase to practically normal before the stop is completed, it will not do so except when stopping from high speed. Moreover, if the travel does increase before the stop is completed it will contribute nothing to smooth handling, as the shock will have occurred while the travel was short.

Other things being equal, the clasp brake will develop a higher percentage of braking power than the single-shoe brake during heavy service or emergency applications, but for light service braking at low speed the brake power developed from a given brake-pipe reduction is much less with the clasp brake than with the single-shoe brake, and it is developed at a much lower rate, thereby insuring smoother train handling than can be had with the single-shoe brake.

The results just cited are due to the fact that with the single-shoe brake the piston travel is practically proportional to the cylinder pressure developed, whereas with the clasp brake, with a shoe on each side of the wheel, the horizontal wheel or shoe movement relatively to the brake cylinder is reduced to a minimum, and such movement if produced from any cause will have no effect on the piston travel. Moreover, with the clasp brake the shoes are located sufficiently close to the horizontal center line of wheel centers to obviate the *pulling down* of truck frames and variations in piston travel resulting therefrom.

The removal of worn shoes and their replacement by a given number of new shoes without readjustment of slack, as is frequently done on long runs, will not affect the piston travel with the clasp type of brake to the same extent as would occur with the single-shoe type of brake.

The only remedy that can be offered for the difficulties arising from improper piston travel, which so seriously affects the braking power resulting from a given brake-pipe reduction and the rate at which it is developed, is to apply a truck-and-body brake gear that will substantially insure uniform piston travel under all conditions of speed and cylinder pressure. The use of the clasp type of braking rigging with body-brake gear to suit will, to a large extent, accomplish these results and restore the flexibility of brake operation which existed prior to the adoption of extremely heavy cars and long trains of the present day equipped with single-shoe brakes.

IMPROVES RIDING QUALITIES OF EQUIPMENT

h The high brake-shoe loads developed one one side of the wheels with a single-shoe brake produce a binding effect between pedestals and oil boxes which interferes with the proper action of the truck springs during an application of the brakes, and when the shoes are hung low, as is necessary with the ordinary six-wheel truck and single-shoe brake, the pulling-down effect of the truck defeats in many cases the purpose of the truck equalizing springs. This binding between pedestals and oil boxes and the increased load on truck springs causes the car to ride hard when brakes are applied. These evils do not exist with the clasp brake.

ELIMINATION OF HOT BOXES

i With the single-shoe type of brake rigging it will be observed that the high pressure exerted by the shoe on one side of the wheel causes the tilting of brasses sufficiently to lift one side of the brass a considerable distance away from the journal (see Figs. 3 and 4) so that a wide space is open for waste to be caught between the brass and the journal when the brake is released and the brasses and journals resume their normal position.

Investigation has shown that waste has been found wrapped around the journal, and that the collars on the axles are forced against the sides of the boxes. Further, these effects are not confined to emergency applications, but will also be noted in service applications of the brake and are all in the direction of producing hot boxes, while the unequal distribution of braking power and binding between boxes and pedestals has a tendency to cause slid flat wheels.

DECREASE IN MAINTENANCE COST AND BRAKE-SHOE COST

j While the principal advantages inherent in the clasp brake, of greater flexibility in service braking, etc., are outlined in the foregoing, and the primary consideration for its adoption must be the increased emergency efficiency over the single-shoe type of brake, providing as it does for the possibility of greatly shortened stops, with a lesser tendency to slide wheels, and consequent increase in safety, the clasp brake will also, due to the principles involved in its design and con-

struction, show a decided decrease in cost of maintenance, not only in the brake rigging itself, but a substantial decrease in the cost of brake-shoe material for equal amounts of energy dissipated.

COST OF TRAIN OPERATION

k Investigation has developed the fact that with the single-shoe type of brake on modern passenger equipment cars and the piston travel adjusted to proper limits, approximately 35 per cent of the available tractive effort of the locomotive was consumed in pulling the train against the effect of brake shoes dragging on the wheels with the brakes released.[1] With the clasp type of brake and the resulting increased shoe clearance, this loss is eliminated, leaving better maintenance of schedules and corresponding decreased cost of train operation.

CONCLUSION

l In considering the application of clasp *vs.* single-shoe brakes to the modern heavy steel passenger car of to-day, the *advantages* of the former over the latter, as enumerated above, are but secondary to the primary question to be settled, namely: Are the present-day trains to be stopped from given speeds in no greater distance than was required ten to fifteen years ago for stopping the lighter wooden cars? If so, the question of whether or not an efficient clasp brake should be used on such trains is conclusively settled.

The collision energy of the heavy steel passenger trains as compared to the lighter wooden train has increased directly in proportion to the increased weight, and in geometrical proportion to the increased speed, in cases where speeds have been increased, to say nothing of the increased density of traffic. It would, therefore, seem that the use of a clasp brake is essential in successfully controlling the speed of present-day or future passenger trains, and without regard to nominal increase in first cost or multiplicity of parts of brake gear resulting therefrom.

m The foregoing discussion on the relative performance of the clasp and single-shoe brake is with the distinct understanding that the former is designed upon a scientific engineering basis and is constructed and installed in accordance with the principles involved in the design; for while the claims made for the clasp type of brake have been conclusively demonstrated by exhaustive tests and road service, it has likewise been demonstrated that where the clasp brake is improperly designed or carelessly manufactured and installed the results obtained in service are in many respects less desirable than with the single-shoe brake.

[1] See M.C.B.Assn. Proceedings, 1910, page 97, paragraph 3.

GAS POWER PAPERS

THE Sub-Committee on Gas Power will have charge of a session at the Annual Meeting at which important papers on gas manufacture, gas analysis, comparison of steam and gas engines, internal combustion engines, and gas tractors will be presented. Two of the papers for this session appear below.

THE INTERNAL-COMBUSTION MOTOR FOR TRACTION ENGINES

BY A. A. POTTER, MANHATTAN, KAN.

Member of the Society

and

W. A. BUCK,[1] MANHATTAN, KAN.

Non-member

AT the present time, over one hundred manufacturing concerns in the United States are building traction engines driven by internal-combustion motors. The designs differ greatly: some have motors with horizontal cylinders, others with vertical cylinders. In some designs the power of the motor is delivered to one wheel, in others to two, and in still others to all four wheels; several designs are of the so-called "creeping grip" types.

The development of the traction engine for agricultural purposes has been along lines entirely different from those of the automobile. The early engines developed 60 to 80 h.p. on the brake and 30 to 40 h.p. on the drawbar; they were expensive, complicated, and unsuited for any but the largest farms of the country. The present tendencies of manufacturers are to build smaller engines and to standardize the product.

[1] Assistant in Steam and Gas Engrg., Kans. State Agrl. Coll.

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

OBJECT OF INVESTIGATION

The purpose of this investigation was to determine the fuel economy and thermal efficiency of a great variety of traction-engine designs, to find out the practicability of the fuels heavier than gasoline for traction engine use, and to compare the rating, valve setting, timing and other details of commercial traction engines. Particulars of the motors tested and of the fuels used are given in Table 1.

GENERAL CONCLUSIONS

From the results of this investigation the authors have derived the following general conclusions:

a The four-cylinder motor is better adapted for belt work on account of the greater number of impulses per revolution.

b The single-cylinder motor and the two-cylinder motor operate better than four-cylinder motors with fuels heavier than gasoline.

c Carburetors now used are satisfactory for gasoline, but a carburetor jacketed with heat from exhaust gases should be employed when operating with kerosene or with the heavier fuels.

d The ordinary automobile motor is too light for traction-engine work. The traction-engine motor should operate at lower piston speeds than the automobile motor. Motors operating at piston speeds of 700 to 900 ft. per min.

are giving satisfaction.

e The vertical types of motors are preferable on account of greater accessibility, longer lift and better balance.

f The valve-in-the-head type of motor has the more efficient combustion space and is to be preferred to the T-head or L-head types.

g The combination of the forced feed and splash oiling system gives good results.

h The jump-spark system, on account of its mechanical simplicity, is the best system of ignition for traction engines.

i The fuel-economy range is from about 1.30 lb. per shaft h.p. per hour at one-fourth load to about 0.7 lb. per hour at full load. The fuel consumption in lb. per shaft h.p. per hour is very nearly the same for both gasoline and kerosene.

j The thermal efficiencies at full load vary from 14.88 to 19.41 per cent for gasoline fuel, and from 13.7 to 15.97 per cent for kerosene.

TABLE 1 PARTICULARS OF THE TRACTION-ENGINE MOTORS TESTED AND THE FUELS USED

Engine	Type (all 4-stroke cycle)	Ignition System	Lubrication System	Carburetor	Cooling System	Governor	Fuel: Gasoline or Kerosene	Fuel: Specific gravity	Fuel: Heating Value, B. t. u. per lb.	Rating, b.h.p.	Bore, in.	Stroke, in.	Rev. per min.
A	hor., twin, 2-cyl.[1]	high-tension, magneto	mech. op. sight-feed oilers	.....	pump	throttling[2]	K	0.809	19,700	60	...	...	...
B	(same motor as A, but	tested when new)		.....	.....	.....	K	0.800	19,680	60	...	...	...
C	vert, L-head,[1] 4-cyl.	high-tension,[3]	splash & mech. op. sight feed	Bennett	pump	throttling[2]	G K	0.739 0.786	19,670 19,500	65	7¼	9	500
D	vert., T-head, 4-cyl.[1]	high-tension[3]	sight-feed pump	Bennett	pump	diaphragm[4]	G	0.741	19,000	50	6	7	650
E	hor., opposed, 4-cyl.[1]	high-tension[3]	st. feed pump splash	Kingston	thermo-syphon	throttling[2]	G	0.735	17,680	50	6½	7	500
F	hor., opposed, 2-cyl.[1]	dual	mech. st. feed oiler	Rayfield	thermo-syphon	throttling[2]	G	0.730	20,600	40	8	9	350
G	vert., L-head, 4-cyl.[1]	high-tension[3]	pump splash	Bennett	pump	throttling[2]	G	0.737	20,000	35	5	7	700
H	hor., L-head, 4-cyl.[1]	high-tension[3]	mech. st. feed oiler	.....	pump	throttling[2]	K	0.789	19,900	25	5¼	8	575
J	hor., opposed, 2-cyl.[1]	high-tension[3]	pump splash	Kingston	thermo-syphon	throttling[2]	G	0.747	19,550	25	6½	7	570
K	vert., L-head, 4-cyl.[1]	high-tension[3]	pump splash	Bennett	pump	throttling[2]	G	0.737	20,000	20	4¼	5¾	800
L	hor., single-cyl.[1,5]	low-tension[6]	sight-feed oiler	.....	hopper	throttling[2]	K	0.805	19,280	16	8	12	400
M	hor., L-hd., 2-cyl., opp[1]	Kingston dual h.-t.	mech. st. feed oiler	Kingston	pump	throttling[2]	G	0.738	20,290	20	5¼	7	650 720

[1] With mechanically operated inlet and exhaust valves.
[2] High-speed throttling type of governor that regulates the quantity of mixture.
[3] With K-W impulse starter magneto.
[4] Diaphragm type, using pressure of circulating water to control the speed.
[5] Valve in the head.
[6] Make-and-break system using an Accurate oscillating magneto.

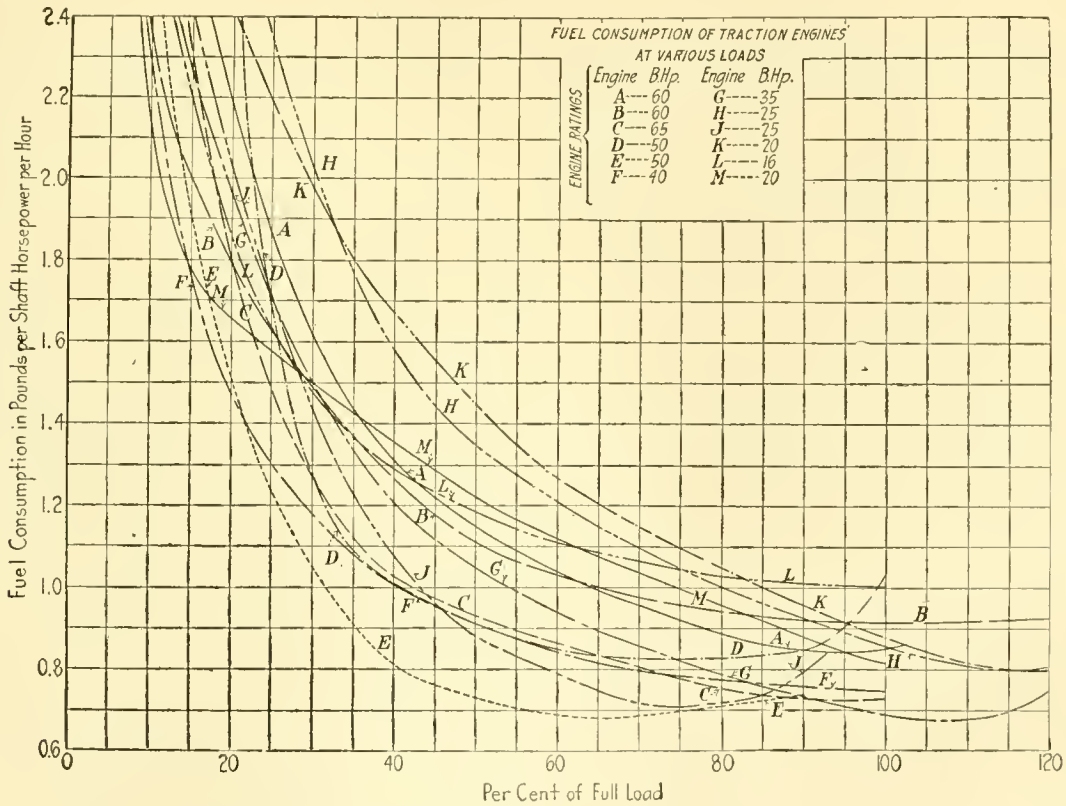

Fig. 1 Curves of Fuel Consumption of Traction Engines at Various Loads

RESULTS OF TESTS

The paper includes a table giving results of the tests relating to fuel consumption and thermal efficiency at various loads, and from the former the curves of Fig. 1 have been plotted.

TABLE 2 COST OF TRACTION-ENGINE POWER WITH GASOLINE AND KEROSENE AS MOTOR FUELS

Per Cent Load	Cost per Horsepower-Hour in Cents with								
	60° Baumé Gasoline at Prices per Gallons (in Cents) of					45° Baumé Kerosene at Prices per Gallon (in Cents) of			
	9	12	15	18	21	5	7	9	11
Group I[1]									
25	2.72	3.62	4.53	5.43	6.34	1.49	2.10	2.70	3.30
50	1.68	2.24	2.80	3.36	3.93	0.95	1.33	1.71	2.09
75	1.38	1.83	2.30	2.75	3.22	0.78	1.10	1.41	1.71
100	1.25	1.67	2.09	2.51	2.93	0.70	0.98	1.26	1.54
Group III[2]									
25	2.16	2.88	3.59	4.31	5.03	1.37	1.92	2.47	3.02
50	1.37	1.82	2.27	2.78	3.18	0.89	1.25	1.61	1.97
75	1.14	1.53	1.90	2.29	2.67	0.76	1.06	1.37	1.67
100	1.07	1.43	1.78	2.14	2.50	0.73	1.03	1.32	1.61

[1]Motors developing 15 to 26 b.h.p. on full load.
[2]Motors developing over 51 b.h.p. on full load.

TABLE 3 VALVE TIMING FOR MOTORS OF TRACTION ENGINES

Speed of Motor, r.p.m.	Exhaust Valve		Inlet Valve	
	Opens before outer center	Closes after inner center	Opens after inner center	Closes after outer center
200	20° to 25°	0° to 3°	0° to 3°	15° to 20°
300	22° to 27°	0° to 5°	2° to 5°	15° to 20°
400	27° to 32°	2° to 5°	2° to 7°	15° to 20°
500	30° to 35°	4° to 8°	5° to 10°	18° to 23°
600	35° to 40°	4° to 8°	8° to 12°	18° to 23°
700	40° to 45°	6° to 10°	10° to 12°	20° to 25°
800	45° to 50°	6° to 10°	10° to 12°	20° to 25°

CONCLUSIONS FROM TESTS

The lower fuel economy shown for engine A as compared with engine B (the same engine) was due to the greater spark advance used in operating engine A, when more cooling water had to be injected into the cylinder with the fuel to prevent pre-ignition. Water injection had to be used also during the tests of engines D, E and F with gasoline fuel.

In the case of several engines the valve setting had to be changed before satisfactory operating conditions could be secured. In one case the preliminary tests indicated that the carburetor was too small for the engine. Some companies in such cases remove several balls from the auxiliary air valve, a practice which is followed by poor fuel economy of the engine. These experiences indicate the poor inspection and testing facilities prevalent with some manufacturers of traction engines.

In order to facilitate comparison of various types, the motors tested were divided into the following groups, according to power developed at full load: I, 15 to 26 b.h.p. (motors H, J, K, L and M); II, 26 to 51 b.h.p. (D, E, F and G); III, over 51 b.h.p. (A, B and C). The average fuel consumption at different loads was then determined for groups I and III, and Table 2 computed. Group II is not considered in this table, as the engines it comprises were not operated on kerosene.

Table 2 shows the advantages of the kerosene-burning engine. Considering Group I, with kerosene at 10 cents per gal. and gasoline at 20 cents, the cost with gasoline fuel will be 1.99 times that with kerosene fuel for the same power developed. For Group III, the ratio will be 1.62 to 1 with prices of fuel the same. The advantages of the kerosene engine are offset to a greater or less degree, depending upon the operator, by the added trouble in handling. The life of the motor will also be somewhat shortened when using kerosene fuel. To this should be added the lower reliability with the heavier fuel. In some work done by traction engines reliability is the main factor.

Due to the high price of gasoline new carburetors are being placed on the market which handle kerosene very satisfactorily, and eventually it will be used more as a fuel for traction engines than will gasoline.

A study of the valve timing of the different motors in these tests shows no uniformity, except that the majority of the motors are so timed that the inlet valve does not open until after the exhaust valve is closed. The timing given in Table 3 is offered as a result of the authors' study and experience with traction engines.

From Fig. 1 it is evident that several of the motors are not rated at the capacity for best efficiency. The motors represented by tests G, H, K and M are underrated, E and J are overrated, while A, B, C and F are properly rated.

THE RATIO OF THE SPECIFIC HEATS AND THE COEFFICIENT OF VISCOSITY OF NATURAL GAS FROM TYPICAL FIELDS

BY ROBERT F. EARHART,[1] COLUMBUS, OHIO

Non-Member

THE present paper may be considered an extension of a previous paper on the physical properties of natural gas.[2] The object of the study with which it deals was to secure measurements on the ratio of the specific heats and the coefficient of viscosity of products similar to those previously studied in the Boyle's Law tests.

A knowledge of the ratio of the specific heats is necessary in computations involving adiabatic changes represented analytically by the well-known formula $PV^n =$ constant, where $n =$ ratio of the specific heats. Physical tables give value of this constant for all of the common gases. The following values, taken from the tables prepared by the French Academy of Sciences in 1913, are for gases frequently found in our natural-gas products. The results apply to pure gases in a dry condition.

Air	1.405	Methane	1.318
Nitrogen	1.410	Carbon Dioxide	1.300
Carbon Monoxide	1.400	Ethane	1.182
Oxygen	1.398		

The composition of natural gas, while fairly constant for any field, varies greatly for different regions. The value for

[1] Professor of Physics, Ohio State University.

[2] Deviation of Natural Gas from Boyle's Law, by R. F. Earhart and S. S. Wyer, read at Spring Meeting (April, 1916), Am.Soc.M.E.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

n used by engineers is usually derived from the data supplied by indicator cards of gas compressors. Various assumptions in securing these values are made, and experience shows that different compressors operating on the same gas give different values.

The methods employed in the present study involve no new principles nor is originality of method claimed. Methods commonly used on pure gases have been merely adapted and utilized for securing appropriate and, it is hoped, accurate data on several of these complex natural products. Gas from ten localities has been secured. Three samples are from Pennsylvania, three from Ohio, two from West Virginia and two from Texas. In each case there was made (a) a chemical analysis, (b) a density determination by direct weighing, (c) a determination of n, and (d) a determination of the coefficient of viscosity.

DETERMINATION OF THE RATIO OF SPECIFIC HEATS

The classical method of Clement and Desormes for determining n, while exceedingly simple in theory and giving absolute values, does not afford satisfactory results for the reason that the adiabatic expansion assumed is not easily realized. This is the fundamental objection to the indicator-card method to which reference was made in an earlier paragraph. The most complete approach to adiabatic changes in gases is found in the transmission of sound waves.

The velocity of transmission of a compression wave through an elastic medium is given by the relation $V = \sqrt{(E/d)}$, where V = velocity of propagation, E = elasticity of the medium, and d = density of the medium. When the medium through which the disturbance passes is a gas, there are two cases: (1) An isothermal compression in which the previous relation becomes $V = \sqrt{(P/d)}$, where P and d are respectively the pressure and density of the gas; (2) an adiabatic compression. In the latter case the relation becomes $V = \sqrt{(nP/d)}$, where n = ratio of the specific heats, the other symbols as before. In the transmission of sound waves through a gas the velocity of the waves is so great and the character of the medium such that adiabatic conditions are almost perfectly realized.

In order to compare the value of n for a gas with the value of n for air, we have to compare the velocity of sound in the two media under the same pressure conditions and to know the relative density of the gas to air.

Letting $N(n)$ = ratio of the specific heats for air (gas)
$D(d)$ = density of air (gas)
P = pressure
$V(v)$ = velocity of sound in air (gas)

we have the following ratio:

$$\frac{V^2}{v^2} = \frac{(NP/D)}{(np/d)}$$

If the velocity be determined in the two media at the same pressure, then $n = N \frac{v^2}{V^2} \frac{d}{D}$, or $n = N \frac{v^2}{V^2} \int d$ (where the density of the air equals unity).

The experimental work resolves itself into comparing the density of gas with air at the same pressure and temperature and in comparing the velocity of sound in gas with that of air for this pressure. The latter comparisons were made by the usual method employed in laboratory investigations—that of Kundt, in which air or gas is set into longitudinal vibration inside a closed glass tube, and the nodal points of the resulting stationary waves are indicated by the disposition of lycopodium powder previously introduced. The distance between nodes equals a half wave length. In a 5-ft. tube 10 or 12 nodes may be distinctly observed, and these may be measured to within an accuracy of 1 mm. The relation between velocity V, frequency m, and wave length l is $V = lm$. Also, provided m is not altered by temperature or by displacements of apparatus, $V/l_{air} = m = v/l_{gas}$ which, substituted in the final equation of the preceding paragraph, gives

$$n = \frac{N(l_{gas})^2}{(l_{air})^2} d$$

The following data from the record illustrate the application and indicate the magnitude of the quantities involved. The value of N for air is taken as 1.405. The results here computed appear again in Table 1.

May 4, 1911.
Gas from the Geo. Secest farm, Vinton County, Ohio.
Tank filled at 200 lb. gage pressure.
Temperature, 20 deg. cent. Barometric pressure, 29.25 in.
To determine density,

Weight of glass bulb exhausted	= 146.370 grams	
Weight of glass bulb filled with gas	= 146.750 grams	
Weight of glass bulb filled with air	= 146.946 grams	
Weight of gas = 146.750 − 146.370	=	0.380 gram
Weight of air = 146.946 − 146.370	=	0.576 gram
Relative density = 0.380/0.576	=	0.666

TABLE 1 DATA ON NATURAL GAS FROM TEN U. S. FIELDS

Sample	Chemical Analysis					B.T.U. per Cu. Ft.[1] (at 32 deg. fahr. and 76 cm.)	Density (Air = 1.0)	Ratio of Specific Heats, n,	Relative Coefficient of Viscosity	Coefficient of Viscosity in C.G.S. Units
	CO_2	O_2	CH_4	C_2H_6	N_2					
Air	...	...	...	...	...	....	1.000	1.405	1.000	178×10^{-6}
West Virginia, Ravenswood	0.0	0.0	82.0	17.5	0.5	1200	0.682	1.238	0.770	137×10^{-6}
West Virginia Connecting Gas Co.	0.0	0.0	86.1	12.1	1.8	1143	0.660	1.214	0.730	130×10^{-6}
Ohio, Sugar Grove Field	0.0	0.0	82.4	6.2	11.4	992	0.660	1.209	0.750	133×10^{-6}
Ohio, Homer Field, Licking County	0.0	0.0	78.8	14.2	7.2	1099	0.690	1.210	0.735	131×10^{-6}
Ohio, Vinton County Field	0.1	0.8	73.0	5.8	20.3	885	0.666	1.259	0.750	133×10^{-6}
Penna., Trafford City	0.2	0.0	95.0	0.0	4.9	1012	0.585	1.285	0.710	126×10^{-6}
Penna. Wet Gas, Ludlow East Branch Intake	0.0	0.0	66.4	34.6	0.0	1351	0.755	1.293	0.760	135×10^{-6}
Penna. Dry Gas, Royston, Penna.	0.1	0.0	74.4	21.8	3.7	1198	0.678	1.220	0.750	133×10^{-6}
Texas, Beatty County	0.2	0.0	55.4	8.0	36.4	739	0.755	1.290	0.820	146×10^{-6}
Texas, Lone Star	0.1	0.0	50.0	10.0	39.9	718	0.770	1.224	0.830	147×10^{-6}

[1] B.T.U. calculated on Bureau of Mines values for CH_4 (= 1065) and C_2H_6 (= 1861).

DETERMINATION OF WAVE LENGTHS

Tube Contains Gas		Tube Contains Air		Tube Contains Gas	
Nodal points on meter stick	Half wave length	Nodal points on meter stick	Half wave length	Nodal points on meter stick	Half wave length
77.4 cm.	8.5 cm.	85.6 cm.	7.3 cm.	84.6 cm.	8.6 cm.
68.9	8.6	77.7	7.3	76.0	8.5
60.3	8.6	70.4	7.4	67.5	8.5
51.7	8.2	63.0	7.4	59.0	8.5
42.5	8.5	55.6	7.4	50.5	8.6
34.0	8.6	48.2	7.3	41.9	8.5
25.4	8.5	40.9	7.2	33.4	8.6
16.9	8.5	35.6	7.3	24.8	8.5
8.4	8.4	26.2	7.5	16.3	8.5
0.0	——	18.7	7.3	7.8	——
	Av. 8.49	11.4	7.2		Av. 8.53
		4.2	——		
			Av. 7.34		

Half wave length in gas = (8.49 + 8.53)/2 = 8.51 cm.

$$n = 1.405 \times \left(\frac{(17.02)^2}{(14.68)^2}\right) \times 0.666 = 1.259$$

In obtaining the data just given, gas was taken directly from the sampling tank without drying or processing of any kind. An experiment was made upon one sample both in the raw state and after passing through a calcium-chloride tube to remove water vapor. The density and wave-length measurements were modified by this, but when combined in the formula for determining n the result was changed by less than one-half of one per cent, which is about the limit of accuracy of the experiment. The value of n found for the raw gas was 1.259; for the dried gas it was 1.257.

DETERMINATION OF THE COEFFICIENT OF VISCOSITY

The coefficient of viscosity is used in computations involving the flow of gas through pipes of considerable length. Two methods are commonly employed for determining this constant. In the method used in this investigation gas is slowly forced through a long capillary tube. The rate of flow is a function of the coefficient of viscosity and is determined by means of the formula[1]

$$V_a = \frac{(p_a^2 - p_e^2)\, R^4}{16\, C L p_e}$$

V_a = volume of gas passing through the capillary per unit time
p_a and p_e = pressure of gas before and after escape
R = radius of capillary
C = coefficient of viscosity
L = length of tube.

A consideration of this formula shows that if equal volumes of two gases under similar pressure and temperature conditions are passed through a long capillary tube, the coefficients of viscosity are in the ratio of the times of efflux. The value of the coefficient of air has been carefully studied during the past ten years on account of its importance in certain electrical measurements. Calling C_g (C_a) the coefficient of viscosity of the gas (air) and t_g (t_a) the time of transportation for the gas (air),

$$C_g = C_a \frac{t_g}{t_a}$$

It was customary to make three measurements with dry air, then a series of three measurements on the gas, to be followed by one or two additional measurements on air.

The chemical analyses were made in the Mines Laboratory of the Ohio State University by Mr. E. C. Smith.

SUMMARY

To summarize,

a Determinations of the exponent n in the expression for adiabatic change PV^n = constant have been made on ten samples of natural gas. The lowest value obtained was 1.209, the highest 1.293. The maximum variation from the mean value (1.243) is 4 per cent.

b Determinations of the coefficient of viscosity give values ranging from 126×10^{-6} to 147×10^{-6} C.G.S. units.

[1] For derivation, see Wüllner, Lehrbuch der Physik, vol. 1, p. 629.

TEXTILE PAPERS

THE work of the Sub-Committee on Textiles is devoted to securing papers upon the mechanical engineering and allied features of the textile industry. The Sub-Committee contributes three important papers to the Annual Meeting this year, one of which, bearing upon the heating of mill buildings, is published below.

HEAT TRANSMISSION THROUGH VARIOUS TYPES OF SASH AND THE CAUSES AND PREVENTION OF INTERNAL CONDENSATION IN DOUBLE-GLAZED SASH

By ARTHUR N. SHELDON, PROVIDENCE, R. I.

Member of the Society

IN the industrial plant of today, where there is so much emphasis placed upon maximum daylight, exterior wall surfaces consist principally of windows, and the heat loss through them is a very important matter. Indeed there may be a question in certain plants whether the window area is not carried to excess—that is beyond a point where increased daylight warrants the increased heat loss. In the absence of authentic data on the relative heat loss through various types of sash, these experiments were conducted by Mr. W. S. Brown, under the writer's direction, to enable us to logically design and proportion the fenestration of industrial buildings.

DESCRIPTION OF APPARATUS

The sash tested were of such a size as completely to fill an opening on the face of a test box 4 ft. 2¾ in. wide by 7 ft. 9½ in. high, the test box being 1 ft. 2 in. deep. The box was constructed of 2-in. tongued and grooved white pine, covered

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

with 2-in. cork boards and made airtight. Wool felt 1 in. thick was placed between the edge of the test box and the sash to reduce air leakage to a minimum. The box rested on two gypsum blocks as shown in Fig. 1.

The test box being set up on end, an electric heater was placed in the bottom. The heater consisted of six sets of resistance wire strung horizontally, and arranged so that, beginning at the bottom, the first two coils might dissipate approximately 0.25 kw. each of electrical energy, the next two 0.50 kw. each, and the uppermost two 0.75 kw. each. The switching arrangement was designed to give a total capacity of 3 kw., obtainable in successive stages of ⅛ kw. each. Fig. 2 shows the arrangement of the heater and the ¼-in. asbestos board plates, 15 in. high, which were fastened against the lower frame of the heater to prevent direct radiation of heat to the lower panes of glass.

Air temperatures within the box were recorded by twelve thermometers, arranged opposite the various panes of glass, and giving a fair average of the internal temperatures. The total average temperature was obtained by averaging the individual temperatures behind each horizontal row of panes. The Fahrenheit long-scale chemical thermometers used protruded about 7 in. through the back of the box and its covering, and were tested for accuracy before and after the experiments.

Air temperatures outside the box were observed by means of an accurate wall thermometer, registering maximum and minimum temperatures. A thermostatically controlled steam radiator maintained a constant temperature outside. Two electric fans directed currents of air against the test box at an angle of 30 deg., and provided a positive and constant circulation over it. While it was not possible or necessary to reproduce actual wind conditions, 11½ mi. per hr. for New England during the heating season, anemometer readings during the tests showed that the conditions obtained were not far from the average to be expected. Vertical baffles protected the back and sides of the box from the air currents.

Measurements of electrical energy converted into heat were obtained simultaneously by means of two meters, the first a standard indicating wattmeter, accurate within ¼ of one per cent, and compensated for temperature changes, and the other a standard service watt-hour meter, installed and adjusted by the service company furnishing the power.

The humidity of the air was kept as constant as possible throughout the series of tests by means of water-saturated felt, and was measured by a wet- and dry-bulb hygrometer. The humidity remained constant during the period of each individual test.

METHOD OF CONDUCTING TESTS

The average temperature of New England during the heating season being 36 deg. fahr., it was decided to make tests at a room temperature corresponding to 76 deg., or a temperature difference of 40 degrees. For greater accuracy, and to obtain the transmission rate in colder weather, there were tests made at 70 deg. temperature difference as well.

To determine what amount of heat was transmitted through the sides and back of the test box, blank runs were made in which the opening in the face of the box was closed by materials of which the box itself was made. These tests were run very carefully over an extended period of time (at least 18 hr.) to make sure that all conditions had become constant, after which hourly readings were taken for eight hours. The temperature difference during the run did not vary more than 1 deg. fahr. The fans were not in operation during the blank-run tests, as the object was to determine the rate of transmission through the box and covering under the conditions of the test; still air on top, sides, back and bottom. In order to reduce any slight error due to a possible change in conductivity of the box itself during the experiments, tests were run to obtain these constants at 40 deg. to 70 deg. heat head both before and after the series of sash tests. It was found that a slight increase occurred due evidently to shrinkage and warping of the boards.

Sash tests were conducted in the same manner, except that the fans were put in operation. In each separate test, the watt-hour meter was calibrated for the load by timing it for ten minutes with the instantaneous meter and counting the revolutions of the disk. During all tests, a careful record was kept of the panes of glass on which condensation occurred.

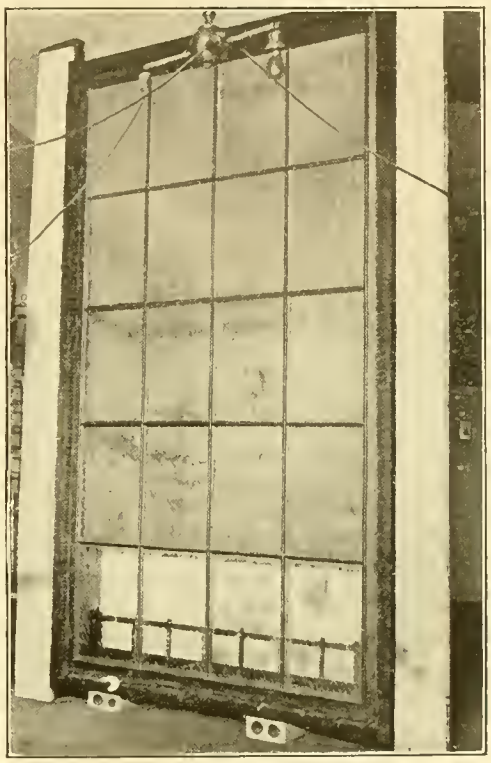

Fig. 1 Sash in Front of Test Box

COMPUTATIONS OF TESTS ON HEAT TRANSMISSION

The heat transmission through the sash has been worked out and expressed on the basis of B.t.u. transmitted per 24 hr. per deg. fahr. per sq. ft. of opening, and is designated in the formula following as H, whence

$$H = (L - l)/ad \qquad [1]$$

where

L = total heat loss through test box and sash in B.t.u. per 24 hr. as computed from wattmeter measurements

l = heat loss in B.t.u. per 24 hr. through top, bottom, back and sides of test box, as determined from blank run and corrected for actual temperature difference during test

a = area of opening filled by sash = 33 sq. ft.

d = temperature difference throughout test

L is found from the formula

$$L = (w \times 3412 \times 24)/t \qquad [2]$$

where

w = electrical energy dissipated in heater as measured in kilowatts at average temperature d

t = duration of test, hours

3412 = the equivalent of 1 kw. in B.t.u.

In the same manner l is found from the blank-run tests by the formula

$$l = R(w \times 3412 \times 24)/t \qquad [3]$$

where

R = the ratio of the top, bottom, sides and back of the box exposed during the sash tests, to the total area of the box, or that exposed during the blank run. As noted above, l should be taken at the same temperature as L by interpolation from the known results if necessary. The other terms have the same meaning as above.

DESCRIPTION OF THE SASH TESTED

Tests were conducted on the following seven samples of sash, all without ventilators. The word "pane" refers to a single sheet of glass, whereas "light" refers to a section of sash, or, in the case of double-glazed sash, two panes and the air space.

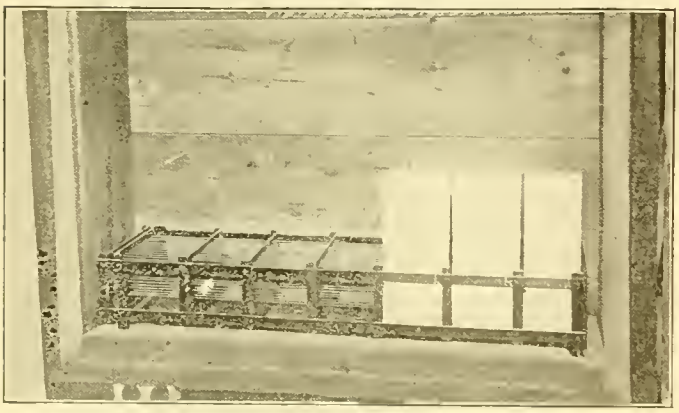

FIG. 2 INTERIOR OF TEST BOX, SHOWING THERMOMETERS AND THREE ASBESTOS PLATES

Sample No. 1 was standard single-glazed, solid, rolled-steel sash of 20 panes, each approximately 12 by 18 in., arranged 4 wide by 5 high. The panes were ¼-in. rough wire glass. The sash bar section was 1⅜ in. deep, the glass being bedded on the front side and puttied from the inside, the putty having a good half-inch body. The exposed glass area was 28 sq. ft., or 85 per cent of the total.

Sample No. 2 was a double-glazed, solid, rolled-steel sash of same size and arrangement of lights as Sample No. 1. The outside panes were ⅛-in. factory ribbed glass (ribs inside) and the inside panes were single-thick plain glass separated from the former by a galvanized-iron channel separator, making a 3/16-in. air space. The sash bar was 1⅜ in. deep, the outer pane being bedded on the outside and the inner pane put on with a good ½-in. body of putty. The glazing was done from the inside.

Sample No. 3 was a double-glazed, solid, rolled-steel sash of the same make, size and arrangement of lights as Sample No. 1. The outside panes were ¼-in. rough wire glass, the inside panes being single-thick plain glass, separated from the former by a galvanized iron channel separator, making a ¾-in. air space. The sash bar was 2⅜ in. deep, the outer pane being well bedded on the outside with a 11/16-in. body of putty. The glazing was done from the inside.

Sample No. 4 was an ordinary double-glazed wood sash, of same size and arrangement of lights as Sample No. 1. The outside panes were ¼-in. rough wire glass, the inside being double-thick plain glass separated from the former by a ⅝-in. air space. The sash was made of 1¾-in. stock, muntin bars being 5/16 in. The outer panes had a 5/16-in. body of putty and the inner panes ½-in. body, bedded. Glazing was done from both sides.

Sample No. 5 was a single-glazed wood sash of the same size and arrangement of lights as Sample No. 1, and was obtained from No. 4 by taking out the inside panes of plain glass.

Sample No. 6 was a double-glazed, hollow metal sash. The lights were made larger than those of Sample No. 1, being 14½ in. by 21 in. and arranged three wide and four high. The outside panes were ¼-in. rough wire glass, the inside being single thick, plain glass, separated from the former by a ¾-in. air space. The exposed glass area was 23.5 sq. ft., or 71.5 per cent of the total. The sash bar was 2⅛ in. deep. Muntin bars were 1¾ in. in external width. The outer panes were bedded to the outside and the inner panes were bedded to both sides.

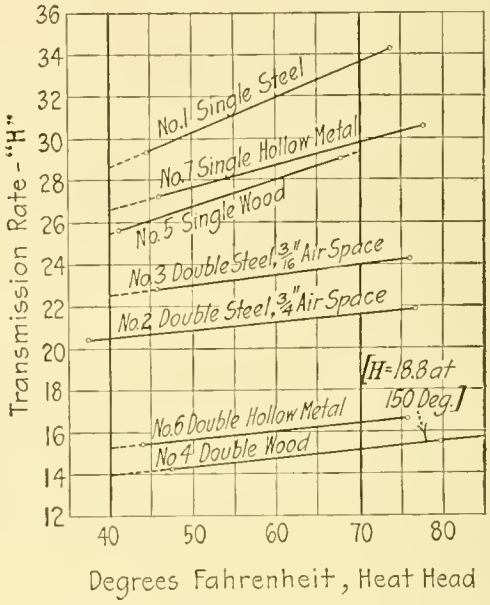

FIG. 3 VARIOUS TRANSMISSION RATES, H, FROM TESTS

Sample No. 7 was a single-glazed, hollow metal sash, of the same arrangement of lights as Sample No. 6, being obtained from it by removing the inside panes of plain glass, together with the galvanized-iron-formed sections which held them in place. This left the muntin bars 1½ in. deep.

RESULTS OF TESTS

A résumé of the comparative heat-transmission rates, H, of formula 1, as deduced from the tests, is given in Tables 1 and 2.

The results of the tests have been plotted in the form of

curves (Fig. 3). It will be noted that the rate of transmission increases with the temperature difference, and that there is a greater increase for the single- than for the double-glazed sash.

To ascertain the cause of the much greater heat-transmission rate through solid steel compared with wood and hollow metal sash, a thermometer was inserted in a chamber in a 2-in. cork board, which, in turn, was placed against the bars of the sash. These tests showed that for a given temperature difference the steel bars were hotter than the wooden, and by their greater conductivity constituted a direct path for the transmission of heat to the outside. The hollow steel sash bars were warmer than the wood, but cooler than the solid steel. The steel bars also serve to increase the temperature of the air in the same space between panes in the double-glazed sash, and hence increase the transmission rate through the panes.

TYPICAL PROBLEM IN RELATIVE COSTS

In order to emphasize the practical application of these experiments, a typical problem is given. In the design of reinforced-concrete buildings there arose the question whether to use single- or double-glazed steel sash. The following data apply to the problem:

Wall openings to be glazed	37,800 sq. ft.
Average inside temperature, heating season	70 deg. fahr.
Average outside temperature, heating season	35 deg. fahr.
Average temperature difference, 70 — 35 deg. fahr.	35 deg. fahr.
Heat delivered from steam plant per pound of coal	8500 B.t.u.
Length of heating season	4850 hours
Cost of coal per 2000 lb.	$4.00
Assumed cost of hot-water heating plant per square foot of heating surface, including heater, based on — 10 deg. fahr. outside temperature	$0.60

Proposition A, single-glazed steel sash. From the tests, H at 35 deg. fahr. = 27.7 B.t.u. per degree difference in temperature per square foot per 24 hours.

Comparative yearly coal bill[1]	$1,750.00
Comparative initial investment cost of sash erected	15,600.00
Cost of heating system to supply heating loss only, based on 18,400 sq. ft. at $0.60	11,040.00
Total investment	$26,640.00

Proposition B, double-glazed steel sash, 3/16-in. air space. From the tests, H at 35 deg. fahr. = 22.3 B.t.u. per degree difference in temperature per square foot per 24 hours.

Comparative yearly coal bill	$1,410.00
Comparative initial investment cost of sash erected	21,000.00
Cost of heating system to supply window loss only, based on 12,800 sq. ft. at $0.60	7,680.00
Total investment	$28,680.00

Proposition C, double-glazed steel sash, 3/4-in. air space. From the tests, H at 35 deg. fahr. = 20 B.t.u. per degree difference in temperature per square foot per 24 hours.

[1] $\frac{\$4.00 \times 37{,}800 \text{ sq. ft.} \times 27.7 \text{ B.t.u.} \times 4850 \text{ hr.} \times 35°\text{F.}}{2000\text{lb.} \times 24 \text{ hr.} \times 8500 \text{ B.t.u.}} = \$1750.00$

TABLE 1 HEAT-TRANSMISSION RATES AT APPROXIMATELY 40 DEG. FAHR. TEMPERATURE DIFFERENCE

Sample	Actual Heat Head, Deg. Fahr.	H Computed at Actual Heat Head	H Corrected to 40 Deg. Fahr. Heat Head	Relative Humidity	Condensation
No. 1 Single-glazed solid steel	44.5	29.3	28.5	36	None
No. 2 Double-glazed solid steel, 3/4-in. air space	37.4	20.4	20.5	34	None
No. 3 Double-glazed solid steel, 3/16-in. air space	45 7	22.8	22.5	43	Very slight on air-space side of one outside pane and box side of one inside pane
No. 4 Double-glazed wood, 5/8-in. air space	47.3	14.2	13.9	49	None
No. 5 Single-glazed wood	41 2	25 6	25.5	44	Hardly noticeable
No. 6 Double-glazed hollow metal, 3/4-in. air space	43.9	15 4	15.2	54	On air-space side of one of outside pane
No. 7 Single-glazed hollow metal	46 0	27 1	26 4	43	All

TABLE 2 HEAT-TRANSMISSION RATES AT APPROXIMATELY 70 DEG. FAHR. TEMPERATURE DIFFERENCE

Sample	Actual Heat Head, Deg. Fahr.	H Computed at Actual Heat Head	H Corrected to 70 Deg. Fahr. Heat Head	Relative Humidity	Condensation
No. 1. Single-glazed solid steel	73.9	34 2	33.6	28	All
No. 2 Double-glazed solid steel, 3/4-in. air space	76.8	21 8	21.6	29	15 outer panes out of 20 showed moisture on air-space side
No. 3 Double-glazed solid steel, 3/16-in. air space	76.0	24.2	24.0	30	One outer pane showed moisture on air-space side; one inner pane showed moisture on box side. Three lights showed both above
No. 4[1] Double-glazed wood, 5/8-in. air space	79.8	15.5	15.1	31	None
No. 5 Single-glazed wood	67 6	28.9	29.3	29	12 lights
No. 6 Double-glazed hollow metal, 3/4-in. air space	75 6	16 6	16.4	36	On air-space side of one outside pane
No. 7 Single-glazed hollow metal	77.7	30.5	29.7	25	All

[1] A test upon this same wood sash with the inside single-thick plain glass substituted for the double-thick showed an increase in H of 3 per cent at 70 deg. fahr. temperature difference.

Comparative yearly coal bill	$1,260.00
Comparative initial investment of sash erected	25,750.00
Cost of heating system to supply window loss only, based on 11,500 sq. ft. at $0.60	6,900.00
Total investment	$32,650.00

From Table 3 it is evident that an investment of $2040.00 for *B* over that for *A* would result in an annual saving of $340.00 worth of coal, or 17 per cent gross on the additional investment. Also, an additional investment of $6010.00 for *C* over that of *A* would result in an annual saving of $490.00 worth of coal, or only 8 per cent gross on the additional investment. The choice, therefore, lies between A and B; and whether or not *B* should be preferred will depend largely upon

TABLE 3 SUMMARY OF RESULTS

	Yearly Coal Bill	Initial Expenditures		
		Sash	Heating System	Total
Proposition *A*	$1,750.00	$15,600.00	$11,040.00	$26,640.00
Proposition *B*	1,410.00	21,000.00	7,680.00	28,680.00
Proposition *C*	1,260.00	25,750.00	6,900.00	32,650.00

what earning the owners expect to make upon their other investments. It should be emphasized here that with a different unit cost of coal, a warmer or a cooler climate, or a different heating system, the conclusion might be changed entirely.

INTERNAL CONDENSATION IN DOUBLE-GLAZED SASH

Where condensation occurred in the air space, it was always on the outside pane of glass which of course was the cooler one. The wood sash showed none, but it was very marked in the solid steel, and not noticeable in the hollow metal sash. To determine, if possible, the cause for this condensation, holes were bored in some of the lights of the solid steel sash which had shown condensation, and in some which had not. Each light was then tested by blowing smoke into the hole, and some were found to leak considerably, some to adjacent spaces, others to front or back, and a few showed combinations of these conditions. It was observed that where condensation was evident, the greatest leakage was to the inside of the box, and that where there was no condensation, the greatest leakage was to the air outside the box.

Following this clue, the entire sash was reglazed, and holes bored in seven of the outer panes, and in five of the inner panes. Free communication was thus established either to the external cool air or to the warmer air inside the test box. Each pane of glass opposite those with holes was carefully bedded to confine and control the air leakage to the side having the hole. Smoke tests before and after each run showed that the desired object had been attained by this means. The remaining eight lights were made as air tight as possible on both sides by careful bedding and setting. The sash was then placed on the front of the box as in the previous tests, the temperature raised to about 70 deg. fahr. above that of the surrounding room, and records were kept as before of temperatures, relative humidity, and condensation, this being allowed to accumulate for a period of at least eighteen hours. The relative humidity in the test box was maintained at 40 per cent, and that of the air outside varied from 60 to 90 per cent, apparently having little effect upon the results.

A careful examination of the sash showed uniformly the following results:

a Lights in which the air space opened to the outside or *cooler* air only showed no condensation.

b Lights in which the air space opened to the *warm* air inside the box showed much condensation.

The sash was then reversed with its outer side toward the interior of the test box and, after a test of three days, examination showed that the air spaces in which there had been condensation during the previous test were now dry, while abundant condensation appeared in those which showed none in the first test. It was also discovered that by varying alternately the temperature in the test box, the processes of condensation and drying could be accelerated. The experiment on the reversed sash, therefore, confirmed conclusions *a* and *b* above.

The explanation is simple. Changes in temperature on either side of the sash cause corresponding, though less marked, changes in the temperature of the air space. The pressure of the confined air, therefore, becomes more or less than atmospheric and air is correspondingly either forced out or admitted through the drilled holes, and, if the temperature difference is alternately increased and decreased, a breathing action obtains in the air space. A similar action occurs through leaks in actual practice and is due to variations in temperature.

Air entering an opening of this kind *from the inside*, coming as it does from the warm interior of the test box or building, becomes chilled, condensation necessarily appearing if the cooling is carried below the dew point. Breathing, or a repetition of this process, necessarily results in a gradual accumulation of condensation.

Conversely, air entering an opening of this kind *from the outside* becomes heated and its relative humidity is correspondingly decreased, making impossible the precipitation of any moisture.

CONCLUSIONS

Condensation in the air space of double-glazed sash can be eliminated almost entirely by connecting the air space directly to the outside air, and at the same time effectively sealing it from the entrance of warm air within the building. In attempting the design of a double-glazed sash according to these principles, it is suggested that the following points be considered:

a The opening should be *very small*, say a ⅛-in. hole, to prevent a direct loss of heat by convection from the air space.

b The *location* of the breathing hole is immaterial, except that a consideration of heat economy makes the bottom preferable.

c The breathing hole should be protected from the weather and dirt.

d A high-grade, elastic putty should be used. On account of wind pressure, difference of expansion between steel and glass (about 65 per cent), careless setting, etc., absolute sealing of the inner panes probably will not be accomplished. However, these tests show that a sufficient degree of tightness can be obtained, and that the larger part of the breathing will occur through the opening made for this purpose.

e Leaks between air spaces should be eliminated.

INDUSTRIAL SAFETY PAPERS

THE Sub-Committee on Protection of Industrial Workers has this year received an important proposed code for safeguarding industrial risks which it will present for consideration and discussion at the Annual Meeting. The subject of this code is Safety Standards for the Operation of Cranes, and it has been prepared by committees of thirty-six representative gentlemen and companies.

PROPOSED CODE OF SAFETY STANDARDS FOR OPERATION OF CRANES

For the Consideration of the Sub-Committee on Protection of Industrial Workers of the American Society of Mechanical Engineers

Caution: Employees shall not remove or make ineffective any safeguards while same are in use, except for the purpose of making repairs, and such safeguards so removed shall be replaced.

THE following Standards apply to cranes which are regularly used in and form part of a permanent industrial plant. In addition to Electric Traveling Cranes, these regulations are to cover Jib Cranes, Monorail Cranes, Hand-Power Cranes, and other hoisting apparatus of a similar nature, in so far as the various sections apply.

The provisions of all Safety Standards issued by the Society shall[1] apply to all matters not specifically covered herein.

ELECTRIC TRAVELING CRANES

General Construction

1 Proper provisions for strength shall be made for all parts subject to impact and rough usage. Journals and shafts shall be of sufficient size to bring pressure within safe limits.

2 All apparatus shall hereafter be designed throughout with not less than the following factors of safety under static full rated load stresses, based on ultimate strength of material used:

a All gears, and complete hoisting mechanism, factor of not less than eight (8).

b All other parts, factor of not less than five (5).

3 Calculations for wind pressure on outside cranes shall be based on not less than thirty pounds per square foot of exposed surface.

4 Cranes should be of what is known as "All-Steel Construction;" no cast iron should be used except for such parts as drums, bearings, brackets, etc. No combustible material should be used.

5 All bolts should be of the through type, and be equipped with approved lock nuts or lock washers.

6 Where access to the crane is necessary, steps or stairs with hand rails should be used.

7 Platforms should be provided for changing and repairing truck wheels on end trucks and provided with stairways leading to them.

8 A platform or footwalk to give access to crane shall be provided accessible from one or more fixed ladders or stairways, and shall be not less than twenty (20) inches in width.

9 A footwalk shall be placed along the entire length of bridge on the motor side except when the construction of the crane prevents or when such platform would not ordinarily be used for the repair or maintenance of crane, and should be at least six feet six inches (6′ 6″) below the bottom of the overhead trusses.

10 Footwalks should be placed across the ends of the trolleys at right angles to the bridge walks and shall be not less than twelve (12) inches in width.

11 Footwalks shall be of substantial construction, rigidly braced.

12 On cranes hereafter erected no openings shall be permitted between bridge footwalks and crane girder. When wire mesh is used the mesh opening must not be greater than one-half (½) inch.

13 Each footwalk shall have a standard metal railing and toe guard at all exposed edges wherever practicable.

14 Not less than twelve (12) inches actual clearance should be allowed between highest point of crane and overhead trusses, and not less than two (2) inches between any part of crane and building, column, or other stationary structure. Where there are more than two crane runways in parallel there should be a clearance of not less than twenty-four (24) inches between the extremities of the cranes.

15 Means of escape shall be provided for operators of hot-metal cranes.

16 Operator's cage shall be located at a place from which signals can be clearly distinguished and be securely fastened in place and be well braced, to minimize vibration. It shall be large enough to allow ample room for the control equipment and the operator. The operator shall not be required to step over an open space of more than eighteen (18) inches when entering or leaving the crane.

A pail filled with sand or an approved fire extinguisher shall be carried in the crane cage for use in case of fire.

17 An approved foot- or hand-operated gong or other effective warning signal shall be placed in a location convenient to operator and be securely fastened.

18 Ladle and other cranes subjected to heat from below should have a steel-plate shield not less than one-eighth (⅛) inch thick and placed not less than six (6) inches below the bottom of floor of cage.

19 The cages of cranes hereafter erected shall be of fire-resisting construction.

20 All gears on cranes hereafter erected shall be provided with standard guards. This should apply to all existing cranes where practical.

21 No overhung gears shall be used unless provided with an effective means of keeping them in place, and keys shall be secured in an approved manner to prevent gears working loose.

22 Unprotected keys shall not be left projecting from ends of shafts.

23 The construction of the crane shall be such that all parts may be safely lubricated when the crane is not in operation.

24 The installation of switchboard, wiring and all electrical equipment must fully comply with the Industrial Board Standards.

25 There shall be a main-line switch or its equivalent so

[1] The word "SHALL" where used is to be understood as mandatory and "SHOULD" as advisory.

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916.

arranged as to cut off all power from crane, and so constructed that it may be locked in its open position.

26 Open-type controllers shall have asbestos-lined steel guards over the movable contact parts, both to protect operator's eyes and prevent articles falling on contact parts.

27 An approved hoist-limiting device, should be provided for each hoist.

28 Suitable brakes shall be provided for the hoist and bridge travel. Each hoist shall be equipped with effective brakes which shall be capable of sustaining at least one and one-half (1½) times the full rated load.

29 The drums on cranes hereafter erected shall have a flange at each end to prevent the ropes from getting off the drum, and be so designed that there will be not less than two full wraps of hoisting cable in the grooves when hook is at its lowest position.

30 Hook block shall be of a type so arranged that it will lift vertically without twisting.

31 Bottom sheaves shall be protected by close-fitting guards, to prevent rope from becoming misplaced.

32 Crane bumpers shall be provided and shall be at least one-half of the diameter of the truck wheel in height. Both truck wheel and trolley bumpers should be fastened to the girder and not to the rails. Bumpers shall be built up of plates and angles, or made of cast steel.

33 Truck fenders shall be installed which extend below top of rail and project in front of all bridge and trolley track wheels, and shall be attached to trolley or bridge and frame. They shall be of a shape and form that will tend to push and raise a man's hand, arm or leg off the rail and away from wheel.

34 Heavy safety lugs or brackets shall be placed on trolley frames and bridge end carriages, to limit drop to one inch or less if a wheel or axle should break.

35 A capacity plate showing the maximum capacity of each hoist in pounds shall be placed on each crane girder in such a manner as to be clearly legible from the floor.

36 A metal tool box or receptacle shall be permanently secured in the cage or on the runway for the storing of oil cans, tools, etc.

37 Trolley should be completely floored.

38 Cranes in outside service shall have the following additional provisions:

a Floors of footwalks to be so constructed as to provide proper drainage.

b Cage shall be enclosed and of fire-resisting construction; there shall be windows on three sides of cage; windows in front and side opposite door to be full width of cage.

c Floor of cage on outdoor cranes should be extended to an entrance landing which shall be equipped with handrail and toeguard of standard construction.

d Where there are no members over crane suitable for attaching blocks for repair work, a structural-steel outrigger should be arranged on the crane of sufficient strength to lift the heaviest part of the trolley.

39 All gantry cranes should be equipped with automatic warning signals.

40 The truck wheels of gantry cranes shall be provided with guards or fenders.

OPERATION OF CRANES

Rules for Operators

1 Cranes shall be operated only by regular crane operators, authorized substitutes, crane repairmen or inspectors; no one else should enter crane cage.

2 Hands shall be kept free when going up and down ladders. Articles which are too large to go into pockets or belts should be lifted to or lowered from crane by hand line (excepting where stairways are provided).

3 Cages shall be kept free of clothing and other personal belongings. Tools, extra fuses, oil cans, waste and other articles necessary in the crane cage shall be stored in a tool box, and not left loose on or about crane.

4 Operator shall familiarize himself fully with all crane rules and with the crane mechanism and its proper care. If adjustments or repairs are necessary, he shall report the same at once to the proper authority.

5 Operator should not eat, smoke or read while on duty nor operate crane when he is physically unfit.

6 Operator or some one specially designated shall properly lubricate all working parts of crane.

7 Cranes shall be examined daily for loose parts or defects.

8 Cranes shall be kept clean.

9 Operators shall avoid, as far as possible, carrying loads over workmen; it must be absolutely avoided when carrying molten metal or with magnet.

10 Whenever operator finds main or emergency switch open, he shall not close it, even when starting on regular duty, until he has made sure that no one is on or about the crane, and shall not oil or repair crane unless main switch is locked open.

11 Before closing main switch, operator shall make sure that all controllers are in "OFF" position.

12 If power goes off, operator shall immediately throw all controllers to "OFF" position until power is again available.

13 Operator should not reverse a motor until it has come to a full stop, except to avoid accidents.

14 Operator shall pay special attention to the block when long hitches are made, to avoid tripping limit switch or running block upon the drum.

15 Operator shall recognize signals only from the one man who is supervising the lift. Operating signals should follow an approved standard; they should be manual, never verbal. Whistle signals may be used where one crane only is in operation.

16 Before starting to hoist, operator shall place trolley directly over the load to avoid swinging it when being hoisted. This precaution is especially important when handling molten metal.

17 Operator shall not make side pulls with crane except when especially instructed by proper authority.

18 When handling maximum loads, particularly ladles of molten metal, operator shall test hoist brakes after load has been lifted a few inches: if brakes do not hold, load should be lowered at once and the brakes adjusted or repaired.

19 Bumping into runway stops or other cranes shall be avoided. When operator is ordered to engage with or push other cranes, he shall do so with special care for safety of persons and cranes.

20 When lowering a load, operator shall proceed carefully and make sure that he has the load under safe control.

21 When leaving cage, operator shall throw all controllers to "OFF" position and open main switch.

22 If crane is located outdoors, operator shall also lock crane in secure position to prevent it from being blown off or along the track by severe wind.

Rules for Floormen

1 Floormen shall give all signals to the operator in accordance with approved standards, preferably manual.

2 Floormen shall be responsible for the condition and selection of all hoisting accessories and for all hitches.

3 Before operator moves crane upon which an empty chain sling is hanging, floorman should hook both ends of sling to block.

4 Floormen where necessary should walk ahead of moving load and warn people to keep clear of it. They shall see that load is carried high enough to clear all obstructions.

5 Floormen shall notify the foreman in advance when an extra heavy load is to be handled.

6 Floormen shall not ride or allow others to ride on hook or load.

Rules for Repairmen

1 Repairmen should have crane that is to be repaired run to a location where the repair work will least interfere with other cranes and with operations on floor.

2 Before starting repairs, repairmen shall see that all controllers are thrown to "OFF" position; that main or emergency switches are opened, one of which shall be locked.

3 Repairmen shall immediately place warning signs or "OUT OF ORDER" signs on crane to be repaired and on floor beneath. If other cranes are operated on the same runway, he should also place rail stops at a safe distance or make other safe provision.

4 When repairing runways, repairmen shall place rail stops or warning signs or signals so as to protect both ends of section to be repaired.

5 Repairmen shall take care to prevent loose parts from falling or being thrown upon floor beneath.

6 Repairs shall not be considered complete until all guards and safety devices have been put in place and block and tackle and other loose material been removed.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal or brief articles of current interest to the membership.

VERTICAL VS. HORIZONTAL OIL ENGINES

To the Editor:

The paper on heavy-oil engines by Mr. Daugherty in the October Journal contains a discussion on the relative merits of horizontal and vertical engines, to the conclusions of which I cannot subscribe. As far as Mr. Daugherty's figures go, there is apparently nothing wrong, and his conclusions would be perfectly correct if we were interested only in the maximum side pressures that act upon the piston and cylinder. However, this is not a question of strength; we all know that no horizontal engine, any more than a vertical one, ever broke to pieces on account of the side pressures exerted upon the piston, or by the piston upon the cylinder. We do know, however, that under the same conditions the cylinders and pistons of horizontal engines wear out much more rapidly, and require more attention and cleaning, than those on vertical engines.

Wear is the result of friction load and rubbing speed which, applied to the case before us, necessitates an investigation into the piston speed and the pressures exerted upon piston and cylinder walls *during the whole cycle of operation.* The maximum side pressure, which occurs at one instant only during the four strokes of a complete working cycle, is, as we shall see, only one of the contributing causes to the serious operating conditions imposed upon horizontal engines.

PRESSURE DIAGRAMS FOR VERTICAL ENGINES

Figs. 1*A* and 1*B* apply to a vertical four-cycle trunk piston engine of a cylinder size somewhat larger than that on which Mr. Daugherty's figures are based. As may be readily seen, this difference in cylinder sizes is of little consequence, since the final result is a matter of relative values rather than absolute figures.

Fig. 1*A* shows in full heavy lines the indicator diagram developed into the four consecutive strokes of the complete working cycle. The pressures during the exhaust and suction strokes are so small (not exceeding 1½ lb. sq. in. in a well-designed engine) that they could be just barely indicated. The inertia effect of each stroke is shown in heavy dashed lines. For vertical engines, especially larger units and moderate speeds, this inertia effect should be corrected for the weight of the reciprocating parts. Since this weight of course is constant, the correction consists in merely drawing a parallel to the inertia curve, as shown by the heavy full lines.

It will be noticed that in this particular case the correction amounts to just ± 10 per cent of the maximum inertia effect. In applying this correction it must be remembered that at the beginning of the downward strokes the weight reduces the inertia effect, while the opposite is true at the beginning of the upward strokes. Combining the corrected inertia effects with the absolute pressures of the indicator card produces the net forces acting in the direction of piston travel. These forces are designated by the lines enclosing the cross-sectional area. All pressures or forces in Fig. 1*A* are reduced to lb. sq. in. piston area; those tending to impart motion to the piston are plotted above the 0-line and are designated +, while those producing the opposite effect are designated — and are plotted below.

The side pressures resulting from the net piston forces are shown in Fig. 1*B*, those acting on one side of the cylinder are again designated + and are plotted above, while those acting on the opposite cylinder side are designated — and are plotted below the 0-line. The absolute value of these side pressures is given (this seems preferable over the presentation used by Mr. Daugherty, lb.sq.in. piston area, which is not representing any actual working conditions and is therefore misleading).

Throughout the expansion stroke the side pressures are positive, their maximum being 12,750 lb. On the following exhaust and suction strokes the side pressures first reach a

positive, then a negative maximum, the respective values being given on the diagram. On the compression stroke the side pressures are entirely negative, their maximum of 4660 lb. being but little higher than that of the exhaust and suction strokes, in spite of the great difference of work done in the cylinder. By integration of all the values above the 0-line we obtain a mean pressure of 2500 lb. acting along one side of the cylinder, while on the other side the mean pressure amounts to 1340 lb. Thus these side pressures are within 33 per cent of being equally divided between the two cylinder sides, and what is more important, at least once in every stroke this pressure reverses from one side to the other, there being a total of six reversals during a complete cycle of operation.

DIAGRAMS FOR HORIZONTAL ENGINES

Figs. 2*A*, 2*B* and 2*C* apply to a horizontal four-cycle engine of the same bore and stroke. Fig. 2*A* gives again the developed indicator card and the inertia effects; these latter do not require any correction here since in horizontal engines the weight of the reciprocating parts acts at a right angle to the direction of piston travel. Note how the resulting forces differ from those of the vertical engine in magnitude as well as location (point of reversal from + to — forces, which under certain conditions may be of considerable importance, as I expect to show in the near future).

Fig. 2*B* shows again the side pressures, with the connecting rod length the same as on the vertical engine. These side pressures are plotted about the abscissa *X-X*, pressures acting downwards being shown above *X-X* and designated +, while those acting upwards, tending to lift the piston, are —. To these side pressures must be added the weight of the reciprocating parts, which of course acts continuously downward. The true 0-line therefore runs parallel to the abscissa *X-X* at a distance equal to the weight of the moving parts. (The inertia effect of the swinging connecting rod, both in the vertical and horizontal engine, would not be sufficient visibly to affect the diagram.) All the values given to the diagram are measured from this actual 0-line.

Thus corrected it appears that with the exception of four very short intervals the side pressures are continuously acting downwards, their mean pressures during all four strokes being 4400 lb. It is very questionable whether the remaining negative pressures will be sufficient in the short time interval to overcome the friction at the piston rings and adhesion between piston and cylinder wall; in all probability the piston is continuously held in contact with the underside of the cylinder. This is even more likely to be the case where the connecting rod is made longer, as shown in Fig. 2*C*, where the length is increased by one crank over that in Fig. 2*B*. This increasing the connecting rod length not only has the effect of decreasing the maximum pressures, as pointed out by Mr. Daugherty; it also decreases the mean pressures to just about the same magnitude as the sum of + and — mean pressures of the vertical engine.

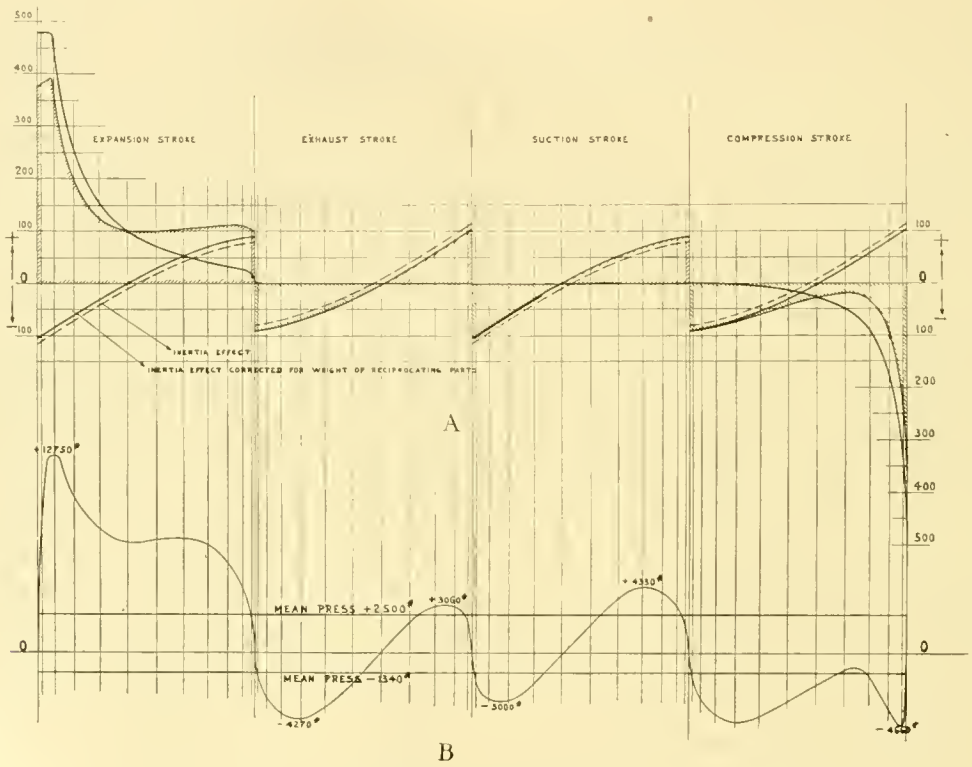

Fig. 1 Pressure Diagrams for Vertical Oil Engine

The friction work in both these engines would therefore appear to be practically the same. There is this fundamental difference, however, that in vertical engines the side pressures cause the piston continuously to shift its contact from one cylinder side to the other, while in horizontal engines approximately the same or larger side pressures are keeping the piston continuously pressed down against the same side of the cylinder. The significance of this shifting of pressures and contact is clearly shown in Mr. Daugherty's description of the superior process of lubrication in the main bearings of horizontal engines, in the last paragraph on page 786 of the Journal. (Incidentally, this applies to a dot to the bearings of vertical engines, to prove which it is only necessary to remove the bearing caps from an engine in operation and

watch the results.) What has been found to be necessary on bearings with their ideal rubbing surfaces and operating conditions in general, certainly is of no less importance for pistons, where cast iron slides on cast iron at a maximum rubbing speed three times as high as in bearings, and at temperatures which would prove disastrous to the latter.

In view of the foregoing facts, the "feature of superiority" attributed to the single oil feed on the upper side of horizontal cylinder does not become so apparent; in fact, noticing that the oil has to find its way by gravity to the under side of a surface continuously under pressure, it looks to be decidedly a feature of inferiority. At best it seems little else than capillary attraction which would permit a trace of oil to get to the underside of the piston during the short intervals of light pressure against the cylinder wall; this, however, is far from having the lubricating system under such control as to meet varying operating conditions, and which is so thoroughly accomplished on vertical engines. In the latter the oil is not only more evenly supplied, but the continuous change of contact of the piston from one cylinder side to the other spreads the lubricant over the whole circumference and ensures the maintenance of an even oil film. The friction work is thus materially reduced and what remains is distributed over twice as large a surface as in horizontal engines. It is entirely due to this increased friction work between piston and cylinder walls that the mechanical efficiency of horizontal engines is lower than that of vertical ones. This friction work is converted into heat and must be dissipated through the adjoining walls. The amount of heat which from this source might have to be dissipated through the underside of piston and cylinder walls of a horizontal engine can easily run up to from 30 to 40 per cent of that transmitted through this same channel from the combustion chamber.

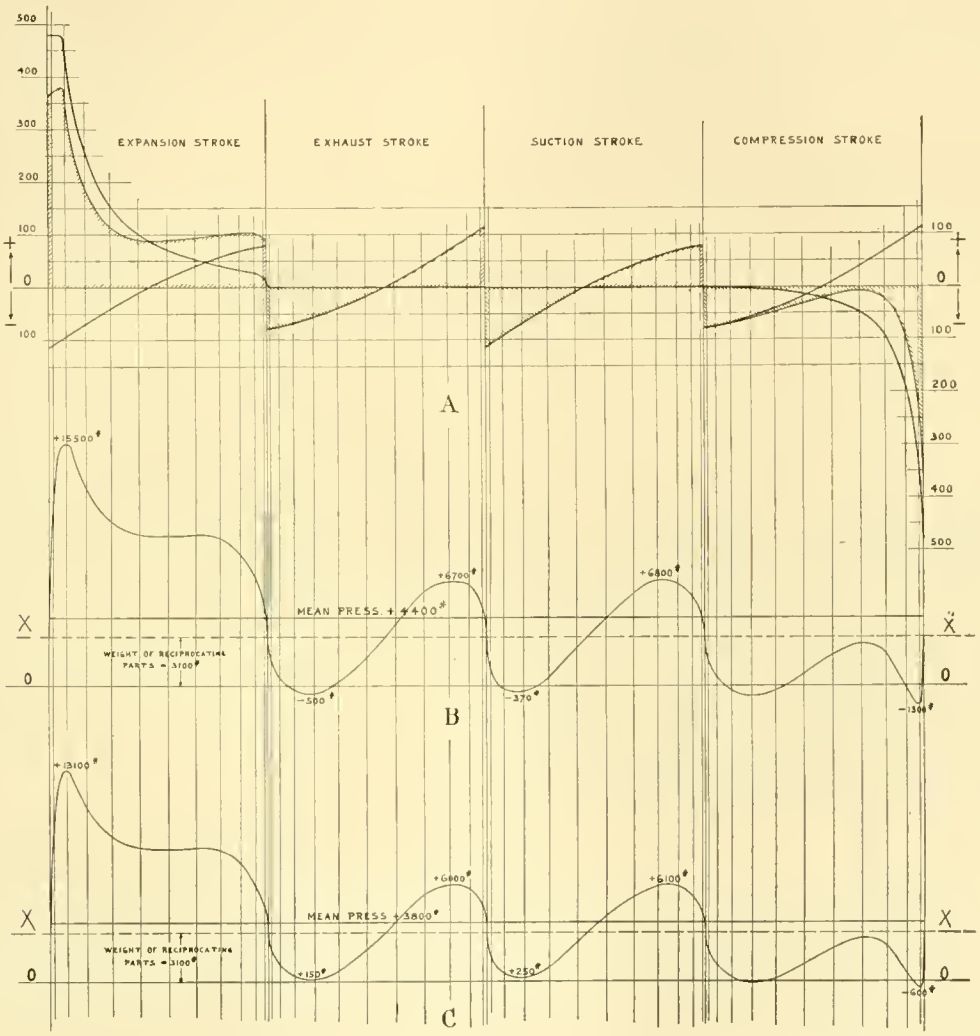

Fig. 2 Pressure Diagrams for Horizontal Oil Engine

STRESSES IN CRANKSHAFT

Mr. Daugherty has failed to give positive reasons, in figures or graphically, why there should be a "better distribution of stresses on the crankshaft and main bearings" of horizontal engines than of vertical engines. Without desiring to go into a useless word argument, I am, however, prepared to prove that the opposite is true. As in the case of side pressures, it is not sufficient merely to determine the maximum load by means of some ready baked formula. The question of distribution of stresses in crankshafts and bearings involves a careful analysis of the affected parts for rigidity and magnitude of deflections, which may very easily greatly augment the stresses set up. If Mr. Daugherty is willing to present in these pages an exposition of his method of computation for a horizontal engine, including the underlying facts as to dimensions and weights to facilitate check-

ing, I shall be glad to follow suit with the nearest size vertical engine on which I am able to get the necessary information. Such a presentation given for a twin cylinder engine would be particularly interesting, since on this type it can be shown even better than on a single cylinder unit how unfavorable the conditions are as compared with vertical engines.

Of all the arguments that Mr. Daugherty has presented in favor of the horizontal engines, that of "easy survey and convenient attendance" is the only one I regard as having merit. Although the valves and valve gear are at least as accessible on vertical engines as on any horizontal one brought out so far, particularly in the larger sizes, the necessity for first having to mount a platform in order to get at these, as well as at the fuel pumps, or for starting and stopping, is a feature which it would seem desirable to do away with on vertical engines. An engine with this in view, as well as containing a number of other features to make the vertical type better adapted to American conditions, both from the operating and particularly the manufacturing standpoint, is being brought out by myself at the present time. I am merely mentioning this now to give Mr. Daugherty time for the preparation of new weighty arguments in favor of horizontal engines.

H. R. Setz.

St. Louis, Mo.

ENGINEERING SOCIETIES AND PUBLIC AFFAIRS

To the Editor:

I noted with interest the comments of Mr. Henry Hess on the relation of engineering societies to public affairs, on page 641 of the August issue of The Journal. With due recognition of the strength of the "consultant" attitude, is it not pertinent to inquire whether the "wait-till-they-ask-me" position does not also have its weakness?

Admittedly this is the safest course from the engineers' standpoint, but suppose the engineer is not consulted. To get things done it is often advisable to step down from the pedestal of dignity and go to work. Whether or not there is a real loss of dignity is determined largely by *what* work is undertaken and *how well* it is done. If our engineering societies are afraid they cannot measure up to the requirements of such a progressive attitude, then by all means let us stay on our pedestal where we will not encounter the difficulties of constructive, aggressive work.

There is much talk about the engineer not getting the recognition that his ability deserves. We can sit back and tell each other that the crying need in our community affairs is the more active participation of engineers with their analytical and constructive abilities. I venture to say that the fundamental cause of the condition referred to is this same dignified, "stand-pat" attitude which leaves the field to the professional politician.

If our engineering societies do not have sufficient wisdom in the management of their affairs to guard against misuse of their powers when taking up constructive community activities then let them stay out or improve their managements.

Anything worth having is worth working for. If we would have the standing in the community our ability warrants, we must perform the work that this same ability fits us for. The same is true of the society as of the individual.

W. Herman Greul.

New York, N. Y.

OUR INDUSTRIES AND CITIZENSHIP

To the Editor:

Referring to Mr. Glynn's letter on page 644 of the August issue of The Journal, I think the salvation of our Industries and Citizenship lies in the direction of scientific management, under which all factories become in effect laboratories for the education of employees. There is no education comparable in efficiency and thoroughness with that of "learning by doing." You cannot learn to ride a bicycle, for instance, by reading a book, nor can you do anything worth while in any direction until you take hold of the work and apply yourself to it; and, to obtain the best results, every worker must have the incentive and the ambition to excel in what he undertakes.

Wilfred Lewis.

Haverford, Pa.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

Interpretation meetings of the Boiler Code Committee have been continued through the summer months, two meetings having been held, one July 27, and another August 24, for the consideration of inquiries received concerning the rules in the Boiler Code. The interpretations rendered in the Cases there considered have been passed by the Council and are published below. The interpretations rendered by the Boiler Code Committee have been published in the January, April, and September, 1916, issues of The Journal, as follows: January issue, Cases Nos. 1-36 inclusive; April issue, Cases Nos. 45, and 47-48 inclusive; September issue, Cases Nos. 49*a* and 59-88 inclusive.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that anyone interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee as approved by the Council on October 13, 1916, in Cases Nos. 86 and 89-103 inclusive. In this report, as previously, the names of inquirers have been omitted.

Case No. 86

Inquiry: (a) How is the lowest permissible water level determined under Pars. 291-294 of the Boiler Code, for

vertical fire tube boilers both with and without submerged tube sheets?

(b) Are fire engine boilers subject to the requirements of the Boiler Code, and if so, what should be the lowest water level?

Reply: (a) With vertical fire tube boilers where the top tube sheet forms the top of the boiler, the lowest permissible water level shall be one-third the length of the tubes, measured from the crown sheet or the top of the lower tube sheet. With vertical fire tube boilers constructed with submerged tube sheets, the lowest permissible water level shall be the top of the upper tube sheet. According to Par. 291, the lowest visible part of the water glass or the lowest gage cock shall be not less than 2 in. above the lowest permissible water level.

(b) Fire engine boilers are necessarily of highly special construction and more of the general type of flash boilers and are not absolutely subject to all the requirements of the Code. Unless special provision is made to keep the water above the fire box crown sheet other than by the natural water level, the lowest gage cock should be at least 5 in. above the top of the fire box crown sheet.

Case No. 89

Inquiry: Will it be desirable for a State, in administering the A.S.M.E. Code, to submit all inquiries that arise concerning the rules to the Boiler Code Committee for interpretation?

Reply: Where there is a question respecting the interpretation of the Code, or where constructions apparently are not covered by the Code, it will be most desirable to have the matter referred to the Boiler Code Committee. Unless this procedure is followed, the aim to obtain uniformity in the application of the Code will be defeated. Naturally, there will be inquiries where it is self-evident that there can be no question as to how the Code should be interpreted, and such inquiries evidently need not be referred to the Boiler Code Committee. The Boiler Code Committee desires to coöperate to the limit of its ability in assisting in the application of the Code, and will take pleasure in considering all matters where there is any question of doubt that may be brought up to it by the various states and municipalities that adopt the Code.

Case No. 90

(In the hands of the Committee)

Case No. 91

Inquiry: Will it not be desirable to require the stamping of the allowable working pressure on all boilers built to the A.S.M.E. Code as is required by the rules for some localities?

Reply: To make any disposition of this suggestion would involve an addition to the Code. The Boiler Code can be changed only after suggestions for changes are considered at a hearing before the Committee, where all interested parties may be heard. The Committee recommended in the Code that hearings to consider revisions be held at least once in two years, and the time for the first hearing is now near at hand.

Case No. 92

Inquiry: In the cone top of a vertical submerged tubular boiler that under Par. 231 requires staying as a flat surface, where should the stays be located, and what length should be taken for calculating the pressure allowable?

Reply: Where a cone top requires staying over a portion of its surface as permitted by Par. 231, the top row of stay bolts must be at a point where the cone top is not over 30 in. in diameter.

In calculating the pressure permissible on the unstayed portion of the cone, the vertical distance between the horizontal planes passing through the center of the rivets at the cone top, and through the center of the top row of stay bolts shall be used as L in Par. 239, and D in that paragraph shall be the inside diameter at the center of the top row of stay bolts.

Case No. 93

Inquiry: Exemption is requested from Pars. 186 and 187 of the A.S.M.E. Code, which apply to the welding of boiler joints, where the electric metal-electrode, or so-called "pencil-type" of autogenous welding is used, as this process is claimed to be greatly superior to any form of gas welding.

Reply: This inquiry is answered by the reply made in Case No. 80, as follows:

The Committee has since its inception had under constant observation all sorts of welding of pressure vessels, and has gone so far as to ask some of the welding experts of this country to write papers for the Society to bring out further information regarding this particular process. Suggestions for changes will be considered at a hearing before the Committee, where all interested parties may be heard. The Committee recommended in the Code that hearings to consider revisions be held at least once in two years, and the time for the first hearing is now near at hand.

Case No. 94

Inquiry: As there seems to be some misunderstanding of the interpretation rendered in Case No. 43, an interpretation is requested of the application of Par. 223 as interpreted by Case No. 43, to the details of construction of diagonal boiler braces.

Reply: This inquiry is answered by the reply made in Case No. 69, as follows:

In previous cases of this kind (See Case No. 29) the Committee has said that all braces used in A.S.M.E. Code boilers should conform to the Code in every detail. Difficulty has been experienced in interpreting Par. 223, which applies to such braces, and the Committee therefore submits the following to explain how this paragraph should be applied:

The requirements in Par. 223 are based on the "required cross-sectional area of the brace." To apply Par. 223, proceed as follows:

1 Determine the "required cross-sectional area of the brace" by first computing the total load to be carried by the brace, and dividing the total load by the values of stresses for unwelded stays given in Table 4.

2 Design the body of the brace so that the cross-sectional area shall be at least equal to the "required cross-sectional area of the brace" for unwelded braces. Where the braces are welded, the cross-sectional area at the weld shall be at least as great as that computed for a stress of 6000 lb. per sq. in. (See Table 4.)

3 Make the area of pins to resist double shear at least three-quarters of the "required cross-sectional area of the brace."

4 Make the combined cross-section of the eye at the side of the pin (in crowfoot braces) at least 25 per cent greater than the "required cross-sectional area of the brace."

5 Make the combined cross-sectional area of the rivets at each end of the brace at least 1¼ times the "required cross-sectional area of the brace."

6 Design each branch of a crowfoot to carry two-thirds the total load on the brace.

7 Make the net sectional areas through the sides of the crowfeet, tee irons, or similar fastenings at the rivet holes at least equal to the required rivet section, that is, at least equal to 1¼ times the "required cross-sectional area of the brace."

8 The cross-sectional areas through the blades of diagonal braces where attached to the shell of the boiler shall be at least equal to the required rivet section, that is, at least equal to 1¼ times the "required cross-sectional area of the brace."

Case No. 95

Inquiry: (*a*) What value of C should be used in the formula in Par. 199 to determine the thickness of tube sheets and spacing of staybolts or braces, where the staybolts or braces

are screwed through the plate, or made a taper fit and the heads formed on the staybolts or braces before installing them and not riveted over, said heads being made to have a true bearing on the plate, and where the diameters of the heads are not less than 1.4 times that of the ends of the staybolts or braces?

(*b*) In Par. 203, can *C* be taken in the proportion of 160 to 135 for forms of stays which allow a greater value of *C* than 135, based on the pitch measured between stays?

Reply: (*a*) The value of *C* should be 150.

(*b*) Yes. The maximum spacing between the rivet surface of the shell and lines parallel to the surface of the shell passing through the centers of the stays or braces shall be determined by the formula in Par. 199, using for *C* the value for regular spacing multiplied by the ratio of 160 to 135.

Case No. 96

Inquiry: An interpretation is requested relative to the actual number of stamps required under Par. 36 of the Boiler Code. Is it essential that the plate manufacturer's stamp appear in three places on the plate if the physical and chemical properties meet the requirements of the Code?

Reply: It is the intent of the Code that one of the several stamps be visible on each sheet after the boiler has been fabricated, which is evidenced by the fact that the word "stamp" in the last line of Par. 36*a* is in the singular. Where the plate manufacturer has placed the stamp or stamps on the plate in an insufficient number of places or in improper places, such plates may be restamped by the plate manufacturer, or his authorized agent, so that at least one stamp per plate shall be visible after the boiler is completed.

Case No. 97

Inquiry: (a) Where can the manhole required by Par. 264 of the Boiler Code be located in a Scotch type boiler with dome, that has no available space in the heads or shell outside the dome?

(b) An interpretation is requested of Par. 194 of the Boiler Code relative to a dome larger than 24 in. with the joint lap-riveted and under a working pressure of 100 lb.

(c) Referring to the requirement of the Boiler Code for reinforcements for threaded openings to give the proper number of threads, is there an exception in the case of water column connections?

Reply: (a) Relative to the location of the manhole, this is answered by Par. 264 of the Boiler Code, which permits a manhole in the head of the dome. Make the opening in the shell directly under the dome sufficiently large for access, and reinforce such opening in the shell with manhole frame as called for in Par. 261.

(b) With regard to the riveting of domes, attention is called to the interpretation rendered in Case No. 75, which states: "The intent of Par. 194 is that all domes 24 in. or over in diameter shall have butt and double strap longitudinal joints irrespective of the pressure used."

(c) With respect to the reinforcements of openings for water column connections, there is no exception in the Code to the number of threads required in openings for pipe fittings.

Case No. 98

Inquiry: (a) Is it permissible under Par. 272 of the Code to use a pop valve with 0.15 in. lift, basing the capacity on 0.15 in. lift and replacing a Code valve larger than this valve having the maximum discharging capacity as given in the table?

(b) Is it permissible with a 500 h.p. water tube boiler having 5000 sq.ft. of heating surface that will evaporate 30,000 lb. of water per hr. to use at 100 lb. pressure, six 3 in. pop valves (bevel seat) lifting 0.15 in., each having a discharge capacity of 5660 lb. of steam per hr.?

(c) Is it permissible to increase by 40 per cent the maximum discharge capacity as given in tables in the Code when using flat seat pops and may six 3 in. flat seat pops be used as outlined under Inquiry (b)

Reply: (a) According to Par. 274, if the marked relieving capacity of the valve exceeds that given in Table 8 of the Boiler Code, the maximum relieving capacity given in Table 8 governs in determining the minimum capacity of safety valve or valves to be placed on a boiler. The maximum capacity given in Table 8 for a 2½ in. bevel seat pop valve at 100 lb. pressure is 2516 lb. per hr.

(b) A water tube boiler with 5000 sq. ft. of heating surface evaporating 30,000 lb. of water per hr. at 100 lb. pressure will require at least eight 3 in. bevel seat pop safety valves.

(c) It is permissible to increase the maximum discharge capacity given in Table 8 by 40 per cent when using flat seat pop safety valves, provided the flat seat valves have the same lift as that given in the table, and six 3 in. flat seat valves will be sufficient for the boiler referred to under (b).

Case No. 99

(In the hands of the Committee)

Case No. 100

Inquiry: (*a*) Does Par. 264, which requires a manhole in the front head below the tubes of a horizontal return tubular boiler apply to the regular brick set type of boiler only, or to portable types of boilers also?

(*b*) Is it permissible where two or more safety valves are used on a boiler, to attach each safety valve directly to the boiler by a forged steel flange?

(*c*) In the hands of the Committee.

Reply: (*a*) Par. 264, respecting the location of a manhole in the front head below the tubes, applies to horizontal return tubular boilers only.

(*b*) In the use of two or more safety valves on a boiler, each may be attached directly to the boiler by a forged steel flange.

(*c*) (In the hands of the Committee).

Case No. 101

Inquiry: What dimensions are permissible under the A.S.M.E. Boiler Code for brass or bronze pipe fittings?

Reply: In the absence of any other special standard, the Boiler Code Committee endorses the use of brass or bronze fittings designed for a factor of safety of five and with diameters of bolt circles, and numbers and sizes of bolts to correspond with those given in Tables 15 and 16 of the Boiler Code.

Case No. 102

Inquiry: Is welding by the acetylene process permissible for the welding of heads and connecting nipples on headers used for furnaces of the down-draft type?

Reply: The Committee has since its inception had under constant observation all sorts of welding of pressure vessels and has gone as far as to ask some of the welding experts of this country to write papers for the Society to bring out further information regarding this particular process. Suggestions for changes will be considered at a hearing before the Committee, where all interested parties may be heard. The Committee recommended in the Code that hearings to consider revisions be held at least once in two years and the time for the first hearing is now near at hand.

Case No. 103

Inquiry: Under Par. 29*a* of the Code, should deductions in the percentages of elongation be made pro rata or in steps to correspond to the increase in size of ⅛ in. above a thickness of ¾ in.?

Reply: It is the opinion of the Committee that deductions in the percentages of elongation should be made in steps as specified in the Code.

Society Affairs

Engineering Survey

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES

OFFICERS AND COUNCIL, 1916

President

D. S. Jacobus

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Vice-Presidents

Terms expire December 1916

Henry Hess
George W. Dickie
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

COMMITTEES, ETC.

STANDING COMMITTEES

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library, John W. Lieb
House, William N. Dickinson
Research, R. J. S. Pigott
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee on Cooperation in American Engineering Standards
Conference Committee to Determine Cost of Electric Power
Conservation
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R. Hutton
Boiler Code Committee, John A. Stevens
Engineering Education
Filter Standardization, George W. Fuller
Increase of Membership, Irving E. Moultrop
Metric System, L. D. Burlingame
National Museum
Nominating Committee, Walter B. Snow
Patent Laws, Edward Weston
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee, R. J. S. Pigott
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Machine Tools, Leon P. Alford
- Sub-Committee on Safety Valves
- Sub-Committee on Steam-Flow Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Standards for Machine Tools
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A. Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, (Secretary not appointed)
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit, M. E. Cooley, (Secretary not appointed)
Indianapolis, (not appointed)
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

SECRETARY'S CHAT WITH THE MEMBERS

As a further development of the new National Defense Act, military education for college students, particularly the reserve officers training corps, was discussed by nearly a score of university and college presidents meeting with the officials of the U. S. War Department in Washington on Tuesday, October 17.

Besides President Howell, of Harvard University, and President Hadley, of Yale University, our own engineer-president, Dr. Drinker, of Lehigh University, participated in the conference. This movement will tie in the reserve corps of civilian engineers about which I have already spoken.

The outcome of this movement will probably be the assumption of a complete course in military drill by practically all the Land Grant Colleges and many of the other colleges in this country. President Wilson has announced the personnel of the Civilian Advisory Commission to the National Defense Council, as follows: Daniel Willard, President of the B. and O. Railroad; Samuel Gompers, President of the American Federation of Labor; Dr. Franklin H. Martin, of Chicago; Bernard Baruch, of New York; Howard E. Coffin, Mem.Am. Soc.M.E., of Detroit; and Dr. Hollis Godfrey, Mem.Am.Soc. M.E., president of Drexel Institute. The appointment of Mr. Coffin to represent Industries is a direct recogniton of his services and that of the engineering societies to the nation in the Industrial Census just completed.

Speaking of the importance of this work, Secretary of War Baker, in an address on September 26 before the Cleveland Chamber of Commerce, said of Mr. Coffin that he "has done perhaps the greatest service that has been done for America by any private citizen in the last fifty years."

The committee of five, of which the Secretary is secretary, appointed to report on a form of organization for a Scientific Civil Alliance to make permanent the organization of State Directors of the Industrial Census, made their report on Tuesday, October 17, at a meeting held in the rooms of the Society.

The Secretary recently addressed the public meeting of the City Planning Committee of the Cleveland Engineering Society, and took occasion to compliment that society and its public-spirited secretary on the many ways in which the society is serving the public. The national engineering societies have their duties to the nation, as in the census and reserve corps above mentioned, and the local societies and the branches have in turn their obligations to the locality which they serve, and, still further, the individual engineer must always be a good citizen, serving in all possible ways for the common good of his community.

The so-called "recognition" of the engineer will follow in direct proportion as he serves unselfishly the welfare of the public. The emphasis should always be on *service.*

Similar good movements to that at Cleveland are in progress in Atlanta, Minneapolis, St. Paul and San Francisco. The difficulty is, however, the desire to officially couple the name of the national society with regulation. If the branches of the Society can keep the two distinct, they will relieve the Council and themselves of embarrassment.

The proper scope of the local as well as the national societies is to furnish technical information in those realms where the society is a recognized authority, and to stop where the society ceases to have no more authority than others.

Calvin W. Rice,
Secretary

COUNCIL NOTES

A meeting of the Council was held on October 13. The following were present: D. S. Jacobus, *President;* J. Sellers Bancroft, John H. Barr, Arthur M. Greene, Jr., Henry Hess, Frederick R. Hutton, W. B. Jackson, Charles T. Main, H. de B. Parsons, Jesse M. Smith, John A. Stevens, Max Toltz, E. H. Whitlock, and Calvin W. Rice, *Secretary;* and by invitation Charles Whiting Baker, member of the Joint Conference Committee of the National Engineering Societies; H. L. Gantt, Chairman of the Committee on Meetings; I. E. Moultrop, chairman of the Publication Committee, and Herman Aaron, Esq., counsel for the Society.

Boiler Code Committee. Interpretations of this Committee Nos. 89 to 103, were approved with slight corrections and ordered published. They are published elsewhere in this issue of The Journal.

A Conference Committee to the Boiler Code Committee was created to consist of representatives of the states and municipalities that adopt the Code, and it was voted to invite each such state and municipality to appoint a representative to act on this committee. All discussions will be confined to the technical field of boiler construction and installation.

It was voted to send invitations to all interested parties to the proposed public hearing on the Boiler Code to be held during the forthcoming Annual Meeting of the Society.

Power Test Committee. Prof. R. H. Fernald and James W. Parker were appointed members of this Committee.

Sections. A Section was approved in New Orleans, La., to include all members residing within sixty miles of that city. W. B. Gregory, chairman; H. L. Hutson, secretary-treasurer; R. T. Burwell and E. W. Kerr were appointed as executive committee of the new Section.

A Section was also approved in Indianapolis, Ind., to include all members residing within sixty miles of the city and in Lafayette and Terre Haute.

Max Toltz was elected a member of the executive committee of the Minnesota Section, in place of Prof. W. H. Kavanaugh,

resigned because of removal from the territory of the Section.

Increase of Membership. C. B. Davis was appointed chairman of the Birmingham, Ala., sub-committee on Increase of Membership.

Section Affiliations. It was voted to appoint a committee, with E. H. Whitlock, Chairman of the Sections Committee, and the Chairmen of the Sections who have been in touch with plans for local organizations, to present a statement covering the rightful affiliations of the Sections with such organizations.

Junior and Student Prizes. Recommendations of the Committees on Award of Junior and Student Prizes by Junior-Members and by members of Student Branches, respectively, during the year ending June 30, 1915, were approved, and the prizes were awarded.

Coöperation in American Engineering Standards. An invitation was received from the American Institute of Electrical Engineers to appoint three representatives from our Society on a joint committee of the national engineering societies to consider ways and means of bringing about coöperation in American engineering standards, the representatives on this committee to report back to their respective societies.

The Committee on Standardization was empowered to appoint three of its members to represent the Society on this joint conference committee.

American Association for the Advancement of Science. President Jacobus was appointed to represent the Society on the council of this association, with W. B. Jackson, previous appointee.

Alterations to Building. Recommendations of the House Committee for the alterations required in the Society's rooms to carry columns through them for the additional stories to accommodate the Civil Engineers were approved.

Spring Meeting, 1917. The date of the Spring Meeting of the Society was fixed for May 22 to 25, 1917.

Biographies. It was voted that a Biographies Committee be appointed in connection with a plan to prepare or edit biographies of notable American engineers.

Communications. The U. S. Navy Department advised the Society of its formal adoption of the recommendations of The American Society of Mechanical Engineers for Machine Screw Standards.

The secretary of the John Fritz Medal Board of Award advised that the award had this year been made to Prof. Elihu Thomson, of Swampscott, Mass. The ceremonies of presentation of the medal will take place at a general meeting of the American Institute of Electrical Engineers, in Boston, on December 8, 1916.

Calvin W. Rice,
Secretary.

OFFICERS OF THE SOCIETY VISIT CENTERS

PRESIDENT JACOBUS and Secretary Rice have just completed a tour to some of the centers at which members have under consideration the advisability of forming Sections, and have also been able to visit some of the Student Branches. They were gratified to find everywhere splendid interest in the affairs of the Society and a spirit of willingness to coöperate in its various activities.

The Secretary's first visit was to Meriden, Conn., where a meeting of members of the Society—the first gathering of mechanical engineers to be called in that vicinity—was held on October 3. Engineers were present from Wallingford, Middletown and Southington. The Committee in charge of the meeting was C. K. Decherd, chairman; R. S. Brotherhood, secretary; J. H. Hutchinson, George A. Horne, C. N. Flagg, Jr., and Frank Roundtree. The Meriden members are ambitious to form a permanent organization for holding regular meetings, and in this way develop the Society in that locality.

On October 16 the Secretary visited the Carnegie Institute of Technology Student Branch, Pittsburgh, and told of recent developments in the work the Society is undertaking, and outlined for them the part they are expected to take in promulgating the objects of the Society.

Proceeding to Cleveland on October 17, Mr. Rice met the Cleveland local committee at luncheon at the Cleveland Engineering Society, when F. A. Scott, Mem.Am.Soc.M.E., gave his views on the industrial preparedness movement.

At six p.m. the Secretary met the members of the Student Branch at Case School of Applied Science. The meeting was held at the Case Club, and a number of Cleveland members of the Society joined with the students in the meeting. Mr. E. H. Whitlock, Chairman of the Committee on Sections, Dr. Ambrose Swasey, Honorary Member and Past-President Am.Soc.M.E., Dr. C. S. Howe, Mem.Am.Soc.M.E., president of Case School, and Mr. F. W. Ballard, president of the Cleveland Engineering Society, were present.

In the evening the Secretary addressed a public meeting held in the rooms of the Cleveland Engineering Society under the auspices of the City Planning Committee of the Society.

Dr. Jacobus met Mr. Rice at Buffalo on October 18, and they participated in an informal luncheon given by a group of Buffalo members of the Society. Matters relating to Society affairs and to the engineering profession in general were discussed.

In the evening the members of the Buffalo Engineering Society joined our Buffalo Section at a formal dinner at the Hotel Statler. President Jacobus afterwards addressed the meeting on the relations existing between the parent Society and its Sections, and on coöperation between the Sections and local engineering societies and clubs. The Secretary described recent developments in the many broad movements in which engineers are participating and in which the Society is taking a leading part.

The next center visited was Erie, Pa., where active members have been considering the advisability of organizing a Section. These members organized a meeting which was held at the Hotel Lafayette, under the auspices of the Engineers' Society of Northwestern Pennsylvania, Mr. Hays H. Clemens, president. Mr. F. J. Wadsworth was instrumental in arranging the details which led up to this meeting.

Dr. Jacobus, Mr. Whitlock, and Mr. Rice were present at this meeting and explained the benefits which accrue to those members who are willing to contribute their time and energy to conduct a Section. They showed also how the establishment of an Am.Soc.M.E. Section tends to develop the local engineering organization because of the close coöperation it affords with vital engineering developments.

As a result of this meeting, the members at Erie are proceeding to petition the Council for the authority to conduct meetings.

Marked progress has been made by the members at Indianapolis, Lafayette and Terre Haute, Indiana, in their plans for coöperative meetings of all branches of engineers, and a

large and enthusiastic audience greeted Messrs. Jacobus, Rice and Whitlock at the organization meeting of the Indianapolis Section which was held on October 20.

At its October meeting the Council approved the recommendation of the Committee on Sections that an Indianapolis Section be authorized, and the Section is now established. All members residing at Lafayette, Terre Haute or within a radius of 60 miles of Indianapolis will be included in this Section, and the members at Rose Polytechnic Institute and Purdue University will constitute part of the organization. The manner in which the newest Section carried through its first meeting gives promise of rapid development.

From Indianapolis Mr. Rice proceeded to the Student Branch at the Kansas State Agricultural College, Manhattan, Kansas, where he was very graciously received by Prof. A. A. Potter and the undergraduate body. He was similarly entertained at the University of Kansas, Lawrence, Kansas, by the members of the Student Branch there and its Honorary Chairman, Prof. P. F. Walker. At both of these colleges Mr. Rice made addresses similar to those he made at the Carnegie Institute and at Case.

On the evening of October 23, the Secretary had the pleasure of meeting some of the active members of the Society in Kansas City who are looking forward to the establishment of a Section, and to them he explained the work which is being done by Sections and the great good resulting therefrom to the engineering profession and in turn to each individual member who takes part in Section activities.

Washington University Student Branch at St. Louis welcomed the Secretary on October 24.

Proceeding from St. Louis to Baltimore, Mr. Rice again met Dr. Jacobus, where they attended a meeting of the mechanical engineering students of Johns Hopkins University for the purpose of organizing a Student Branch. On October 25 they were present at an organization meeting held by the members of the Society in Baltimore and vicinity, when it was voted to file a petition to the Council for the establishment of a Baltimore Section. At this meeting a paper was read by Mr. W. L. DeBaufre, of the Naval Academy at Annapolis describing the work of the U. S. Naval Experiment Station there.

On his return journey to New York, the Secretary visited the recently established Student Branch at Bucknell College and also the Student Branch at the Pennsylvania State College.

JOINT SECTION MEETING TO BE HELD AT NEW LONDON

Boston, New Haven, New York and Worcester Sections and Providence Engineering Society to Visit Submarine Base and Engine Works There on November 11.

As The Journal goes to press plans are being perfected for an excursion which is unique in the annals of the Society. In view of the current interest in submarines, and of the expressed desire of a number of members to inspect a plant where submarine engines are built, special permission has been secured by the Society for a party of members to visit the works of the Electric Boat Company at New London, Conn., on Saturday afternoon, November 11, and arrangements made for the participation of the Sections at Boston, New Haven, New York, Worcester, and the Providence Engineering Society, affiliated with our Society, in the trip.

Some of the largest Diesel Engines manufactured in this country have been designed and built at the Electric Boat Company's plant, and the party will have the unusual opportunity of witnessing the processes and methods of construction of this class of prime mover for submarine service. A special test will be run on a high-power 8-cylinder, 4-cycle Diesel Engine. A large number of submarine and other oil engines will be seen in various stages of construction, and such operations as the boring of torpedo tubes, cylinders and other equipment for submarines examined.

Through the courtesy of Rear-Admiral A. W. Grant, in command of the submarine arm of the United States Navy, the visitors will be given a special exhibition at close range of several submarines submerging, and will also be shown a surface attack by a submarine. This exhibition will take place at the submarine base and training school, near New London.

SCHEDULE

Boston members will leave South Station on Train No. 7, at 8:30 a.m. on Saturday, November 11. Those coming from Providence will board this train at 9:36 a.m., and these contingents will arrive at New London at 11:13 a.m.

Worcester members will leave on Train No. 745 at 8:36 a.m., arriving at New London at 10:58 a.m.

The New York party will leave Grand Central Terminal at 8:31 a.m. on Train No. 8. This train will leave New Haven at 10:30 a.m. and arrive at New London at 11:39 a.m.

Each group will, upon arrival, proceed directly to the Mohican Hotel, where luncheon will be served promptly at 11.45 a.m., enabling the party to leave for the plant of the Electric Boat Company promptly at 1:00 p.m. The inspection trip through this plant will require about one and a half hours.

The party will then be taken out into the Sound, where the submarine exhibit and attack will take place.

The party will return in time to make one of the following connections:

For Boston and Providence.

Leaving at 4:07 and 6:00 p.m. and arriving at Boston at 7:00 and 8:43 p.m. respectively.

For New Haven and New York.

Leaving at 3:57 and 5:41 p.m. and arriving at New York at 7:11 and 8:45 p.m. respectively.

For Worcester.

Leaving at 4:20 p.m. and arriving at Worcester at 8:00 p.m.

Members of the Society residing within radius of New London and not receiving a personal invitation to this meeting but seeing this announcement are cordially invited to participate.

Members of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the Boston Society of Civil Engineers, the Brooklyn Engineers Club, the New York Engineers Club, the Providence Engineering Society, the Philadelphia Engineers Club, the Engineering students at Brooklyn Polytechnic Institute, Brown University, Columbia University, Massachusetts Institute of Technology, New York University, Stevens Institute of Technology, Worcester Polytechnic Institute, Yale University and other organizations of engineers living near New London, will also be welcomed.

THE THIRTY-SEVENTH ANNUAL MEETING, NEW YORK CITY, DECEMBER 5 TO 8

THE program of the thirty-seventh Annual Meeting of the Society, to be held in the Engineering Societies Building, New York, December 5 to 8, 1916, is announced below in as complete a form as is possible at this early date.

No less than eleven professional sessions have been arranged, with papers on similar subjects grouped in so far as practicable. This large number of sessions and the great variety of topics are the result of many months of work on the part of the Committee on Meetings and its sub-committees.

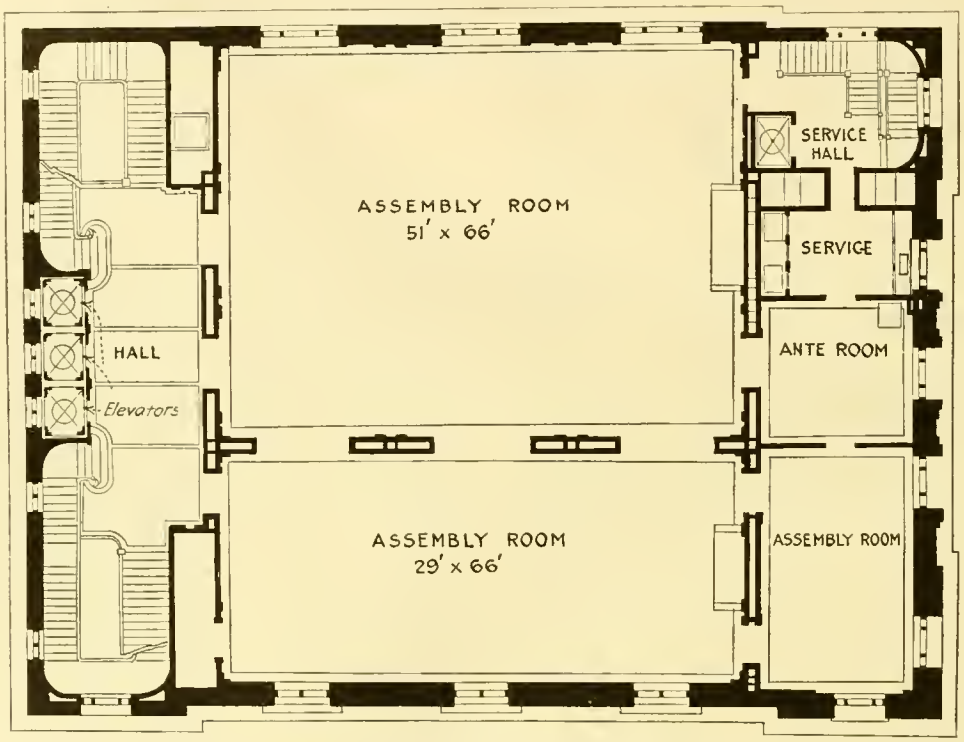
Elsewhere in this issue advance publication is made of a number of the papers to be presented and discussed, and others will follow in the next issue of The Journal. The papers are published in the form of abstracts, prepared in collaboration with authors and as complete and comprehensive as possible. Work on the printing of the complete papers in pamphlet form has been proceeding satisfactorily, and copies of any of these papers will be sent to members of the Society gratis upon application in advance of the meeting.

In view of these special efforts on the part of the Committee on Meetings and the Publication Committee to get the material of the papers in the hands of every member well in advance of the meeting, it is anticipated that the opportunity for contributing discussion will be widely taken advantage of.

The first Annual Meeting papers printed in this issue are those selected for presentation at one or other of the three Miscellaneous Sessions. These are the papers not secured by sub-committees, but presented to the Society directly by their respective authors.

These are followed by papers on valuation, which the Committee on Meetings has taken special pains to secure in order that such live subjects as appraisal of industrial property and industrial vs. public utility valuation may be discussed at a general meeting of the Society for the purpose of bringing out facts of value to engineers.

A Safety Code for Cranes to be presented by the Sub-Committee on Protection of Industrial Workers is published in this issue. The field of work of this committee is a large one, and is also an important one since, through this committee, the Society is endeavoring to effect an approach to uniform requirements in the matter of safeguards. The committee coöperates in its activities with state bureaus, insurance interests, organized societies, departments of industrial concerns and individuals, and has already discussed a number of standards.



PLAN OF FIFTH FLOOR OF ENGINEERING SOCIETIES BUILDING, NEW YORK, SHOWING ALTERATIONS FOR SOCIAL FUNCTIONS OF FOUNDER SOCIETIES

The Sub-Committee on Gas Power will have charge of an important session, and two of its papers are published this month.

A strong feature of the meeting will be the session in charge of the Sub-Committee on Railroads. This committee is a very representative one, and at the sessions at general meetings in its charge a large amount of valuable material has been brought out. Two of this committee's papers are included in this issue.

The remaining Annual Meeting paper published this month is one of the three papers contributed by the Sub-Committee on Textiles. It reports the results of an important investigation upon the transmission of heat through window frames in mill buildings.

Papers to be presented at the Machine Shop Session and the session in charge of the Boiler Code Committee, as well as the remaining papers of the sessions noted above, will be published next month.

ENTERTAINMENT FEATURES

As usual, the social features of the meeting will be opened with the president's reception on Tuesday evening. This will follow Dr. Jacobus' presidential address in the Auditorium, and instead of being held in the Society's rooms on the eleventh floor, which have long since been inadequate for the purpose, will be held on the fifth floor, where with the alterations now in progress there will be splendid provision for such affairs.

The Engineering Societies Building has always lacked suitable accommodations for the social functions of the Founder Societies. The larger room on the fifth floor was not large enough for such functions and the floor was not suited for dancing. For some time there has been under consideration the arranging for the two assembly rooms on this floor to be thrown together and the laying of a hard wood polished floor in both. This improvement was agreed upon, and is now being carried out, and will be completed by the time of the Annual Meeting.

It was not feasible to make the partition between the two rooms entirely removable on account of the ventilating shafts and the necessity of having nearly sound-proof isolation of the two rooms when they are used independently, so the three double doorways are being increased to twice their former width as indicated on the accompanying plan. This will give ample means of communication between the two rooms for such purposes as dances, receptions and reunions. Any meetings that require the seating capacity of the two rooms combined will still be held in the Auditorium.

In addition to the president's reception, the two luncheons, Wednesday and Thursday noon, the smoker on Wednesday night, and the dance and reunion following the lecture on Thursday evening, will also be held on this newly-adapted fifth floor. It is not a little satisfaction to the committee in charge of the social arrangements that it will be possible this year for the first time to hold all of the Annual Meeting social events in the Engineering Societies Building.

TENTATIVE PROGRAM

Tuesday Evening, December 5

Presidential Address and Reception

President's address on the Relation of Education to Engineering, by Dr. D. S. Jacobus, President of the Society. This will be followed by the annual report of the Tellers of Election of Officers, the introduction of the President-elect, and a reception to the President, President-elect, ladies, members and guests. This gathering will be informal.

Wednesday Morning, December 6

Opening Session

Business Meeting.

Reports of the Council, Standing Committees and Special Committees, Constitutional Amendments and new business.

Award of Junior and Student Prizes.

John E. Sweet Memorial

Following the regular business of this session, there will be memorial exercises in honor of the memory of John E. Sweet, Past-President, Honorary Member and founder of the Society.

Miscellaneous Session

The Proportioning of Surface Condensers, George A. Orrok

The Testing of House-Heating Boilers, L. P. Breckenridge and D. B. Prentice

Water for Steam Boilers—Its Significance and Treatment, Arthur C. Scott and J. R. Bailey

Industrial Safety Session

Under the auspices of the Sub-Committee on Protection of Industrial Workers

Report on Safety Standards for the Operation of Cranes.

Wednesday Afternoon

Miscellaneous Session

The Utilization of Waste Heat for Steam Generating Purposes, Arthur D. Pratt

Graphic Methods of Analysis in the Design and Operation of Steam Power Plants, R. J. S. Pigott

Power Plant Efficiency, Victor J. Azbe

Textile Session

Under the auspices of the Sub-Committee on Textiles

Heat Transmission Through Various Types of Sash, Arthur N. Sheldon

Other papers will be presented on the question of moisture and humidity in the textile industry; and on the effects of vibrations in textile mill buildings.

Machine Shop Session

Under the auspices of the Sub-Committee on Machine Shop Practice

This session will be devoted to the discussion of papers on the standardization of machine tools and on a classification of machine shop practice and a proposed plan of work of the Sub-Committee on Machine Shop Practice.

Wednesday Evening

Smoker

The success of last year's smoker has decided the repeating of this form of entertainment for Wednesday evening. Entertainment will be provided, and a feature will be a short talk by Frank B. Gilbreth, Mem.Am.Soc.M.E., on his experiences in Europe during the war.

Thursday Morning, December 7

Valuation Session

It is expected that this session will continue both morning and afternoon.

Accurate Appraisals by Short Methods, J. G. Morse

Productive Capacity a Measure of Value of an Industrial Property, H. L. Gantt

Other authors will present papers on the relation between industrial valuation and utility valuation; on the interest of the public in valuation; on the relation between perpetual inventory value and appraisal value, and on amortization and depreciation.

Thursday Afternoon

Besides the continuation of the Valuation Session, there will be a Gas Power Session.

Gas Power Session

Under the auspices of the Sub-Committee on Gas Power

A Gas Producer for Bituminous Coal, O. C. Berry

Commercial Sampling and Gas Analysis, P. W. Swain

An Investigation of the Internal-Combustion Engine as Applied to Traction Engines, A. A. Potter and W. A. Buck

The Ratio of the Specific Heats and the Coefficient of Viscosity of Natural Gas from Typical Fields, Robert F. Earhart.

Illustrated Review of the Werkspoor Marine Diesel Engines, Thomas O. Lisle

Thursday Evening

Lecture and Annual Reunion

The Committee is making arrangements for a popular lecture to be given in the Auditorium on Thursday evening.

Following the lecture, the members and guests are invited to adjourn to the fifth floor of the Engineering Societies Building for the annual reunion and dance.

Friday Morning, December 8

Miscellaneous Session

The Impact Tube, Sanford A. Moss

Heat Treatment of Wrought Iron Chain Cable, F. G. Coburn, W. W. Webster and E. L. Patch.

The Flow of Air and Steam Through Orifices, Herbert B. Reynolds

Railroad Session

Under the auspices of the Sub-Committee on Railroads

Clasp Brakes for Heavy Passenger Equipment Cars, T. L. Burton

Mechanical Design of Electric Locomotives, A. F. Bachelder

Steam Boiler Session

Under the auspices of the Boiler Code Committee

An Analysis of the Working Parts of Safety Valves Met with in Marine Practice, with Suggestions for Repairs and Improvements, E. F. Maas

The Talbot Boiler, Paul A. Talbot

Friday Afternoon

Public Hearing by the Boiler Code Committee.

Saturday Morning, December 9

Public Hearing by Boiler Code Committee continued.

PLAN OF ACTIVITIES FOR THE SEASON 1916-17

Below is a continuation of the announcement in the last issue of The Journal, of the proposed activities for the season of Sections and Student Branches. At some of the colleges where the work of the term in the engineering department does not begin until the middle of October, the opening meeting of the Student Branch has not yet been held, and information regarding plans for the year has not come to hand.

SAN FRANCISCO SECTION

The San Francisco Section, through C. F. Braun, Secretary, reports that the coming season will be a really active one. In order to get the members together an informal smoker was held at the Engineers' Club during the first week of October.

In the fourth week of October the Section held a joint meeting with the A.I.E.E. Some of the members of the latter section presented papers on the Propulsion of Ships.

On November 16 a second joint meeting with the A.I.E.E. will be held, and W. W. Thompson will present a paper on The Trumbull Process of Refining Oil. Another social gathering is also planned for about the 26th of the month.

In the first week of December the section will hold a meeting at which W. J. Davis, Mem.Am.Soc.M.E., will present a paper on Turbine Blowers.

At a meeting to be held in February the Chairman, F. W. Gay, will present his paper on Engineering Economics of Partial Construction.

Besides these above meetings two other formal meetings and three smokers will be held during the season; at each of the latter some subject will be discussed informally.

Mr. A. C. Paulsmeier, Mem.Am.Soc.M.E., has signified his willingness to serve on the local committee and one other member will also be appointed on this committee, to fill vacancies caused by the resignations of Messrs. Terwilliger and Meredith. E. A. Rogers will act as Section Correspondent.

NEW HAVEN SECTION

The New Haven Section will follow its previous plan of holding two meetings during the season with afternoon and evening sessions and a dinner between them. The first of these meetings will be held on Wednesday, November 15, in the Hammond Mining Laboratory when the subjects of Applied Metallography, Prof. C. H. Mathewson and Testing of Metals, Prof. William Kent Shepard, will be presented. These papers will be followed by discussion. Following this session dinner will be served in the hall of the Yale Dining Club. The evening session will be held in the Mason Laboratory and two papers will be presented and discussed. The first of these is Recent Developments in Time-Study Devices, by Frank B. Gilbreth, Mem.Am.Soc.M.E., and the second, Processes of Facsimile Reproduction with demonstrations, by Samuel J. Berard, of the Mechanical Engineering Department of the Sheffield Scientific School. The local membership of the Section has increased greatly and interest in the Society is very keen. The Section has the coöperation of the Sheffield Scientific School and the service of its faculty on the Section Committee.

STUDENT BRANCHES

The *University of Colorado Student Branch* plans to hold two meetings each month during the school year. One meeting each month will be in charge of the students, and at the other professional men will be invited to speak.

The program for the year will include a trip to the smelting works at Pueblo, at least two trips to large plants in Denver, besides visits to sugar plants and power stations around Boulder.

The Branch held its first meeting on October 4, and an account of this is given elsewhere in this issue.

The *State University of Iowa Student Branch* will also hold semi-monthly meetings throughout the college year. It is proposed that at a majority of these meetings students shall present papers upon subjects of their own choosing. Excursions will be made to manufacturing plants in the vicinity of the University, and arrangements for these excursions will be discussed at the next meeting.

The Branch began the year with a business meeting on October 11, when plans were discussed. Many new men have signified their intention of enrolling, and a banner year is looked for.

The *University of Wisconsin Student Branch* will hold both

social and technical meetings during the year. In the former, it will participate with other engineering clubs at the college and will also take part in the annual sophomore smoker. At the technical meetings engineering subjects will be presented and discussed, as well as topics of general engineering history.

Meetings are held the first and third Thursdays of every month.

The increase in membership of the *Brooklyn Polytechnic Student Branch* will serve as an incentive toward the increase in social and technical activities for the coming year. A unique feature of the program for the meetings is that the speakers will be members of the alumni. The graduates are employed in such varied and interesting phases of the mechanical engineering profession that an attractive list of papers is assured.

The usual trips to places of interest to the future engineer will be continued with added zest. The Program Committee is now corresponding with the executives of many of the manufactories, power plants and office buildings situated in or near New York City.

A great endeavor will be made this season to focus attention on the social side of our activities. While heretofore it has been customary after meetings to turn to general discussion, it has not been customary to have an informal dance. A canvass will be made and if opinion approves of the idea, there is no reason why such events cannot be held.

The *Penn State Chapter* opened their season with a preliminary meeting, at which the new committees were announced, followed by a social meeting at which the new faculty members were introduced and made addresses. These members are Professor E. A. Fessenden, J. W. Haney, J. O. Keller and R. C. Fielding.

The program for the year includes the following addresses by faculty members and others and discussions by student members:

Calvin W. Rice, Secretary, Am.Soc.M.E., on Work of the Student Chapters.

R. L. Sackett, Mem.Am.Soc.M.E., Dean, School of Engineering, on Revision of Steam Power Plants.

E. A. Fessenden, Mem.Am.Soc.M.E., Professor of Mechanical Engineering, on How Scientific Investigation is Attacked.

Hugo Diemer, Mem.Am.Soc.M.E., Professor of Industrial Engineering, on The Scientific Determination of Processing Standards.

J. A. Mease, Mem.Am.Soc.M.E., Associate Professor of Machine Design, on The Steel Industry, from Ore to Finished Product.

E. N. Bates, Assistant Professor of Mechanical Engineering, on Development of the Gas Engine.

J. P. Calderwood, Mem.Am.Soc.M.E., Associate Professor of Mechanical Engineering, on The Use of Kerosene in Gas Engines.

On October 13, H. L. Swift, Mem.Am.Soc.M.E., addressed the Chapter on Electric Railroad Operation.

The *University of Maine Student Branch* is anxious to make this year the best in its history. Tentative plans are under consideration for meetings to be held once a month. It is hoped that the Society will make it possible this year for the Branch to receive visits from some of its speakers.

The *Case School of Applied Science Student Branch* will hold its first meeting on October 17. Secretary Rice has very kindly consented to address this meeting, and a number of Cleveland members of the Society have accepted an invitation to be present. This generous coöperation of the Secretary and the local members of the Society will assist the Branch in attaining the proper momentum for the year.

Other meetings of the Branch will be held on November 1, December 6, January 10, February 7, March 7, April 4 and May 2. The last meeting is designated as the Annual Meeting.

The usual procedure will be to hold a dinner at six p.m. on meeting nights, the meeting to follow the dinner.

The program for these meetings includes papers on salesmanship, advertising, and also some papers on special engineering topics by Cleveland members of the Society who have kindly offered their assistance. One meeting will be given over to a discussion of technical subjects by various members of the Branch.

The local branch is now very happily situated in being able to use the new Case Club for its meetings.

Regular meetings of the *Worcester Polytechnic Student Branch* will be held on the first Friday of each month. The several professors in charge of the work of the department of mechanical engineering have been assigned one meeting each, and will assist the student officers in securing speakers and making other arrangements.

The October meeting will be devoted to Steam Engineering; November to Shop Engineering; December to Heat Treatment of Steel; January to Machine Design and Materials of Construction; February to Hydraulic Engineering, and March to Automobile Engineering. The regular time for the April meeting coming this year during the Spring recess, a Joint Meeting will be held under the auspices of the Electrical Engineering Society. In May will occur the annual meeting of the Branch for the election of officers and reports by members from the senior class on their thesis work.

The friendly rivalry between the several sub-departments in arranging for the meetings results in a series of well-balanced and most interesting lectures as each professor tries to secure the best talent possible for his special meeting.

It is expected that the meetings will be well attended judging from the way this arrangement has worked in the past.

The meetings are open to the public and special invitations are sent each month to those interested.

The newly organized Branch at the *Louisiana State University and Audubon Sugar School* plans to make a special campaign early in the season for increasing its membership.

The programs of the meetings will include several addresses by practising engineers, and a strong effort will also be made to get well-prepared papers by students. The University has lately acquired a motion picture machine, and the Branch will secure a number of films on engineering subjects. Inspection trips will be made, particularly to sugar factories and oil refineries in the vicinity of the college.

In carrying out its program for the year, the *Carnegie Institute of Technology Student Branch* will hold meetings the second Wednesday of each month. The Branch expects to obtain addresses from Elmer K. Hiles, Mem.Am.Soc.M.E., George H. Neilsou, W. C. Bates, F. W. Winter, H. F. Ferguson, Frederick H. Parke and J. C. Hobbs, Mem.Am.Soc.M.E., and also some of its own alumni.

Light refreshments will be served at each meeting.

The business session and Dutch Lunch will be held in May, 1917.

The *University of Minnesota Student Branch* plans for the coming year contemplate improvements on past methods. For instance, during the past year many regular meetings were given over to addresses and talks of a general nature. All were excellent, but the students were not taking part, and it is proposed that each one shall be up and doing and therefore a greater number of reviews and discussions will form the basis for future meetings.

An open debate upon some live engineering question will furnish material for one or more meetings. It is hoped that the Branch may be able to get motion pictures of manufacturing processes and to-the-point lectures to accompany each set of films. It is proposed to keep in closer touch with the other student branches and try out a plan for the interchange of ideas and methods.

The annual "Get-together" is the best scheme yet evolved for getting up enthusiasm in the work and attracting prospective mechanical engineers to the Branch.

It is further proposed to give a dinner-dance just before the Christmas vacation in order that the Branch members and guests may have an opportunity to get better acquainted.

The first meeting of the Branch will consist of discussions of plans to govern future activities, and at that meeting there will undoubtedly be proposed further means to make the Branch of greater service to the members and to the University.

The *Bucknell University Student Branch* has decided to follow its plan of last year. About once each three months the Branch expects to have some outside engineer give an address, and other meetings will be devoted to expositions, given by seniors, of work done during the summer months. These expositions will be followed by discussions.

The general idea of the Branch is to acquaint its members with the various branches of the engineering profession, and the leading thought in all discussions will be that of instruction as to processes, methods and efficiency in system.

The *Colorado State Agricultural College Student Branch* will hold regular meetings twice every month. The programs will be arranged by the officers of the Branch and topics assigned to members for presentation. Topics are to be chosen from The Journal, from other technical papers and from practical experience. It is also the aim of the Branch to arrange for addresses by men of the engineering profession. The Branch plans to get in touch with the engineers of the under classes and keep them interested in the mechanical engineering profession. Some time during the year it is proposed to have a joint meeting with the other technical organizations.

The *Lehigh University Student Branch* will hold monthly meetings as heretofore the second Thursday of each month. At each of these meetings there will be two addresses, one given by a student-member of the Society, and the other by a graduate, prominent in engineering circles. Among the list of speakers scheduled for the coming year are Dr. J. W. Richards, of the American Electrochemical Society, whose talk will deal with the work of the newly-organized Naval Advisory Board, of which he is a member; R. E. Anderson, 1st Assistant General Superintendent of The Winchester Repeating Arms Co., who will speak on the Taylor System as it is in vogue where he is working. Then there will be an address on the Schwab Bonus System by some prominent member of the Bethlehem Steel Co. In an endeavor to bring about closer coöperation between the several engineering societies of the University, there will be a combined meeting of these societies in the near future.

The president of the *Armour Institute of Technology Student Branch* reports that it has repeatedly been brought before the attention of engineering students that engineers in general are greatly lacking in the presentation of papers or as factors in a general discussion. The absence of debating societies and declamation contests in the present day engineering colleges has led the student members of the Society at Armour Institute of Technology to adopt a different procedure in meetings for 1916-17 than has been followed in years previous. At each semi-monthly meeting, three or four members will be called upon for 5-minute talks on subjects as they themselves shall select. After each talk a general discussion on the speaker's topic will take place. During the discussion every member will be called upon for a short extemporaneous speech on one or other of the 5-minute talks.

The addresses by prominent engineers and lecturers for the year will be attended by the Civil, Chemical, Electrical, Fire Protection and Mechanical societies coöperatively.

The A.S.M.E. smoker given in honor of the mechanical engineering students of the class of '18 was very successful. A banquet to be given before the Christmas holidays is contemplated.

The Student Branch of the Society at the *University of Kentucky* will hold bi-monthly meetings throughout the college year. Technical magazines will be closely studied by all the members, each of whom will report on the contents of the particular magazine assigned to him. In this way a large number of the engineering problems that confront the technical graduate will be brought into discussion.

A smoker to which the freshmen will be invited is contemplated for the near future as an informal but effective means of arousing their interest in the work of the Mechanical Engineering department.

The officers for the Student Branch of the A.S.M.E. of *Cornell University* for the coming school year are as follows:

R. C. Carpenter, Honorable Chairman, Sibley College; W. C. Bliss, President; R. O. Compton, Vice-President; S. M. Barr, Secretary; W. W. Robertson, Treasurer.

It was decided to have as a program of meetings for the year a combination of lectures, social meetings and debates. The first lecture will be given on the subject of the Quebec bridge disaster, by Prof. H. S. Jacoby, in the first week in November. The other meetings will be arranged for later. A canvass of all the students will be made immediately to secure active members for the Branch.

The *Yale University Student Branch* is planning to have Mr. Rice speak at its first meeting to be held November 3 and have it an organization meeting open to members only. No other definite dates have been arranged as yet, but the Branch has had many good offers from some of the best men in the country on labor questions, from manufacturers wishing to send moving pictures of their business, and well-known engineers. It is its policy to have as many demonstrations as possible of recent developments in the mechanical engineering field. One 2-hour recitation period each month has been given the Branch, in which time the heads of the other engineering schools of Yale are coming in to talk. This time will also be used for debates among the members and with other Engineering Student Organizations here.

In the winter term an exhibition in the laboratory to promote interest in Mechanical Engineering will be held. All the apparatus and machines will be run by the students and the opportunity to see what is being done in the Mechanical Engineering Department will be afforded to everyone.

There seems to be an unusual amount of interest in the Branch as is shown by a large increase in membership and the Branch is looking forward to a most successful year.

The officers for 1916-1917 are Graham M. Brush of Greenwich, Conn., President, and Irving C. Shepard of New Haven, Secretary and Treasurer.

ROLL OF HONOR

Lists of those members enlisted or contemplating enlistment in the National Guard, the Regular Army, the Naval Militia, the Navy, and in other capacities in the services of the country, have been published monthly in The Journal since the August issue. Further names of such members received since the publication of the last list appear below.

CLUETT, SANFORD L., Major, Signal Corps, National Guard, New York

HANSELL, WILLIAM H., Private, Company B, Engineer Battalion, National Guard, Pennsylvania

HERSEY, MAYO DYER, Investigation of Aviation Instruments, U. S. Bureau of Standards

KRAUS, SIDNEY M., Lieutenant, U. S. N.

OTTO, HENRY S., Private, Squadron A, National Guard, New York

PERRY, FRANK B., Civilian Volunteer Training, Cruise U. S. Navy

SHAAD, GEO C., Associate-Member of Naval Consulting Board, Member of Kansas State Committee on Industrial Preparedness

STEEL, REGINALD A., Master Engineer of 1st Battalion, 22nd Regiment of Engineers, National Guard, New York

STRAHLMANN, O. E., Aeronautical Engineer, Office of Chief Signal Officer

TREAT, SIDNEY W., Sergeant, 7th Infantry, U. S. National Guard

TRUSCOTT, HAROLD S., Captain, Company I, 4th Infantry Regiment, National Guard, Hawaii

AMERICAN CHEMICAL EXPOSITION

The Chemical Exposition at the Grand Central Palace in New York City in October emphasized the surprising adaptability of American industries to exceptional conditions, as well as the equally surprising fact that it required these very exceptional conditions to give the American chemists a chance to show what they could do.

This exposition has also shown that, contrary to the impression still held by a good many people, this country is entitled to a full share of credit for certain splendid work done in industrial chemistry. While it is true that until lately Germany led the world in the development of synthetic dyes, in the field of heavy chemicals, and especially in petroleum technology, American chemists have done highly creditable, if not quite so spectacular, work. The oil-refining and cracking process and the creation of "casing-head" gasoline are essentially American achievements. The war has found American industries dependent for some staple articles of vital importance on foreign markets which for one reason or another could not continue to supply us. In a time measured by months problems were solved which would take years under any ordinary conditions.

That America led the world in the production of heavy steel materials was shown many years ago by Captain William Jones at the now historical meeting of the British Association, but until 1914 the highest grades of automobile steel used still came from Europe. Some of these were secret steels made according to carefully preserved recipes. In a surprisingly short time leading companies in this country have developed the production of these special steels so that their physical characteristics are in no wise inferior to the imported articles.

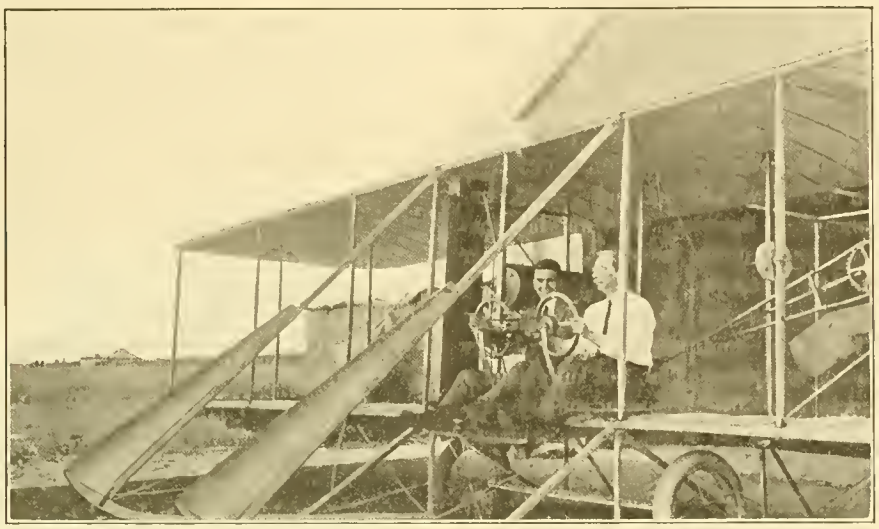
The spectacular development of the production of munitions in this country is too widely known to need more than passing mention. Less is known of the fact that, for example, this country is now leading in the production of radium and is likely to continue to do so. Even in the production of dyes, photographic chemicals and pharmaceutical products remarkable advancement has been made, especially remarkable if we consider the shortness of the time during which it was made.

A PAST-PRESIDENT'S AVIATION EXPERIENCES

A Letter from James Hartness Describing His Interesting Experiences in Aviation and Emphasizing the Importance of This New Field to Engineers

To the Editor:

My vanity or something else has suggested to me that Journal readers might be interested to know one of the uses to which ex-Presidents may be put. After my term of service I tried aviation and found it fully as preoccupying as the duties of President of the Am.Soc.M.E. I think it is one of the ways by which ex-Presidents may be kept busy.



James Hartness, Past-President Am.Soc.M.E., as Aeronaut and Pilot

Seriously, I consider the question of aeronautics one of vital importance to the members of our Society. It is distinctly an engineering problem. The aeroplane at the present stage needs the engineer more than anything else. I am looking forward to a great development in this direction within the next five years, and in view of the importance of the subject believe it should be kept prominently before our members.

One of the results of my experience in learning to fly has demonstrated the fact that it is possible for a man of my age to reach a point where he can handle a machine with reasonable safety. The Canadian Government does not take any men for training for war service who are over 23 years old. Some authorities think that good flyers cannot be made out of timber that is over 35 years of age, and, as a matter of record, I believe few men have learned after passing the fiftieth mark. I am, as you know, 55 years old, and I have gone through my course at the Wright school and passed the examination for aviator's certificate which is issued under the rules of the Federation Aeronautique Internationale, with the authority of the Aero Club of America. I have had in all over 60 flights and have been intrusted with a machine without a pilot for six flights.

I became interested in the matter of flying when taking my first flight in a Zeppelin at Leipsic during our joint meeting with the Verein deutscher Ingenieure. This was followed when the opportunity afforded by a flight in a Burgess-Dunne seaplane at Marblehead and about half a dozen flights in the Heinrich tractor at Garden City. Then I entered on a course of instruction with the Wright school which was established at Garden City last spring. The usual length of time for the regular students runs from one to two months, but my lessons were drawn out over a longer period because I spent alternating weeks at home.

I am told that the usual course of instruction in other schools begins with familiarizing the student with the working of the engine and the various controls of the aeroplane and the general behavior of the machine while on the ground. A number of runs, at first short and then longer, are taken in the machine on the ground without rising into the air. This is followed by jumps, during which the machine is allowed to rise from the ground for short distances. After that actual flights of gradually increasing duration are attempted.

The machine used was a slow-flying type known as their Type B biplane, which is practically the same as the Wright machine of eight years ago, with the wings warped to effect the banking and lateral lever control. The course was completed, however, with another machine, in which both wings were rigidly braced and flaps or ailerons were used for the lateral control.

But the instructor, Mr. Howard Rinehart, did not follow that method. He started the student first with a "joy ride." After that he allowed the student gradually to assume the control. The art of getting the machine off the ground and alighting was left to the latter part of the course. In my own experience, the order of my acquisition of the various elements of the art of flying might be summarized as follows:

I first gained the ability to keep the machine in lateral bal-

ance in flying straight away; then followed the use of rudder and warp for turning in a large circle; next the smaller circles in both right and left turns, making figure 8's, and during these flights, which vary from 2 to 10 min., I was permitted gradually to assume more and more of the control during the get-away. But the art of controlling the angle of climb and the art of landing were the last and the most difficult.

Barring unsteady air currents and machine troubles, the amateur's danger seems to lie chiefly in stalling in getting away and in flying, and in the general problem of landing.

The stalling is due to trying to climb too fast, for this retards the speed of the machine through the air and renders the control ineffective.

In steady air the experienced pilot is able to make his landing by swooping down and nicely leveling his course just to clear the ground, and let the wheels touch at the slowest speed at which the controls are effective.

The machine used is shown in the photograph. It is a slow-flying Wright biplane known as their Type B. It is practically the same as the Wright machine of eight years ago, with the wings warped to effect the banking and lateral control. The course was completed, however, with another machine, in which both wings were rigidly braced and flaps or ailerons were used for the lateral control.

In these machines, the dual control with instructor and student sitting side by side, the conditions seem ideal, for each may see what the other is doing. This not only makes it possible for the instructor to direct the student by prearranged signals, but it also leaves no doubt in the student's mind of the extent of control exercised by the instructor. In the machines in which the two sit in tandem position, the student is not always sure that the instructor has not gently changed the control.

The machines were driven with a 35-h.p. Wright engine. I have no accurate data as to the speed, but I understand it would get away from the ground at less than 30 miles an hour and could not fly over 45 miles an hour. This is a training biplane, different from the high-speed tractors which the Wright Company is building for other purposes. The slow-speed machines fly so close to a stall that they must be handled properly or they go wrong. A stall of the machine does not necessarily indicate a stall of the engine. It simply means that the aeroplane loses its speed in the air below a point at which the controls are effective. Then it is liable to side slip or do any one of the number of things that invite trouble.

The type of control used is a modification of the Wright system which brings it nearer to the Deperdussin control, called "Dep" control, but the Wright does not use the foot control rudder. For lateral balance the "Dep" control uses a wheel located about the same as an automobile steering wheel, only in normal position it is vertical instead of inclined. Turning the wheel to the right or left tips the machine in similar directions. The wheel is pivoted to the frame, on which it may be moved forward and back, and this motion controls the elevator which raises or lowers the course of the machine. The Wright rudder is a lever on this hand wheel which is similar to the throttle of an automobile.

This letter may seem very elementary, especially to the aeronautical members of the Society, but in view of the newness of the art I think we should not hesitate to set forth the subject in a way to benefit those who have not entered into it.

I am sending a photograph showing the two seats of the aeroplane occupied by the youngest and oldest members of the class. Mr. Mott from Winnipeg is the younger man. He is one of the many Canadians who have come to this school to train preparatory to entering the British aviation service.

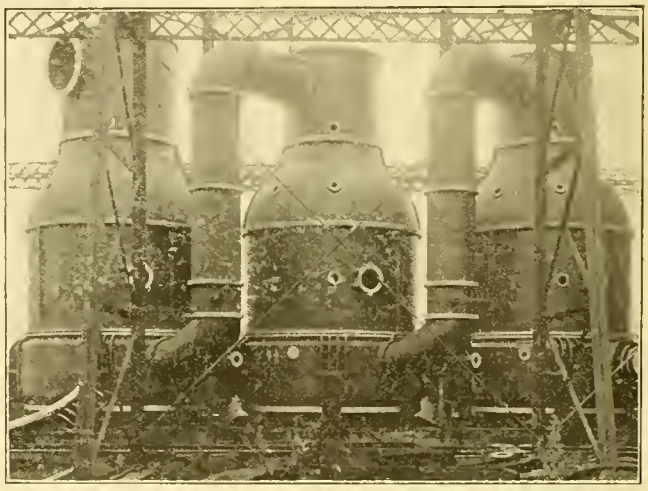
Yours sincerely,

James Hartness.

BIRMINGHAM SECTION INSPECTION TRIP

Our new Section at Birmingham has formed the opinion that not only is the "inspection trip" type of meeting beneficial to the members, but that it has also a great value in the stimulating of interest among the manufacturers and managers of large works and will do much toward bringing the engineering profession into public notice and recognition.

The first meeting of the Section for this season, held on September 16, was of the nature of an inspection trip through two of the local manufacturing establishments, and R. E. Brakeman, chairman, considers that the meeting was one of the best the Section has had and reports that the next trip is looked forward to with interest. In Mr. Brakeman's own words:



Vacuum Pans Partially Erected at Works of Coyne and Joubert Foundry Co.

The members of the Section met at 1:30 p.m. at the Tutwiler Hotel, where automobiles were in waiting to carry them for the trip.

The first stop was made at the Avondale Works of the Continental Gin Company, which has two factories and its central office in Birmingham. Mr. R. S. Munger, a pioneer developer of ginning machinery, and his two sons met the members and escorted them through the plant. We first visited the experimental laboratory, where a four-gin unit was set up for our inspection. The principal features of construction and design were explained to us, the unit was put into operation, and the members were given an opportunity to see cotton ginned and baled.

From the laboratory we were taken through the factory and shown how the saws were stamped out, how the fine teeth were made and how these teeth were filed and sharpened.

The next factory visited was the plant of the Coyne & Joubert Foundry Company. This company makes a specialty of large loam castings and at present is engaged almost entirely on orders for sugar-making machinery. The illustration shown gives an idea of the large size of castings made in this shop; these vacuum pans range from 12 to 15 ft. in diameter. The general manager, Mr. Goslin, conducted our party through his shop and showed every part of the works to us.

APPLICATIONS FOR MEMBERSHIP

MEMBERS are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every Member to promote. Unless objection is made to any of the candidates posted by December 10, 1916, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected will be notified about January 15, 1917.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

AKIMOFF, N. W., Mechanical Engineer, Dynamic Balancing Machine Co., Philadelphia, Pa.

BROWN, LEWIS K., Vice-President, The Burton-Townsend Co., Beverville, Ohio

BRYAN, ALBERT H., Supervising Chemist, Arbuckle Bros., New York

CARRELL, WILLIAM A., In charge of Tractor Motors, International Harvester Co., Milwaukee, Wis.

CASHEN, HENRY C., Master Mechanic, The Bradley & Hubbard Mfg. Co., Meriden, Conn.

CHISHOLM, CHARLES R., Cristobal Shops, Panama Canal, Cristobal, C. Z.

CROCKER, ERNEST B., Mechanical Engineer, The Ashcroft Mfg. Co., Bridgeport, Conn.

FLYNN, CHARLES A., Superintendent, Park Row Building, New York

HERNON, JOSEPH L., Superintendent of Engineering, Repair Dept., Douglas Robinson, Charles S. Brown Co., New York

IMESON, CHARLES V., Resident Engineer for "The Quebradas Co.," La Quebradas, Guatemala, C. A.

JACKMAN, CHESTER C., Factory Manager, Massachusetts Saw Works, Springfield, Mass.

KENDALL, MYRON A., Chief Engineer and Superintendent, Stephens-Adamson Mfg. Co., Aurora, Ill.

LANDFEAR, GEORGE H., Works Engineer, Kathodion Bronze Works, Nyack, N. Y.

LINKER, HARRISON S., Squad Foreman, Drawing Room, Cambria Steel Co., Johnstown, Pa.

McILTON, JOHN P., Designing and Inspecting Engineer, Locomotive Superheater Co., New York

MUELLER, HERMANN, Manager Laidlaw Sales Dept., Worthington Pump & Machinery Corp., Cincinnati, Ohio

PERRY, OLIVER N., Mechanical Engineer, Ashcroft Mfg. Co., Bridgeport, Conn.

PUGH, ACHILLES H., President, The A. H. Pugh Printing Co., Cincinnati, Ohio

RADDANT, WALTER C., Chief Engineer, Elia Sugar Co., Elia, Province de Camguay, Cuba

RANDEL, B. F., Mechanical Engineer, Los Angeles Gas & Electric Corp., Los Angeles, Cal.

RENKIN, WILLIAM O., Chief Engineer, A. M. Byers Co., Pittsburgh, Pa.

SCHATZ, WILLIAM J., Lubrication Engineer, Platt & Washburn Co., New York

SHARPE, GEORGE H., Mechanical Engineer, New York Central Railroad, New York

SHAW, JOHN C., In charge Special Design, Keller Mechanical Engraving Co., Brooklyn, N. Y.

STEVENS, EDSON M., Consulting Engineer, Stevens & Stiles, Kansas City, Mo.

STINSON, IRVING J., Chief Draftsman, American Steel & Wire Co., New Haven, Conn.

STRENG, LEWIS S., Superintendent Electric Dept., Louisville Gas & Elec. Co., Louisville, Ky.

WAGENSEIL, EDGAR W., with Burke Furnace Co., Chicago, Ill.

WILLIUS, GUSTAV, JR., Mechanical Engineer, Robinson, Cary & Sands Co., St. Paul, Minn.

WILSON, JOSEPH H., Assistant to General Superintendent, The American Rolling Mill Co., Middletown, Ohio

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BACHMEYER, WALTER G. C., formerly with Walter Kidder, Engineer and Constructor, New York

BAKER, DONALD A., Chief Tool Designer, Williams Mfg. Co., Ltd., Montreal, Canada

BARKELEW, JAMES T., Engineer and Patent Attorney, Los Angeles, Cal.

BAUMGARTNER, ARTHUR A., Draftsman, Thomas Devlin Mfg. Co., Burlington, N. J.

BAYLIS, JOHN R., Manager Water Works, Jackson, Miss.

BIGELOW, CARLE M., Efficiency Engineer, Cooley & Marvin Co., Boston, Mass.

BREWER, ALLEN F., Inspector, Appraisal Dept., Board of Public Utility Commissioners, State of New Jersey, Newark, N. J.

CHUCAN, JOHN, Designer, Tractor Works, International Harvester Corp., Chicago, Ill.

ELSTON, SIDNEY B., Chief Draftsman, Climax Mfg. Co., Corry, Pa.

FINN, STEPHEN M., Assistant Engineer, American Engineering Co., Philadelphia, Pa.

HEEKIN, DANIEL M., Superintendent, The Heekin Can Co., Cincinnati, Ohio

HUXFORD, GEORGE T., Designing Engineer, Builders Iron Foundry, Providence, R. I.

JOHNSON, ASHMORE C., With Coatesville Boiler Works, Philadelphia, Pa.

KEENAN, WALTER M., Assistant to Mechanical Engineer, New York Edison Co., New York

KOSSIF, NISSIM, Engineer of Tests, Schaum & Uhlinger, Inc., Philadelphia, Pa.

MARSH, FRANCIS G., Lieut. (Jr. Grade), U. S. Navy, Post Graduate Course, Columbia University, New York

SHANLEY, FREDERICK R., Efficiency Engineer, Staff of L. V. Estes, Inc., Chicago, Ill.

WOLFF, WILLIAM S., Graduate, University of Minnesota, 1916, St. Paul, Minn.

FOR CONSIDERATION AS JUNIOR

AAGAARD, ARTHUR H., Instructor, Steam & Gas Engineer, College of Mechanics and Engineering, University of Wisconsin, Madison, Wis.

AMES, JOHN H., Engineering Division, The Lunkenheimer Co., Cincinnati, Ohio

BARKER, GEORGE S., Draftsman, Niles-Bement-Pond Co., New York

DIETRICH, FRED C., Assistant to Chief Engineer, Standard American Dredging Co., Oakland, Cal.

EBERHARDT, JOHN D., Draftsman, Plan Dept., Associated Factory Mutual Ins. Cos., Boston, Mass.

EHRHARDT, JOHN J., Assistant Engineer, American Sugar Refining Co., Brooklyn, N. Y.

HENLEY, ERL K., 2nd Assistant Engineer, Naval Auxiliary Service, U. S. S. "Nereus," New York

HOBART, JAMES C., JR., The Le Blond Machine Tool Co., Cincinnati, Ohio

HORN, NORMAN E., On staff of Walter B. Snow & Staff, Boston, Mass.

HULBURT, Wynne D., Rate Setter, German-American Button Co., Rochester, N. Y.

KENT, Robert W., Industrial Engineer, Cooley & Marvin Co., Boston, Mass.

KRAMPE, Hugo J., With Armstrong Cork & Insulation Co. of Pittsburgh, Pa., Cincinnati, Ohio

PROZAN, Moses, Draftsman, Brunswick Refrigerating Co., New Brunswick, N. J.

SHETLAND, Walter A., Industrial Engineer, Remington Arms & Ammunition Co., Bridgeport, Conn.

WOOD, Charles E., In charge Erection New Foundry, Lunkenheimer Co., Cincinnati, Ohio

WOODCOCK, William E., Special Apprentice, New York Central R. R., West Albany, N. Y.

WOODWARD, Hiram W., with Alex. Brown & Sons, Baltimore, Md.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

LUNDGREN, Frederick G., Master Mechanic & Efficiency Engineer, American Car & Fdy. Co., Milton, Pa.

PROMOTION FROM JUNIOR

BAILLIERE, Marion V., Mechanical Engineer, New York Central R. R. Co., Cleveland, Ohio

DAUCHY, Samuel E., General Superintendent, Worcester Mfg. Co., Worcester, Mass.

GILLAN, Howard A., Assistant Engineer with Consulting Engineer, Union Pacific System, New York

KOCH, William H., Jr., Consulting Engineer, Staff with Meyer, Morrison & Co., Inc., New York

RICHARDSON, George P., Assistant Engineer, Isbell-Porter Co., Newark, N. J.

RUPPEL, Richard, Chief Engineer, J. Byers Holbrook (Griggs & Holbrook), Consulting Engineer, New York

UNDERWOOD, Charles N., Head Time Study Department, Remington Typewriter Works, Ilion, N. Y.

SUMMARY

New Applications	65
Applications for change of grading:	
Promotion from Associate-Member	1
Promotion from Junior	7
Total	73

SUMMARY SHOWING AVERAGE AGE AND POSITIONS OF APPLICANTS ON BALLOT CLOSING SEPTEMBER 26, 1916

Average Age of Applicants:

Members	44
Associates	40
Associate-Members	34
Juniors	24

Classifications of Positions Held:

Cadet Engineer	1
Chemical Engineers	2
Chemical Engineer (Asst.)	1
Chief Engineers	15
Chief Engineer (Asst.)	1
Commercial Engineer	1
Construction Engineers	5
Construction Engineer (Asst.)	1
Consulting Engineers	7
Cons. Marine Engineer	1
Designers	10
Draftsmen	15
Draftsmen (Chief)	4
Draftsmen (Asst. Chief)	3
Efficiency Engineers	2
Electrical Engineers	2
Experimental Engineer	1
Engrg. Examiner	1
Executives (Pres., Vice-Pres., Treas., Secys., Mgrs.)	34
Head Educational Dept	1
Industrial Engineers	2
Inspectors	6
Inspector (Asst.)	1
Laboratory Asst	1
Mechanical Engineers	28
Mechanical Engineers (Asst.)	14
Operating Engineer	1
Production Engineer	1
Professors (Asst.)	4
Sales Engineers	8
Sales Engineer (Asst.)	1
Students	9
Superintendents	15
Superintendents (Asst.)	7
Safety Engineers	2
Steam Engineers	4
Supervising Engineers	4
Service Engineer	1
Spcl. Exper. Engineer	1
Utility Engineer	1
Works Manager	1
Works Manager (Asst.)	1
Ballistic Engineer (Asst.)	1
Advisory Engineer	1
Master Mechanic	1
Manufacturer	1
Junior Mechanical Engineer	1
Miscellaneous	18
Unemployed	4

GEOGRAPHICAL LIST

(Applications for promotion will be indicated by the initials of the grade)

California
Los Angeles—Barkelew, J. T.
Randel, B. F.
Oakland—Dietrich, F. C.

Canal Zone
Cristobal—Chisholm, C. R.

Canada
Montreal—Baker, D. A.

Central America
Las Quebradas—Imeson, C. V.

Connecticut
Bridgeport—Crocker, E. B.
Perry, O. N.
Shetland, W. A.
Meriden—Cashen, H. C.
New Haven—Stinson, I. J.

Cuba
Elia—Raddant, W. C.

Illinois
Aurora—Kendall, M. A.
Chicago—Chucan, J.
Shanley, F. R.
Wagenseil, E. W.

Kentucky
Louisville—Streng, L. S.

Maryland
Baltimore—Woodward, H. W.

Massachusetts
Boston—Bigelow, C. M.
Eberhardt, J. D.
Horn, N. E.
Kent, R. W.
Springfield—Jackman, C. C.
Worcester—Dauchy, S. E. (J)

Minnesota
St. Paul—Willius, G. Jr.
Wolff, W. S.

Mississippi
Jackson—Baylis, J. R.

Missouri
Kansas City—Stevens, E. M.

New Jersey
Burlington—Baumgartner, A. A.
New Brunswick—Prozan, M.
Newark—Brewer, A. F.
Richardson, G. P.

New York
Brooklyn—Ehrhardt, J. J.
Shaw, J. C.
Ilion—Underwood, C. N. (J)
New York—Bachmeyer, W. G. C.
Barker, G. S.
Bryan, A. H.
Flynn, C. A.
Gillan, H. A. (J)
Henley, E. K.
Hernon, J. L.
Keenan, W. M.
Koch, W. H. Jr. (J)
McJilton, J. P.
Marsh, F. G.
Ruppel, R. (J)
Sebatz, W. J.
Sharpe, G. H.
Nyack—Landfear, G. H.
Rochester—Hulburt, W. D.
W. Albany—Woodcock, W. E.

Ohio
Beverville—Brown, L. K.
Cincinnati—Ames, J. H.
Heekin, D. M.
Hobart, J. C., Jr.
Krampe, H. J.
Mueller, H.
Pugh, A. H.
Wood, C. E.
Cleveland—Bailliere, M. V. (J)
Middletown—Wilson, J. H.

Pennsylvania
Corry—Elston, S. B.
Johnstown—Linker, H. S.
Milton—Lundgren, F. G. (A. M.)
Philadelphia—Akimoff, N. W.
Finn, S. M.
Johnson, A. C.
Kossif, N.
Pittsburgh—Renkin, W. O.

Rhode Island
Providence—Huxford, G. T.

Wisconsin
Madison—Aagaard, A. H.
Milwaukee—Carrell, W. A.

PERSONALS

In these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

CHANGES OF POSITION

J. S. Kerins, formerly draftsman with the New York Edison Company, New York, has become affiliated with The Dayton Power and Light Company, Dayton, O.

E. W. Kerr, professor of mechanical engineering at the Louisiana State University, Baton Rouge, La., has become identified with the Cuba Cane Sugar Corporation, Havana, Cuba.

Thomas Richardson has entered the employ of Franco-Swiss Dyes, Inc., New York. He was formerly connected with W. S. Barstow and Company of New York, in the capacity of chief draftsman.

R. W. Rogers, formerly in the employ of the Erie Railroad Company, New York, has accepted the position of chief engineer of The Superno Company, New York.

J. H. Tuvin, formerly identified with the Scientific Materials Company, Pittsburgh, Pa., has become manager of The Tuvin Company, sales engineers of the same city.

John H. Wynne, formerly identified with the Montreal Locomotive Works, Ltd., Montreal, Que., Canada, in the capacity of manager, has become associated with the American Locomotive Company, New York.

Herbert C. Hunter has resigned his position with the Otis Elevator Company, Harrison, N. J., as shop engineer of escalators, to accept the position of manager of the printing and engraving business of Walter Hunter.

Allen V. Moyer has resigned his position as mechanical engineer with The Geo. T. Ladd Company, Pittsburgh, Pa., to assume the duties of chief draftsman and assistant chief engineer of Struthers-Wells Company, Warren, Pa.

Frank A. Burr has resigned from his position as professor in power plant economics and design at Pennsylvania State College, to assume the responsibilities of director of a school of automobile engineering in Brooklyn, N. Y.

Robert W. Morse has resigned as assistant examiner in the United States Patent Office, Washington, D. C., and has accepted a position as patent attorney with the firm of Foster, Freeman, Watson and Coit, Washington, D. C.

W. L. Bean, formerly mechanical engineer with the Oxweld Railroad Service Company, Chicago, Ill., has accepted the position of expense and method analyst with the New York, New Haven and Hartford Railroad Company, Boston, Mass.

H. S. Dickerson, until recently assistant professor of mechanical engineering at Purdue University, Lafayette, Ind., has been appointed professor of mechanical engineering at the School of Mines and Metallurgy of the University of Missouri, Rolla, Mo.

Harry A. Atwater has assumed the position of fuel engineer with the Central Coal and Coke Company, Kansas City, Mo. He was until recently in the employ of the Union Stock Yard and Transit Company, Chicago, Ill., in the capacity of mechanical engineer.

Alex. Vallance has accepted the position of assistant professor of experimental engineering at the Georgia School of Technology, Atlanta, Ga. He was until recently instructor of theoretical and applied mechanics at the University of Illinois, Urbana, Ill.

Will H. Baltzell, formerly with the Crucible Steel Company, Aetna Explosives Company and lately with the Mackintosh, Hemphill Company, Pittsburgh, Pa., has been appointed chief engineer of the Canadian Steel Corporation, Ltd., at Ojibway, Ontario, Canada.

Joseph Esherick has resigned as manager of the valve and specialty department of the Yarnall-Waring Company of Philadelphia, Pa., to become the Philadelphia representative of The D. Connelly Boiler Company, National Steam Pump Company and the Foxboro Company.

Claude M. Barron, who for the past five years has been studying and cultivating the Australasian market for railway supplies, machine tools and raw materials, has assumed the duties of consulting and purchasing engineer with Charles M. Terry, Inc., of Sydney, Australia, with offices in New York. Mr. Barron was, until recently, associated with R. W. Cameron and Company, New York, in the capacity of consulting engineer.

ANNOUNCEMENTS

Morris Kind has become associated with the Hercules Cement Corporation of Philadelphia, Pa.

Crosby Field-Frank announces that in accordance with a recent court decision, his legal name is Crosby Field.

A. W. Foote, president of the Foote-Burt Company, Cleveland, O., builders of drilling machinery, has been elected president of the H. A. Lozier Company, automobile builders of Cleveland, O.

Ross Anderson, manager of production of the Poole Engineering and Machine Company, Baltimore, Md., has assumed general management of the shops and has been given the title of works manager.

Robert E. Hall, vice-president of the Goulds Manufacturing Company, located formerly at Seneca Falls, N. Y., is now in charge of the Chicago office and Northwestern territory, with offices at 12 S. Clinton St., Chicago, Ill.

Robert R. McKechnie, who has acted for many years as mechanical engineer and assistant to the general manager of The Variety Iron and Steel Works Company, Cleveland, O., has resigned his services with that company.

Cary T. Hutchinson has been selected as the executive secretary of the Engineering Foundation to represent the engineering professions in the organization of the National Research Council proposed by the National Academy of Sciences.

George S. Hessenbruch has left the employ of the Union Electric Light and Power Company and the St. Louis County Gas Company, St. Louis, Mo., and has opened offices in the same city for the practice of gas engineering, with special attention to the by-product end.

Guy L. Bayley, who was chief of the mechanical and electrical departments of the Panama-Pacific International Exposition, has opened an office as consulting engineer in the First National Bank Building, San Francisco, Cal. Mr. Bayley is at present engaged in building an hydroelectric plant for the Department of the Interior in the Yosemite Valley on the Merced river.

W. P. Barba, vice-president of the Midvale Steel Company, Philadelphia, Pa., has severed a many years' connection with that company, during which he has occupied many positions of responsibility. He plans to spend some time in travel and later will engage in special work for which his long experience has fitted him, such as the manufacture of ordnance, guns, armor plate and high grade shell products.

Carl L. Svensen opened an evening school of drafting, on October 3, to be known as the Ohio Technical Drawing School, in Columbus, O. The purpose of the school is to furnish an opportunity for draftsmen, machinists, pattern makers, molders and others engaged in mechanical lines to study drawing as a means to increasing their earning power. The addition of courses in mechanism, mechanics and strength of materials and machine design is planned for the near future.

Ford W. Harris of Los Angeles, Cal., who has been Acting Secretary of the Los Angeles Section of this Society since its inception, was on October 5, 1916, admitted to practice law before the courts of the State of California. Mr. Harris is, therefore, in addition to being a member of this Society and a Fellow of the American Institute of Electrical Engineers, an attorney-at-law. Mr. Harris' practice is, however, limited to patent causes, which generally involve in a large measure engineering questions.

APPOINTMENTS

Hazen G. Tyler has been appointed instructor in mechanical engineering at the Rensselaer Polytechnic Institute, Troy, N. Y.

Charles M. Reed has been appointed instructor in marine engineering at the United States Naval Academy, Annapolis, Md.

Walter MacGregor has been appointed general manager of Plant No. 4 of the Timken Detroit Axle Company, located in Canton, O.

S. R. Willock, who has been assistant general manager of sales of The William Tod Company, Youngstown, O., since June, 1915, has been appointed general manager of sales, vice R. D. Day.

AUTHORS OF PAPERS, ETC.

William Knight has contributed an article on The Mechanical Design of Turbo-Generators to the October 17 issue of *Power*.

John Younger has contributed a brief article on Inspecting High-Grade Gears to the October 5 issue of the *American Machinist*.

W. E. Moore has contributed an article on One-Man, Light-Weight Electric Railway Cars, to the October number of *The Electric Journal*.

W. H. Timbie is co-author with H. H. Higbie of a book, recently issued, on Alternating Current Electricity and its Applications to Industry

C. F. Hirshfeld and T. C. Ulbricht are joint authors of a book on Steam Power. This is one of the John Wiley and Sons' technical series of books for vocational schools.

Walton Clark, president of The Franklin Institute, is the author of A Century of Light, graduating address of the Institute's school, in the October *Journal of The Franklin Institute*.

John E. Ericson, city engineer of Chicago, was among the speakers at the October 6 "membership booster dinner" of the American Association of Engineers, held at the City Club, Chicago, Ill.

Joseph A. Steinmetz, president of the Aero Club of Pennsylvania, presented a paper on Aerial Warfare and Some Devices Terrestrial and Submarine at the October 26 meeting of the Engineers' Club of Trenton.

Frank B. Gilbreth, expert on management and time-study work gave an illustrated lecture on Motion Study—The Science of Obtaining Least Waste, at the October 20 meeting of the Detroit Engineering Society.

William C. L. Eglin presented a paper entitled Power Company's Problem in the Electric Supply for Large Single-Phase Loads at the October 13 meeting of the American Institute of Electrical Engineers held in Philadelphia, Pa.

G. Laurence Knight presented a paper at the October 12 meeting of the Brooklyn Engineers' Club on The Construction of the Foundations for Two Large Turbo Generator Sets and for a Building under Similar and Difficult Sub Surface Conditions.

Morris L. Cooke, acting director of the Utilities Bureau, Philadelphia, Pa., delivered an address before the City Club of Chicago on October 10, on The City and Its Public Utilities, in which he showed the need for the bureau and its work and made a plea for its support.

Edwin D. Dreyfus is the author of Graphic Analyses of Managerial Problems which appears in the October 7 number of *Electrical World*. The author cites instances when curves and diagrams are of great practical value in facilitating the solution and understanding of the problems of investment, revenue and expense.

NECROLOGY

HENRY FISLER RUGAN

Henry Fisler Rugan was born in Philadelphia, July 7, 1857, and died in New Orleans, September 3, 1916.

In 1864, his parents removed to Terre Haute, Indiana, where he received his education in the public schools. Later he attended Smithson College, Logansport, Indiana, where he completed his studies. He left college to become an employee of the Terre Haute and Indianapolis Railroad in Terre Haute as an apprentice-machinist, remaining with the company until 1880, in the meantime advancing to the position of foreman of one of the erecting gangs.

After two years, spent in various parts of the country working for several railroads, he returned to Terre Haute to accept a position of instructor in the Rose Polytechnic Institute. He remained with the Institute for nearly three years, leaving it to accept the position of foreman of the railroad shops of the Texas and Pacific Railroad at Big Springs, Texas. He continued with this road for five years, advancing to a position where he had charge of a division and was located in Longview and Marshall, Texas, and in Gouldsboro, Louisiana.

Leaving railroad work, he became identified with the sugar industry as chief engineer and superintendent on several large plantations of Louisiana.

In 1895, Professor Rugan accepted the position of Instructor in Mechanic Arts at Tulane University of Louisiana, in New Orleans. Here he spent the last twenty-one years of his life. He was soon advanced to the grade of Assistant-Professor, later to that of Associate-Professor and finally to that of Professor of Mechanic Arts.

He spent the year 1898-9 in Europe, most of the time at Manchester University, where he, in collaboration with Professor Carpenter of that institution, conducted extensive research work upon The Growth of Cast Irons After Repeated Heatings. The results of the work were published in the Journal of the Iron and Steel Institute, 1909. A further paper in the same Journal in 1912 was devoted to details of this work. Professor Rugan was also a contributor to the discussion of similar problems in this Society.

Mr. Rugan was devoted to the Masonic order, and received many honors from that organization.

He became a member of the Society in 1900.

ROBERT CAIRD

Robert Caird, a managing director of the old family shipbuilding and engineering company of Caird & Co., Greenock, Scotland, was born on May 22, 1852. He was educated at the Grange School, Sunderland, at the Greenock Academy, and at Glasgow University. He entered his father's works as an apprentice-engineer, continuing at this time for eleven years in the business. The years of 1881-2 he spent with the Maritime Construction Co., of Havre, and in the two following years was engineer-in-charge of construction for the Pullman Co. of Chicago. In 1888 he returned to his father's business and became one of the managing directors, taking special charge of the engineering department.

Dr. Caird was a member of the Royal Society of Edinburgh, the Institute of Metals, the Philosophical Society of Glasgow and the Philosophical Society of Greenock, and became a member of the Institution of Civil Engineers in 1900. From 1899-1901 he was president of the Institution of Engineers and Shipbuilders in Scotland.

In 1900 Glasgow University conferred upon him the honorary degree of Doctor of Laws. This was a well-merited distinction, and in bestowing it upon him the Faculty of Law gave the following reason: "His eminence as a shipbuilder has already won for him the gold medal of the Institution of Engineers and Shipbuilders in Scotland and the presidentship of that important body. The University which possesses the only British Chair of Naval Architecture may well associate herself with the Royal Society of Edinburgh in marking her appreciation of Mr. Caird's valuable contributions to this branch of applied science. We cannot keep out of view the interest which Mr. Caird has displayed in the present movement for the improvement and extension of the scientific side of the University. Mr. Caird is not merely a practical man. Following the early traditions of Scots students, Mr. Caird completed on the Continent the education he began here. In the course of several years' residence abroad he acquired an intimate and extensive acquaintance with the language and literature of France, Germany, and Italy, and he was also privileged to carry on important investigations in the domain of history and art under the direction of Mr. Ruskin. His labors in this department were recognized in 1895, when he was created a Knight of the Crown of Italy. His papers, lectures and addresses on the subject in which he is interested display not merely solid erudition, but marked literary charm."

Dr. Caird was a close student of the work of James Watt, and in 1910 delivered the Watt Anniversary Lecture before the Greenock Philosophical Society. This lecture was a characteristically scholarly memoir of Watt's contributions to the advancement of engineering. Dr. Caird was much interested in technical education, and was the author of several monographs on this subject, including The Study of Science in Relation to Education and Technical Education.

He was an active supporter of institutions in the city of Greenock. He was prominent in the founding of the James Watt Memorial School, and took the part of a captain of industry in connection with a number of local business and philanthropic institutions.

He was elected to membership in the Society in 1884. He died at his home at Greenock on December 1, 1915.

ELMER NEILL STACY

Elmer Neill Stacy was born on December 11, 1876, in Minneapolis, Minn. He received his early education at the District School and the Central High School, Minneapolis, and was graduated from the College of Engineering, University of Minnesota, in 1907. Before entering college he spent about three years in the drafting department of the Plano Manufacturing Company at West Pullman, Ill. After graduation he was employed by the Minneapolis Threshing Machine Company as draftsman and designer, and did considerable work on the testing floor. About June, 1908, he associated himself with the Decarie Incinerator Company as assistant to the general manager, and in March, 1909, he became general manager of the company, directing the design and construction of refuse disposal plants.

In April, 1914, the Stacy Bates Company was organized with Mr. Stacy as president, and arranged for the exclusive sale of the Decarie Incinerator Company's plants. He joined this company and performed the same work as with the Decarie Company.

Mr. Stacy was a member of the Sigma Xi and the Tau Beta Pi Fraternities. He became a member of the Society in 1911. He died on September 9, 1916.

ROBERT COCHRAN MCKINNEY

Col. Robert Cochran McKinney was born at Troy, N. Y., on January 20, 1852, and died on October 3, 1916. His parents moved in 1861 to Cincinnati, where he attended the public schools and Woodward High School until 18 years of age. In 1872 he entered Cornell University and took a partial course in mechanical engineering. Following this he was employed at Hamilton in the drafting room and office of a company manufacturing steam pumping machinery.

In 1877, Mr. McKinney became associated with the Niles Tool Works. Within two years he was elected secretary of the company and a little later treasurer and general manager. Under his skillful management the company grew until the business was recognized and capitalized at $2,000,000. Shortly after this, when it was necessary to secure additional property, the plant and the business of the Cope and Maxwell Manufacturing Company whose products were steam pumps was bought by the Niles Tool Works Company; later the machinery and business of the Cope and Maxwell Company was sold to another corporation and became a part of the International Steam Pump Company.

In 1898 the Niles Tool Works Company purchased control of the Pond Machine Tool Company of Plainfield, N. J., the purchase being supplemented by options on the works of Bement, Niles & Company of Philadelphia, Pa., as well as the Philadelphia Engineering Works. The company thus created is known widely as Niles-Bement-Pond Company, of which Colonel McKinney was president.

Other purchases have been made by this company including the Pratt & Whitney Company of Hartford, the Bertram Company of Canada and the Ridgway Machine Company of Ridgway, Pa.

Colonel McKinney was a member of the Union League Club, Sotos, Engineers' and Cornell Clubs of New York, the Hartford Club of Hartford, and the Queen City Club of Cincinnati, and was president of the Machinery Club of New York. He became a member of the Society in 1890.

FRANKLIN MCMILLAN STANTON

Franklin McMillan Stanton was born in New York City on May 23, 1865, and died on September 12, 1916.

Following a course of public school instruction, he entered Columbia University, graduating from the School of Mines in 1887. He immediately took up his profession, working as a surveyor and assayer for about two years, when he decided to embark in the mining field on his own account. The undertaking proved successful and led to his long connection with the Superior companies.

After a few years he was offered a position with the Atlantic Mining Company, which he accepted, soon advancing to the post of superintendent. He served in that capacity for twenty-three years, improving mining methods and creating what was considered one of the best organizations in the mining field.

Because of failing health, Mr. Stanton retired in 1910, visited most of the European countries and availed himself of the opportunity to study the mines of the Continent.

In 1914 he became treasurer and director of the Mohawk

Mining Company, the Wolverine Copper Mining Company, which controls some of the best territory in America's principal copper district and the Michigan Copper Mining Company. He was also treasurer of the White Pine Extension Copper Company which has recently been organized.

In addition to his activities in the mining field, Mr. Stanton was identified with several other enterprises. He was president and a director of the Ft. Mountain Talc Company, which operates a mine in northern Georgia, where talc abounds, and was also a director of the First National Bank, Houghton, Mich., the Ohio and Kentucky Railroad, which penetrates the coal region of those states, the Copper Range Co., etc.

A large number of professional, social and patriotic organizations included Mr. Stanton in their membership. He was a member of the American Society of Civil Engineers, American Chemical Society, American Forestry Association, American Institute of Mining Engineers, American Revolver Association, American Mining Congress, Life Membership; American Society for Prevention of Cruelty to Animals, American Museum of Natural History, Burns Society, American Automobile Association, Psi Upsilon Fraternity, Lambda Chapter; Washington Continental Guards, The Navy League of the United States, Life Membership; Seventh Infantry N. G. N. Y., Regimental Mess, Life Membership; Seventh Regiment Veteran and Active League, Society of Upper Eighties of Columbia University, St. George's Society, Sons of the Revolution, Society of Colonial Wars, United Engineering Society, Columbia College Alumni, Houghton Life Infantry, Horticultural Society of New York, Lake Superior Mining Institute, Michigan State Rifle Association, Life Membership; National Security League, Life Membership; National Rifle Association and the Columbia University Athletic Association. He was also a member of a number of social clubs. He became a member of the Society in 1892.

SOCIETY MEETINGS

MEETINGS of the Society are now being held regularly at established Sections at Atlanta, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Indianapolis, Los Angeles, St. Paul and Minneapolis (Minnesota Section), New Haven, New Orleans, New York, Philadelphia, St. Louis, San Francisco and Worcester; also the Providence Engineering Society, which is affiliated with our Society, holds regular meetings. Sections are in prospect at Baltimore, Erie, Kansas City, Meriden and Rochester.

ORGANIZING A SECTION

The Committee on Sections is anxious to have the number of Sections extended to all centers where the membership is sufficiently large to warrant the holding of regular meetings. In the places where Sections are now established, those participating in the work find it interesting and beneficial, and much good has resulted to the individual members as well as to the Society.

A Section of the Society may and preferably should coöperate with and help build up the local engineering organizations by the holding of joint meetings, and invite all members of such organizations and all engineers generally to its meetings. This phase of Section work has been specially well developed at several large cities represented on our Section list.

The Society is willing to assist groups of members in the organizing and developing of Sections, both by appropriation to cover fixed expenses and by advice regarding lines of activity.

It is suggested that in places in which the membership in the Society is over twenty some member or members take the initiative in organizing a meeting to discuss the advisability of petitioning the Council for the formation of a Section.

STUDENT BRANCHES

The Society has now affiliated with it forty Student Branches, which are independent organizations of students in the following educational institutions:

Armour Institute of Technology.....Chicago, Ill.
Bucknell College .....Lewisburg, Pa.
Carnegie Institute of Technology.....Pittsburgh, Pa
Case School of Applied Science.....Cleveland, Ohio
Colorado State Agricultural College...Fort Collins, Colo.
Columbia University .....New York
Cornell University .....Ithaca, N. Y.
Georgia School of Technology.....Atlanta, Ga.
Kansas State Agriculture College.....Manhattan, Kan.
Lehigh University .....So. Bethlehem, Pa.
Leland Stanford Jr. University, Stanford University, Cal.
Louisiana State University.....Baton Rouge, La.
Massachusetts Institute of Technology, Cambridge, Mass.
New York University.....New York, N. Y.
Ohio State University.....Columbus, Ohio
Pennsylvania State College.....State College, Pa.
Polytechnic Institute of Brooklyn.....Brooklyn, N. Y.
Purdue University .....Lafayette, Ind.
Rensselaer Polytechnic Institute.....Troy, N. Y.
State University of Iowa.....Iowa, Ia.
State University of Kentucky.....Lexington, Ky.
Stevens Institute of Technology.....Hoboken, N. J.
Syracuse University .....Syracuse, N. Y.
Throop College of Technology.....Pasadena, Cal.
University of Arkansas.....Fayetteville, Ark.
University of California.....Berkeley, Cal.
University of Cincinnati.....Cincinnati, Ohio
University of Colorado.....Boulder, Colo.
University of Illinois.....Urbana, Ill.
University of Kansas.....Lawrence, Kan.
University of Maine.....Orono Me.
University of Michigan.....Ann Arbor, Mich.
University of Minnesota.....Minneapolis, Minn.
University of Missouri.....Columbia, Mo.
University of Nebraska.....Lincoln, Neb.
University of Wisconsin.....Madison, Wis.
Virginia Polytechnic Institute.....Blacksburg, Va.
Washington University .....St. Louis, Mo.
Worcester Polytechnic Institute.....Worcester, Mass.
Yale University .....New Haven, Conn.

Johns Hopkins University has recently held an organization meeting with the idea of establishing a Student Branch.

Institutions in which the entrance requirements are equivalent to those established by the Carnegie Foundation are eligible for Student Branches. Bodies of students in the engineering departments of such colleges are invited to apply to the Secretary of the Society for information regarding the form of petition to the Council for a Student Branch.

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the Sections and Student Branches are urged to make

every effort to get the complete reports of their meetings to the office of the Society as quickly as possible after the meetings are held, and also where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. Reports of meetings must be received before the 18th of the month in order to appear in the next issue of The Journal.

MILWAUKEE, SEPTEMBER 13

The first meeting of the Milwaukee Section for the season 1916-1917 was very encouraging. There were 183 members and guests present. L. J. D. Healey, chief chemist of the Federal Rubber Company, gave an interesting talk on Growing and Gathering of Rubber Latex.

Following the talk, Mr. Hutchens, Chairman of the Section, arranged for those present to be conducted through the plant of the Federal Rubber Company, where they were shown how automobile tires and mechanical rubber goods are made. The party was then shown some very interesting moving pictures of the rubber industry. A surprise supper, served in the dining room of the Federal Rubber Company, concluded the meeting.

Fred H. Dorner,
Section Secretary.

MINNESOTA, SEPTEMBER 14

The first meeting of the Minnesota Section for the season 1916-1917 was held in the main engineering building of the University of Minnesota, at Minneapolis. Prof. J. V. Martenis, chairman of the Section, presided and outlined in detail his plans for the work of the Section for the coming season. Working committees for the ensuing year were also appointed.

Following the regular business meeting, a very interesting talk was given by C. W. Obert, Mem.Am.Soc.M.E., and Secretary of the A.S.M.E. Boiler Code Committee, Secretary of the American Society of Heating and Ventilating Engineers on the plan of working of the Society and the method of presenting and publishing papers.

Fred A. Otto,
Section Correspondent.

BIRMINGHAM, SEPTEMBER 16

The first meeting of the Birmingham Section for the season 1916-17 was held on September 16, and was in the nature of an inspection trip through the Avondale Works of the Continental Gin Company and the plant of the Coyne and Joubert Foundry Company, which makes a specialty of large loam castings and at present is engaged almost entirely on orders for sugar-making machinery. A more detailed description of the trip appears elsewhere in this issue.

Paul Wright,
Section Secretary.

CINCINNATI, SEPTEMBER 21

A joint meeting of the Cincinnati Section of the Society and the Engineers' Club was held on September 21, at which C. F. Kettering, Mem.Am.Soc.M.E., assistant general manager of the Dayton Engineering Laboratories Company, spoke on Some Present and Future Carburetion Problems. Mr. Kettering mentioned the enormous increase from year to year in power obtained from liquid fuels, and stated that the horsepower for motor car engines at the present time runs into many millions. He pointed to the increasing density of the liquid fuels that are used in internal combustion engines, particularly in motor car engines. Many of the difficulties of carburetion and of ignition that have occurred in the past and are occurring now are due, he stated, to this increasing density, which is necessitated by the enormously increasing use of liquid fuels. Manufacturers who are getting out a certain model of car will be working with a fuel which is representative of the kind that is available in the market at the time, but by the time the model is manufactured, the character of the fuel will have changed so much as to cause ignition and carburetion difficulties. Mr. Kettering gave specific instances of this and mentioned that such difficulties are liable to increase, rather than diminish.

Mr. Kettering traced the progress of the mixture, in an internal combustion engine, from the carburetor through the manifold into the cylinder, and throughout the operations of compression and ignition. He showed the effect of increasing density upon carburetion, and in rendering the fuel liable to be precipitated by centrifugal action at bends in the manifolds. The precipitation of the heavier fuel upon the walls of the cylinder, where it would dissolve the lubricating fuel and run down past the piston, and the liability, under some conditions, of the water of combustion to pass by the piston, accounted, he stated, for some remarkable cases of water in the crank case, and also for the apparent increase of the quantity of lubricating oil in the crank case.

The speaker dwelt upon the double explosion obtained with some engines using kerosene and other low-density fuels, and stated that the first of these explosions occurs at lower temperatures than would ignite lighter liquids. This apparent paradox he explained by the catalytic action of carbon just released from its bond in a compound.

He predicted a great future in this country for the Diesel engine, because its action is very positive and many carburetion and ignition difficulties inherent in other types disappear in this. He believed that improvements in workmanship and materials used for Diesel engines would be necessary before great success would be obtained.

He gave a short account of a recent visit to Fremont, where many tractors of all sizes had been tested. He analyzed some of the troubles encountered with these tractors.

He concluded by stating that the many attempts being made displace the horse with power-operated agricultural tools were extremely significant, and would undoubtedly meet with success. We have progressed beyond the point where a man will be satisfied with the moderate amount of power that a horse can give, when he is compelled to set aside five acres of land upon which to raise the feed to maintain the horse. He believed that it was possible to use the forces of nature manifested in plant life and obtain power much more economically. When our present stores of fuels are exhausted, he believed we will have progressed to a state of knowledge to enable us to utilize water power in the manufacture of hydrocarbons which can be stored and used for power generation as required.

John T. Faig,
Section Secretary.

NEW YORK, OCTOBER 10

The opening meeting of the New York Section was held on the evening of October 10, with E. J. Prindle in the chair.

The chairman introduced Dr. Charles L. Reese, Chemical Director of the du Pont de Nemours Powder Co., who gave an instructive address on the subject of Explosives.

Dr. Reese described the evolution of the art of manufacturing explosives for industrial purposes, from the time of the commercial production of black powder to the present. With the aid of samples of explosives and of lantern slides he traced clearly the steps in the manufacture of the nitrocellulose and also of the nitroglycerin classes of smokeless powders, and of dynamite and blasting gelatin and their modifications. He described in detail the various processes under which modern types of high explosives are manufactured.

Dr. Reese followed with descriptions, particularly interesting to mechanical engineers, of the methods of testing explosives for such factors as velocity of detonation, sensitiveness of high explosives, comparative strengths of explosives, etc.

He concluded with an interesting description of the use of explosives for agricultural purposes, illustrating particularly how sub-soil of hardpan is broken up with dynamite, resulting in greatly increased production of crops.

At the close of Dr. Reese's talk several members present put questions to the speaker, which he answered. A unanimous vote of thanks was extended to Dr. Reese for his able address, and the meeting adjourned.

The meeting was preceded by an informal dinner at Offer's Restaurant, where this function will be continued until further notice.

The Section held a technical excursion on October 28 to the Ridgewood Pumping Station of the Department of Water Supply, Gas and Electricity, of the City of New York.

A. D. Blake,
Section Secretary.

MINNESOTA, OCTOBER 12

The Minnesota Section held its second meeting of the season at the St. Paul Gas Light Company's offices in St. Paul, Minnesota, on Thursday evening, October 12, 1916, at which a talk was given by Charles Fortner of the Standard Oil Company, Minneapolis, on the subject Lubricants. This talk was very interesting indeed, and dealt not only with manufacturing processes, but also the conditions governing the proper selection of an oil for any given installation. It was followed by a lively discussion, participated in by most of the members present.

D. M. Forfar,
Section Secretary.

DETROIT, OCTOBER 13

On October 13 a dinner was held by the newly-constituted Section of the Society at Detroit. There were 35 members present. The following officers were chosen by the Section to serve for the coming year: M. E. Cooley, president; E. C. Fisher, T. H. Hinchman, G. W. Bissell and J. W. Parker.

PROVIDENCE, OCTOBER 13

The Providence Engineering Society opened its new rooms on Friday, October 13, with a house-warming. The House Committee has been busy all summer with furnishing and redecorating the rooms, which are rented from the Rhode Island School of Design. Their work has been well done, and with the help of the generous gift of Henry D. Sharpe the rooms and equipment are all that could be desired for a modern club.

The President, Prof. Brookes, of Brown University, took charge of the formalities of the evening, and after an address of welcome, in which he outlined the proposed work of the club for the coming winter, he introduced Ex-Lieutenant Governor Zenas W. Bliss, also a member of the Society, who spoke on The Relation of Engineering to Public Affairs. Following this a collation was served, and a general social time concluded the evening's programme. The spirit of the meeting augured well for the winter's activities of the Society.

Albert E. Thornley.
Section Secretary.

PHILADELPHIA, OCTOBER 24

The Section at Philadelphia had its first meeting on Tuesday, October 24. There was an excellent attendance of both members of the Society and of affiliated clubs.

Professor Wm. Cathcart, formerly of the United States Navy, delivered a most interesting and timely address, illustrated by lantern slides, upon the Development of Our Fleet and Naval Stations. He outlined at the outset the engineer's relation to modern naval war; its structures and mechanisms —its hulls, turbines, guns, dynamos, wireless, torpedoes and aircraft—are his in conception and construction.

Professor Cathcart pointed out that, while America possessed many advantages due to its geographical position, its efficient devices and inventions, its up-to-date fighting facilities and its well-trained navy, the country was decisively at a disadvantage due to the number of its fighting units and the development of its fortification equipment. The speaker believed that our dreadnaughts should be as large as our dry docks.

He described in turn the various strategic situations on our coasts, the use of mines and submarines, marksmanship, naval guns, and the organization and personnel of the Navy.

The very spirited discussion after the meeting showed that engineers nowadays are giving a very important place in their minds to the proper defense of our seacoasts.

W. R. Jones,
Section Secretary.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

A business meeting of the Student Branch of the Armour Institute of Technology was held on September 18. The resignation of L. A. King, president of the Branch, was accepted with regret and C. R. Pomeroy was elected vice-president.

On September 25, a meeting of the Branch was held at which several of the members gave short talks. H. Luttge spoke on Carburetors, O. W. Armspach on Heating and Ventilation and B. Robecheck on the heating and ventilating system at the Armour Institute of Technology.

An open meeting of the Branch was held on October 4 which was devoted to social events.

E. W. Haines,
Branch Secretary.

BUCKNELL UNIVERSITY

A meeting of the Student Branch of Bucknell University was held on October 2. Plans for the season were discussed, and it was decided to have a talk upon some engineering subject by a student at every monthly meeting.

Prof. F. E. Burpee, Mem.Am.Soc.M.E., gave a very interesting talk on the Mechanical Engineering Course, Its Scope and Advantage.

C. M. Kriner,
Branch Secretary.

CARNEGIE INSTITUTE OF TECHNOLOGY

The following officers have been chosen to serve the Student Branch of the Carnegie Institute of Technology for the year 1916-17: Harry A. Madison, president; W. H. Sturgeon, vice-president; J. Davis, secretary; A. L. Heston, treasurer.

Harry A. Madison,
Branch Chairman.

LELAND STANFORD JUNIOR UNIVERSITY

A meeting of the Leland Stanford Junior University Student Branch was held on September 13. Following the transaction of business, R. W. Hope, honorary secretary of the American Institute of Electrical Engineers, gave a very interesting talk about his early work as assistant engineer for the project of intercommunication between Europe and America, giving the routing from New York to San Francisco, up the Pacific Coast to Alaska with a short submarine cable across Behring Strait to Siberia, then to Saint Petersburg and from there to London.

A. L. Morgan,
Branch Corresponding Secretary.

PENNSYLVANIA STATE COLLEGE

The Pennsylvania State Chapter opened the 1916-17 season on September 26 with a preliminary meeting at which the season's programme and committees were announced. This meeting was followed by a social meeting at which the new faculty members were introduced and invited to make addresses. These members include E. A. Fessenden, Professor of Mechanical Engineering; J. W. Haney, Instructor in Mechanical Engineering, and J. O. Keller, Instructor in Industrial Engineering, members of the Society.

Hugo Diemer,
Branch Corresponding Secretary.

POLYTECHNIC INSTITUTE OF BROOKLYN

The opening meeting of the Polytechnic Institute of Brooklyn Student Branch was held on October 7. Arthur Bielek, chairman of the Branch, presided, and told what the Branch had accomplished in the year just past and what it expected to do during the coming year.

At the close of the business meeting Arthur Seubert, Mem. Am.Soc.M.E., gave a paper on Chlorination and Water Purification. Mr. Seubert traced the history of water supply from the time of the Roman Empire to the present day. He said that while the Romans had built a complex and reasonably sanitary system of water supply, the people of the middle ages made no attempt to purify the water or investigate the source of their supply of drinking water.

He then discussed the use of the sand filter from the early days in London to modern times, and also spoke of the impurities in water which cannot be removed by filtering. He pointed out that the best method of removing these impurities is by injecting fine particles of chlorine into the water.

The speaker described the apparatus designed by the Wallace and Tiernan Company for chlorinating water, and illustrated by the use of lantern slides the application of the apparatus to many water-supply systems.

Frank R. Stamer,
Branch Secretary.

PURDUE UNIVERSITY

On September 29, the Student Branch of Purdue University held an open meeting for the purpose of increasing acquaintanceship among the new students in mechanical engineering. Dean Benjamin, Mem.Am.Soc.M.E., and Professor Young, Mem.Am.Soc.M.E., discussed the relation of the Student Branch to the Society and the value of The Journal to members of the Branch.

G. A. Ruess,
Branch Corresponding Secretary.

UNIVERSITY OF ILLINOIS

The University of Illinois Student Branch opened the semester's work on Thursday evening, September 28. About seventy-five members were present, which is an indication of activity.

Dean Goss, Past-President Am.Soc.M.E., addressed the meeting, his theme being A High Standard for the Engineering Profession. He urged the members to be active in the affairs of the Branch, pointing out that the activity of each member would be reciprocal in benefiting both the Branch and the member.

A new recording secretary, H. O. Isaacson, was chosen to succeed R. N. Foster, and R. Rahn was appointed representative to the *Technograph*, the Engineering Societies' publication.

The treasurer's report showed a membership of over a hundred and a substantial account in the bank in the Branch's name. Two committees were appointed, for advertising meetings and for soliciting subscriptions for Branch pins respectively.

Plans are being formulated for the delivery of several student lectures, so that the work of the Branch for the semester is very promising.

V. S. Day,
Branch Chairman.

WORCESTER POLYTECHNIC INSTITUTE

At the last meeting of the school year of the Worcester Polytechnic Institute Student Branch held on June 1, the following officers were elected for the year 1916-17: John A. C. Warner, chairman; Charles Hollerith, vice-chairman; Earl R. Knight, treasurer and Franklin T. Holmes, recording secretary. Following the election, abstracts of several of the students' theses were read and discussed. Arthur Nutt presented a paper on Thermostatic Control of Jacket Water in Automobiles, Aurelio E. Zamberano on Automobile Acceleration, and Arthur K. Ingraham on Tests of Ammonia Safety Valves.

The first regular meeting of the Branch for 1916-17 was held on October 6, at which F. E. Stanley, of the Stanley Motor Carriage Co., Newton, Mass., gave an illustrated lecture on Steam-Propelled Vehicles.

Mr. Stanley related how he first became convinced of the possibility of driving a 4-wheeled carriage by steam propulsion, and told of overcoming the various difficulties which presented themselves at the first trials of his steam-driven automombiles. He described fully the functions and details of the fire regulator, fuel pump, steam and water gages, as well as other major mechanisms of the car, each mechanism illustrating the solution of the engineering problems which he and his company encountered in the car's early career. He also described the company's new car, in which the engine is run condensing, and gave figures showing its efficiency. He concluded with slides illustrating the main points of difference between the latest model of the Stanley Steamer and its predecessors.

Mr. Stanley then read extracts from a biographical paper of the life and accomplishments of George Stevenson, who is credited with having designed the first practical locomotive.

H. P. Fairfield,
Branch Secretary.

The American Association for the Advancement of Science and some thirty national scientific societies affiliated with it will meet in New York City during the last week in December, 1916, under the auspices of Columbia University, New York University, the College of the City of New York, the American Museum of Natural History and other scientific and educational institutions. Dr. C. R. Van Hise, president of the University of Wisconsin, will preside.

EMPLOYMENT BULLETIN

THE Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 18th of the month.

ASSISTANT ENGINEER for preparation of plans and specifications and supervision of installation of electric lighting, steam-heating and ventilating systems in buildings of Eastern University. Some installations are in new buildings and others involve remodeling of present buildings. Wide variety of work and position offers excellent opportunities for experience. Salary $75 to $90, depending on experience. 559

YOUNG MAN for engineering computation department and answering engineering correspondence. Technical education preferable. Location Massachusetts. 560

PRACTICAL ENGINEER experienced in handling machinists, pipe fitters and electricians. Salary $1800 to commence. Good opportunity for advancement. Location New York. 562

EXPERIENCED MAN to take charge of manufacture of soap powder. Salary $30 to start. Location New York. 563

DRAFTSMEN for Stoker Department. Work involves making layouts of stoker installations and also requires general knowledge of boiler-room work for concern manufacturing specialty. Good draftsmen with some knowledge of this class of work more valuable than good designers. Salary up to $25 weekly to start, depending on ability and experience. Location Philadelphia. 565

SUPERINTENDING OPERATING ENGINEER, technical graduate, for plant making pipe coverings. State salary desired, experience, etc. Location N. J. Apply by letter. 567

DRAFTSMAN, experienced in rolling mill machinery, etc. Salary $150. Location Easton, Pa. 571

YOUNG MAN, preferably '15 graduate, for general office, drafting and purchasing work, with opportunity to sell special chemical apparatus. Salary $20 per week to start, with opportunity to make additional money on profit-sharing basis on sales. Location New York. 575

ASSISTANT DIRECTOR of shop laboratories, department of mechanical engineering of prominent university. Salary $1800. College graduate who has had some direct connection with organization work and development of manufacturing methods in thoroughly modern plant; requires excellent personality, possessing initiative and ability. Considerable possibility for future. 576

INSTRUCTOR or ASSISTANT PROFESSOR in mechanical engineering, to teach thermodynamics, steam engines, boilers and power plant design. Preferably man who has had some experience in engineering in connection with power plants. Applicant must be available immediately. Salary $1200 to $1500 according to experience and training. Location Pennsylvania. 577

CHIEF DRAFTSMAN, experienced, for manufacturer of automobile parts. Location New Jersey. 587

CHECKER on drawings for manufacturer of automobile parts. Location New Jersey. 588

DESIGNER of jigs, tools, special machines, for manufacturer of automobile parts. Location New Jersey. 589

MECHANICAL DRAFSMAN for general factory work to lay out work of a general character and be a leader and direct others in the drafting room. Familiar with conveying systems, power plant equipment, steam heating and electrical equipment. Salary $110 per month to start, with opportunity for advancement for right kind of man. Location Newark, N. J. 590

ENGINEER, capable of handling detailers and tracers and production in shop; experienced in manufacture of large machinery. State age, technical training, experience, salary expected and give reference. Location New York. 591

SUPERINTENDENT of construction for power house. Salary depends on man. Location New York. 592

YOUNG MAN, ambitious and energetic for maintenance and construction department of large corporation in Middle West. Experienced in handling men, plant engineering and operation, such as installation of machinery and shafting, construction and maintenance of buildings, including carpentry, steam fitting, painting, plumbing, masonry and electrical work, as well as power plant operation. Opportunities for advancement exceptional. State age, education, previous and present employment, full details of experience and salary expected. All correspondence strictly confidential. 593

PUBLICITY ENGINEER, technically trained, with experience in building construction and if possible general acquaintance with power-plant engineering. Must have demonstrated ability to write technical and popular matter for publication. Both editorial and reportorial experience desirable. Permanent position assured to the right man. 594

ASSISTANT SUPERINTENDENT for munitions plant producing high explosive shells. Location New York State. 600

DESIGNER of machine tools, preferably with experience in design of tools for shell work. Location New York State. 601

YOUNG ASSISTANT ENGINEER, preferably technical graduate, Christian, to act as assistant to engineer of service department. Location New York. 603

THREE MEN competent to devise and take charge of the installation of cost and production systems. Work near Boston, New York and Chicago. State age, salary, experience and references. 615

CADET ENGINEER, technical school graduate preferred. Good opportunity for young engineer. Location New Jersey. 616

YOUNG MAN for drafting and record work. Location New Jersey. 617

ENGINEERS for production department of plant manufacturing steel-plate receptacles of all sizes and shapes. Prefer men with technical education, fair draftsmen, with experience in industrial plants in connection with production, working knowledge of routine, scheduling, time study, etc. All correspondence strictly confidential. In first letter state age, experience, married or single, and salary expected. Location New York State. 618

DISTRICT SALES MANAGER. Established firm desires sales manager to take charge of new office in Cleveland, O. Competent to sell stokers and other steam equipment. Salary and commission. First letter must state—whether employed at present; experience and education; reasons for leaving last three positions; reasons for answering this advertisement; age, married or single, height, weight and complexion; recent photograph if possible (enclose stamp for return); present salary; knowledge of Cleveland territory, if any. 619

TECHNICAL EXPERT, familiar with manufacture of grindstones. Prominent French firm about to engage in manufacture of specially shaped grindstones as side line, requires first-rate technical man in its establishment in France. Must be thoroughly conversant with every detail of the industry. Excellent permanent position to right man. Knowledge of French unnecessary. State qualifications, age, salary desired, etc. 620

DRAFTSMAN on agricultural machinery. Salary $125 and living quarters. Position in Santiago, Cuba. 621

DRAFTSMAN in engineering department of paper mill. Should have experience in machine work and be able to do any class of drawing from notes or free-hand sketches. Speed is the principal requirement. Location central Massachusetts. 622.

MECHANICAL or ELECTRICAL ENGINEER, technical graduate, with best personal qualifications for integrity and sobriety, good understanding of principles of mechanics and general fundamental knowledge of main elements of electrical engineering. Must also be capable surveyor. Work will be in development of range-finding instruments. 624

GENERAL SALES CORRESPONDENT. Engineering and correspondence experience such as involved in formulating proposals covering sale and calculation of size adaptation in steam and power-driven pumping equipment of displacement types, including application of steam engines, combustion engines and electrical equipment that may be employed. Applicant should supply references bearing upon a record as correspondent, capable of formulating propositions of character indicated, proper closing of contracts, execution of orders and closing of accounts. Salary not less than $2500. Location Ohio. 627

SUPERINTENDENT, to take active control of modernizing old established manufacturing plant, including pattern shop, foundry, machine shop, etc.; unusual opportunity for young man 30 to 35, with thorough experience and strong personality, who can firmly and quietly get results. Location Missouri. 628

MECHANICAL DRAFTSMEN and DESIGNERS familiar with power plant and factory layouts. Location Boston. 629

ENGINEER, practical as well as theoretical, to have charge of tubing mill manufacturing brass covered steel tubes, welded steel and brazed tubing. Salary depends on man. Location New York. 633

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 18th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

MECHANICAL ENGINEER. Designer of high-speed automatic machinery. Executive ability. Ten years' experience. Desires position in vicinity of New York or Newark. At present employed. K-363

MECHANICAL ENGINEER and DRAFTSMAN. Chief draftsman or assistant superintendent. Technical graduate. Age 36. Thirteen years' experience. Familiar with manufacture of water-gas, soaps, leather belting, coal-mining and handling machinery. At present employed. Salary $1800 to $2400. K-364

SALES ENGINEER, mechanical-electrical, American, age 34. Eleven years' experience in selling electrical and mechanical machinery and supplies. Executive ability. Speaks Portuguese, Spanish and German. Just returned from Brazil. Desires position as representative or branch manager for South America or Cuba. K-365

MECHANICAL ENGINEER, technical graduate, American. Sixteen years' experience designing and estimating on Corliss engines, hoisting engines, air compressors, gas engines, pumps. Two years' experience answering correspondence and selling. Open for responsible position. Middle West preferred. K-366

REPRESENTATIVE. Engineer having his own office in New York City desires to secure additional representation on commission basis for out-of-town manufacturer. Graduate M. E. Cornell University. K-367

COMBUSTION ENGINEER and SMOKE ABATEMENT EXPERT, at present completing 4-year term as chief smoke inspector of large city, wishes connection with stoker or boiler concern or on special city smoke-abatement work. K-368

FUEL TESTING ENGINEER. Graduate, age 34, seven and a half years' experience in scientific testing of coal in industrial plants, for large coal company in Middle West. Desires position as combustion engineer for large user of coal. At present employed. K-369

COAL TESTING and SALES ENGINEER. Graduate, experienced in scientific testing and selling of coal. Desires position as sales manager for coal-operating company. At present employed. K-370

MECHANICAL ENGINEER. Graduate M. E. Four years' experience in boiler design and kindred work. Seven years in large rubber manufacturing plant as assistant engineer, inaugurating many labor-saving schemes, conveyors and plant layouts. Familiar with shop management along scientific lines, time-study system. Tactful, good organizer and good executive. Capable of taking full charge responsible work. K-371

PRODUCTION ENGINEER. Technical graduate with thorough shop training. Experienced in time-study work and investigations. Familiar with cost-routing and store-keeping systems. Able to obtain increased production and decreased costs. K-372

MECHANICAL SUPERINTENDENT or MASTER MECHANIC. Associate-Member, 39. Extensive experience in entire charge of machine shops, also erection and test in field manufacturing all sizes surface and jet condensers, engines, high-vacuum air and centrifugal pumps, heaters, etc. Competent to take entire control of machine shops in any line of manufacture. Good executive. Excellent references. Will go anywhere. K-373

EXECUTIVE ENGINEER, familiar with experimental engineering. Twelve years' practical experience in designing and operating industrial plants and large power stations. Age 34, married. Salary $2500 to start. K-374

NAVAL ENGINEER. Stevens graduate, with fourteen years' experience in marine engine designing, steam, gasoline and Diesel as well as other general designing required in shipyard work. Desires to make change. K-375

MECHANICAL ENGINEER, ten years experience in machine shops and engine works, fifteen years in present position as head of a known engineering school, desires change. Summer vacations have been spent on engineering staffs of prominent concerns. Responsible position with manufacturing or consulting engineering firm or executive position with high-grade school of technology will be considered. East preferred. K-376

RAILWAY MECHANICAL ENGINEER at present employed as mechanical engineer. Age 37, technical education, seventeen years' experience as railway machinist, draftsman, chief draftsman and mechanical engineer; desires mechanical engineering position with railway company, railway supply house or industrial plant with greater responsibility and opportunity. Location immaterial. Salary $2400. K-377

CHIEF ENGINEER or CHIEF DRAFTSMAN. Technically-trained engineer, sixteen years' experience in steel works, blast furnace and steam power plant work, designing, testing and investigating, seeks opportunity for advancement. Age 39. At present employed. References furnished. K-378

PUBLIC UTILITIES EXECUTIVE. Associate-Member. Technical graduate. Ten years' experience in designing, inspecting, as construction superintendent, operating superintendent, assistant chief engineer; one and a half years as mechanical designing engineer for large public utilities corporations. Desires position as general manager of utilities or construction or designing engineer for large holding company. At present holding position with large corporation supervising all mechanical construction. Minimum salary expected $3300. K-379

MECHANICAL ENGINEER. Junior-Member, Cornell graduate, age 28. Six years' experience testing, executive work and selling. Now employed but desirous of making change. Has good record. K-380

ASSISTANT TO EXECUTIVE or SALES MANAGER. Technical graduate, age 36, desires change. Experience in testing, research, designing and commercial engineering, in connection with steam turbines, turbo-blowers and centrifugal pumps, with responsible charge of men. New York City or eastern location preferred. K-381

CHIEF DRAFTSMAN or MASTER MECHANIC. Ten years' experience in manufacture of interchangeable parts; thoroughly experienced in design of punch and dies, jigs, tools, fixtures, special and automatic machinery for manufacturing parts on interchangeable basis. Location preferred in or vicinity of New York City or Newark. K-382

EXECUTIVE or MECHANICAL ENGINEER, experienced in organization, design of special, and elevating and conveying machinery. Technical graduate. At present employed. Desires interview with parties seeking reliable, aggressive man for responsible position. Location New York or vicinity. K-383

MECHANICAL ENGINEER. Junior-Member, technical graduate, age 32, married. Five years' experience in design, installation and operation of mechanical equipment of coal mines, including boiler plants, pumping and ventilating plants; machine shop experience. Desires position with a future. K-384

STEAM ENGINEER. Can design, build and operate first-class power plants. Age 40. Can make change about January 1, 1917. K-385

ASSISTANT TO EXECUTIVE or CONSULTING ENGINEER. Cornell graduate. Mechanical and electrical engineer. Associate-Member. Age 31. Nine years' experience, six years in charge. K-386

PURCHASING or INSPECTING ENGINEER. Eight years' experience in inspection and purchasing of all classes of engineering material for leading railroads and U. S. Government; wide acquaintance and familiar with all largest industrial plants and sources of supply throughout the country. Thoroughly experienced in the purchasing, testing and inspection of steel structures, railroad and industrial supplies, etc. Age 30, college graduate, now employed. K-387

SALES or ASSISTANT TO EXECUTIVE. Graduate M. E. from prominent university; ten years out of college, with six years' experience in general sales office of steel foundry. Desires responsible posi-

tion in general sales or executive office, preferably in Middle West. K-388

EXPERIMENTAL ENGINEER, for mechanical laboratory and research work. Graduate M. E., shop and long engineering experience in Germany and United States. Last six years in scientific experimental research work. Desires permanent position with private firm or consulting engineer. Specialty heat and combustion, calorimetry, fuel economy, measuring apparatus. K-389

MECHANICAL ENGINEER, over 20 years' experience on construction, maintenance and manufacture in connection with power plants, mining, machine tools, arms, ammunition, engines, boilers, gas machinery and engines, turbines, paper, jute. At present finishing up power construction work; will be available about December 1. Location desired in or near New York. K-390

ENGINEER-EXECUTIVE, experienced in design, construction and operating quarries, chemical, and ore-dressing plants. Age 39. Good executive. Prefers development work in West or South. Now employed near New York. Salary $7500 or equivalent. K-391

ROLLING MILL ENGINEER. Technical graduate. Ten years' thorough experience, having full charge of design of rod mills, continuous and looping, flat, billet and reversing mills, also complete wire mills, furnaces, etc. Desires position as chief or assistant chief engineer or in other responsible capacity. K-392

TECHNICAL GRADUATE, Junior-Member, age 27, experienced in operation, construction and maintenance of small power plant with test work on boilers up to 300 h. p. Location not essential. K-393

MECHANICAL or CHIEF ENGINEER, fifteen years' experience in designing, shop and executive work. Systematic and reliable. Capable of assuming responsibility and handling men. Inventive ability. Resourceful designer of automatic labor-saving machinery. Research, experimental and development work. Can report immediately. K-394

MECHANICAL ENGINEER and CONSTRUCTION SUPERINTENDENT. Associate-Member. Graduate M. E., eight years experience supervising complete layout, purchase, construction and maintenance of mechanical and electrical equipments for factories and mercantile buildings. Can handle men and get results. Desires position with industrial building concern. Middle West preferred. K-395

MECHANICAL ENGINEER, age 32. Ten years experience teaching machine design, safety inspection of factories, drafting and engineering on commercial motor vehicles. Desires position as engineer or assistant engineer with manufacturer of motor cars, accessories, or special machinery. New York or vicinity. K-396

RESIDENT ENGINEER, SUPERINTENDENT OF CONSTRUCTION, general superintendent or manager of industrial plants. Age 40, 19 years engineering and executive experience. Salary $3,000 to $6,000 depending on position offered. Salary last two years $6,000 per year. Available at once. K-397

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

LIBRARY NOTES

The actual moving of the library of the American Society of Civil Engineers to the United Engineering Societies Building awaits the purchase of additional shelving.

The consolidation of this collection with the joint library will make the latter the most important of its kind in the world. In addition to the many sets of periodicals which are new to the U.E.S. Library and the very important sets of Government, State and Municipal reports which will come from the Civil Engineers, there is an extensive collection of pamphlets, maps and specifications. Reorganization of the collection will take some time, but is being carefully planned.

The periodicals and society publications currently received in the Library of the Engineering Societies now number over 1100, published in 32 countries and in 11 languages.

Attention of the membership is called to the "Catalogue of Technical Periodicals in the Libraries of New York and Vicinity," published recently by the Library. This lists, with full catalogue entry, about 2500 technical periodicals, and tells where they are to be found. Changes of title, discontinuances, and indexes are noted. When it is remembered that any article in these periodicals can be furnished in an accurate photostat copy, the value of the catalogue to the engineering student is manifest. Copies are sold by the Library for three dollars, postpaid.

The Library is very anxious to obtain all the trade catalogues in engineering lines, and the coöperation of members in rendering assistance in this direction is requested. Catalogues are carefully analyzed for the use of readers.

ADDITIONS BY THE SOCIETY

AIR BRAKE ASSOCIATION. Proceedings of 23d annual convention, 1916. *Atlanta, 1916.* Gift of Air Brake Association.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Condensed Catalogues of Mechanical Equipment, with general classified directory. *New York, 1916.* Gift of A.S.M.E.

CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE. Year Book, 1916. *Washington, 1916.* Gift of Carnegie Endowment for International Peace.

CHEMICAL AND BIOLOGICAL SURVEY OF THE WATERS OF ILLINOIS. Report for year ending Dec. 31, 1914. Water Survey Series no. 12. *Urbana, 1916.* Gift of A.S.M.E.

CITIZENSHIP SYLLABUS. Reprinted from 12th Annual Report of the N. Y. State Department of Education. *Albany, 1916.* Gift of C. W. Rice.

CLIMATIC AND LIVING CONDITIONS AT VARIOUS CENTERS, Geo. H. Davis. *New Orleans, 1916.* Gift of G. H. Davis.

FOWLER'S MECHANICAL ENGINEER'S POCKET BOOK, 1916. Eighteenth annual edition. *Manchester, England, Scientific Publishing Co., 1916.* Price 2s. 9d., post free. Gift of publisher.

FOWLER'S ELECTRICAL ENGINEER'S POCKET BOOK, 1916. Sixteenth annual edition. *Manchester, England, Scientific Publishing Co., 1916.* Price 2s. 10d., post free. Gift of publisher.

These two little pocketbooks of about 500 pages each have a large sale in England, and should appeal from their varied contents and their low price to engineers in this country.

W. P. C.

LINEAR HOT-WIRE ANEMOMETER AND ITS APPLICATIONS IN TECHNICAL PHYSICS, L. V. King. Reprinted from Franklin Institute Journal, Jan. 1916. *Philadelphia, 1916.* Gift of author.

LOOKING SQUARELY AT THE WATERPOWER PROBLEM, H. J. Pierce. Gift of A.S.M.E.

NEW JERSEY. BOARD OF PUBLIC UTILITY COMMISSIONERS. Financial and miscellaneous statistics compiled from the annual reports made by Public Utilities, 1914. *Union Hill, 1916.*

——— Annual Report, 1915. *Trenton, 1916.* Gift of Board of Public Utility Commissioners.

NEW YORK CITY. BOARD OF WATER SUPPLY. Contract 174—Information for bidders, forms of proposal, contract, bond and certificates, specifications and drawings for furnishing, delivering and installing riser-valve controlling mechanisms and appurtenances in the shafts of the city tunnel of the Catskill Aqueduct. *1916.*

——— Contract 178—Information for bidders, forms of proposal, contract, bond and certificates, specifications and drawings for grouting a portion of the Eastview Tunnel of the Catskill Aqueduct, in the town of Mount Pleasant, Westchester County, N. Y. Gift of Board of Water Supply.

NEW YORK STATE ENGINEER AND SURVEYOR. Supplement to the Annual Report, Vol. II, 1915. *Albany, 1916.* Gift of New York State Engineer and Surveyor.

OWNERSHIP OF INVESTED EARNINGS OR INVESTED SURPLUS, Samuel S. Wyer. Gift of author.

ON SOME PROPOSED ELECTRICAL METHODS OF RECORDING GAS FLOW IN CHANNELS AND PIPES BASED ON THE LINEAR HOT-WIRE ANEMOMETER, L. V. King. *Philadelphia, 1916.* Reprinted from Franklin Institute Journal, August 1916. Gift of author.

Railway Regulation and Locomotor Ataxia, Frank Trumbull. *New York, 1916.* Gift of Railway Executive Advisory Committee.

A Work on the Conservation of Water by Storage, Geo. F Swain. Gift of A.S.M.E.

EXCHANGES

Brooklyn Engineers' Club. Proceedings, 1915. *Brooklyn, 1915.*

TRADE CATALOGUES

Flannery Bolt Co., *Pittsburgh, Pa.* Staybolts. *September, 1916.*

Greenfield Tap & Die Corporation, *Greenfield, Mass.* Catalogue no. 37. Gages, taps, dies.

Greenfield Tap & Die Corporation, *Greenfield, Mass.* The "Gun" tap. 12 pp.

Leschen, A. & Sons Rope Co., *St. Louis, Mo.* Leschen's Hercules. *September, 1916.*

Sleeper & Hartley, Inc., *Worcester, Mass.* Bulletin no. 252. Helical bed spring coiling machine. *March, 1915.*

——— 254. No. 2 Universal coiler. *April, 1915.*

——— 264. Spring setting machines. *April, 1916.*

——— 267. Automatic tube straightening machines. *June, 1914.*

——— 268. Helical cutting and hooking machine. *March, 1915.*

——— 269. Wire nail machines. *December, 1914.*

——— 270. Torsion spring machines. *July, 1916.*

——— 272. Music wire straightening and bundling machines. *June 1915.*

——— 275. No. 1 wire rolling and flattening mill. *November, 1915.*

——— 277. Spring hooking machines. *November, 1914.*

——— 280. Special spring coiling machines. *June, 1916.*

——— 287. Furniture spring coiler. *June, 1916.*

——— 288. No. 0 and No. 1 Universal coilers. *May, 1916.*

——— 306. No. 4 Universal coiler. *August, 1916.*

——— 308. Flexible shaft coiling machine. *May, 1916.*

——— 309. Flexible metallic tube coiling machines. *May, 1916.*

——— 318. No. 3 Universal coiler. *January, 1916.*

——— 319. Flexible casing coiler. *May, 1916.*

——— 326. No. 5 Universal coiler. *August, 1916.*

List of standard machines offered to the trade.

Texas Company, *New York City.* Lubrication. *September, 1916.*

Walworth Mfg. Co., *Boston, Mass.* Walworth Log. *September, 1916.*

Whiting Foundry Equipment Co., *Harvey, Ill.* A model foundry, no. 125.

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

Abstracts of Current Decisions on Mines and Mining, Reported from January to April 1916. U. S. Bureau of Mines. Bulletin 126, *Washington, 1916.*

American Express Company. Foreign Trade Building. *October 1915.* Gift of American Express Co.

American Foundrymen's Association. Year Book, 1916. *Cleveland, 1916.*

American Iron & Steel Institute. Annual Statistical Report, 1915. *New York, 1916.*

Antimony Deposits of Alaska. U. S. Geological Survey. Bulletin 649. *Washington, 1916.*

Bibliography of North American Geology for 1915. U. S. Geological Survey. Bulletin no. 645. *Washington, 1916.*

Black Damp in Mines. U. S. Bureau of Mines. Bulletin 105. *Washington, 1916.*

Carnegie Steel Company. Bulb Sections. Ship building bulb angles, British standard and miscellaneous sections, car building bulb angles and bulb beams. ed. 3. *Pittsburgh, 1916.*

Chisana-White River Distraict, Alaska. U. S. Geological Survey. Bulletin 630. *Washington, 1916.*

Coal Resources of the Clintwood and Bucu Quadrangles, Virginia. Bulletin no. XII, Virginia Geological Survey. *Charlottesville, 1916.*

Colorado River and Its Utilization. U. S. Geological Survey. Water Supply Paper 395. *Washington, 1916.*

Competition in Electricity. No. 5—The "Block" heating and electric plant. Evidence that groups of buildings under same or different ownership can obtain heat and electricity from one privately owned central utility plant. No. 6—How many of New York's greatest factories are supplied with power from private power plants. No. 7—How many of Chicago's "Notable Buildings" are supplied with electricity from private power plants. Gift of Charles Meigs Ripley.

Construction of Roads and Pavements, T. R. Agg. *New York, 1916.*

Continuous and Alternating Current Machinery, J. H. Morecroft. *New York, 1915.*

Dependable Concrete, Hydrated Lime and Its Effect on Workability, Segregation, Uniformity, Strength, Permeability. Bulletin A-2. Gift of National Lime Manufacturers' Association.

Economic Geology, Heinrich Ries. ed. 4. *New York, J. Wiley & Sons, 1916.* Gift of publishers. Price $4.00 net.

The third edition was published in 1910, and advances in the knowledge of economic geology since that date have been so great as to require quite complete revision. In addition, descriptions of the more important mineral deposits of Canada have been added. The work is notable for the completeness of the lists of references given at the end of each chapter, for the excellence of its numerous illustrations, and for its extensive index.

W. P. C.

Elements of Chart Making. U. S. Coast and Geodetic Survey, Special publication no. 38. *Washington, 1916.*

Engineering Applications of Higher Mathematics, V. Karapetoff. Parts 2-5. *New York, J. Wiley & Sons, 1916.* Gift of publishers. Price $0.75 for each part.

Part 1, on Machine Design, was published in 1912. The parts now issued give problems in the application of mathematics to hydraulics, thermodynamics, mechanics of materials, and electrical engineering, respectively.

W. P. C.

Engineers' Hand Book of Tables, Charts and Data on the Application of Centrifugal Fans and Fan System Apparatus. *New York, Buffalo Forge Co., 1914.* Gift of publishers.

Fifty Years of a Business Man's Life. Reminiscences by Frederick A. Riehlé. *Philadelphia, 1916.* Gift of Riehlé Bros. Testing Machine Co.

Frontier Forts of Pennsylvania. Report of the Commission to locate the site. ed. 2. vols. 1-2. *Harrisburg, 1916.*

Handbook for Highway Engineers, W. G. Harger and E. A. Bonney. ed. 2. *New York, McGraw-Hill Book Co., 1916.*

Health Conservation at Steel Mills. U. S. Bureau of Mines. Technical Paper 102. *Washington, 1916.*

History and Development of Gold Dredging in Montana. U. S. Bureau of Mines. Bulletin no. 121. *Washington, 1916.*

History of Manufacturers in the United States, 1607-1860, V .S. Clark. *Washington, 1916.*

Institution of Civil Engineers. Minutes of Proceedings. vol. CCI. *London, 1916.*

5th International Congress on Inland Navigation. 1892. Reports (4 folios). *Paris, 1892.*

International Engineering Congress, 1915. Vol. IX—Metallurgy. *San Francisco, 1915.*

Iron & Steel Institute. Journal. vol. XCIII. *London, 1916.*

Lignite Field of Northwestern South Dakota. U. S. Geological Survey. Bulletin 627. *Washington, 1916.*

Lower Eocene Floras of Southeastern North America. U. S. Geological Survey. Professional Paper 91. *Washington, 1916.*

Municipal Index. August 1912-December 1913, January-December 1915. *New York, 1913, 1915.*

National Association of Cotton Manufacturers. Transactions no. 100. *Boston, 1916.*

Norwich University, 1819-1911. Her history, graduates, roll of honor. vols. 1-2. *Montpelier, 1911.* Gift of W. A. Ellis.

Ore Sampling Conditions in the West. U. S. Bureau of Mines. Technical Paper 86. *Washington, 1916.*

Pittsburgh Experiment Station, Bureau of Mines. Library Bulletin, Oct. 1, 1916. Author index of U. S. Bur. Mines publications. Gift of A. Slobod.

Poor's Manual of Industrials, 1916. *New York, 1916.*

Ports of the United States. Report on terminal facilities, commerce, port charges, and administration at 68 selected ports. (Miscellaneous Series—No. 33, Department of Commerce). *Washington, 1916.* Gift of U. S. Dept. of Commerce.

Principles of the Telephone. Part 1—Subscriber's Apparatus, C. M. Jansky and D. C. Faber. *New York, 1916.*

Quebec. Ministére de la Colonisation, des Mines et des Pêcheries. Rapport sur les Operations Minieres dans la Province de Quebec. 1915. *Quebec, 1916.*

Reasons Why Natural Gas Ought Not to Be Sold at Low Prices for Industrial Use, S. S. Wyer. *Columbus, 1916.* Gift of author.

Rhodesia Munitions and Resources Committee. Interim Report for period ended June 30, 1916. *Bulawayo, 1916.*

Rochester (N. Y.) Government. General Survey, Critical Appraisal and Constructive Suggestions. *Rochester, 1915.* Gift of Rochester Bureau of Municipal Research.

——— 1916 Budget of the City of Rochester. Gift of City Comptroller.

Safe Practice at Blast Furnaces. U. S. Bureau of Mines. Technical Paper 136. *Washington, 1916.*

Smithsonian Institution. Annual Report of the Board of Regents. 1915. *Washington, 1916.*

Spirit Leveling in Arkansas, 1896-1915, inclusive. U. S. Geological Survey. Bulletin 636. *Washington, 1916.*

Spirit Leveling in Georgia, 1896-1914, inclusive. U. S. Geological Survey. Bulletin 635. *Washington, 1916.*

Spirit Leveling in New Mexico, 1902-1915, inclusive. U. S. Geological Survey. Bulletin 638. *Washington, 1916.*

Surface Condenser (in Russian). Wheeler Condenser & Engineering Co., Carteret, N. J. Gift of Leon Goldmerstein.

Surface Water Supply of the United States, 1913, Part X—The Great Basin. U. S. Geological Survey. Water Supply Paper 360. *Washington, 1916.*

——— 1914, Part IV—St. Lawrence River Basin. U. S. Geological Survey. Water Supply Paper 384; Part VII—Lower Mississippi River Basin. U. S. Geological Survey. Water Supply Paper 387. *Washington, 1916.*

U. S. National Museum. Proceedings vol. 50. *Washington, 1916.*

Upper Ordovician Formations in Ontario and Quebec. Canada. Department of Mines. Memoir 83. *Ottowa, 1916.*

U. S. Census Bureau. Financial statistics of cities having a population of over 30,000, 1915. *Washington, 1916.*

Waterworks Handbook, A. D. Flinn, R. S. Weston and C. L. Bogert. *New York, 1916.*

GIFT OF AERONAUTICAL SOCIETY

The Aeroplane. Dec. 18, 1913.

Deutsche Luftfahrer Zeitschrift. Nov. 26, 1913.

La Navigazione Aerea. Sept., 1913.

Osterreichische Flug Zeitschrift. Nov. 25, 1913.

Schweiz Aero Club. Bulletin Dec., 1913.

GIFT OF BUREAU OF RAILWAY ECONOMICS

Railroads and the Press. Address by Daniel Willard. Apr. 27, 1916.

Railways and the Shippers. Address by A. W. Thompson. March 14, 1916.

Will the Railroads Come Back? By Lockwood Barr.

GIFT OF C. A. DOREMUS

Death from Electrical Currents.

American Impulse Wheel Company. The perfect American Hurdy-gurdy, 1897.

De Forest Wireless Telegraph Company, Descriptive pamphlet.

Gramme's Magneto Electric Machines.

International Electrical Exhibition, 1884. General Report of the Chairman of the Committee on Exhibitions.

——— Report of examiners of Section XXIX. Educational Apparatus.

Mining Laws of Texas and Tables of Magnetic Declination. Univ. of Texas. Bulletin No. 6, 1903.

New York City. Board of Electrical Control. Second Report 1888.

Peyrusson, E. Electrolyseur et procedes d'electrolyse.

The Poulsen Telegraphone.

Report of the Special Committee on the Static Induced Current, Appointed at the 10th annual meeting of the American Electro-Therapeutic Asso., Sept. 27, 1900.

Report of Engineers of the U. S. Navy Upon Experiments With Saturated and Superheated Steam Made at the Massachusetts Institute of Technology, March 1877.

Thermit Steel for Welding, Goldschmidt Thermit Co., Sept. 1904.

Tommasi, D. Electrolytic processes for the extraction, separation and refining of metals. *Paris, n.d.*

GIFT OF ARTHUR WORISCHEK

Cazin, A. L Etincelle electrique. *Paris, 1876.*

DeCuverville, C. Cours de Tir. *Paris, 1864.*

DeParville, Henri. Causeries scientifiques. *1888.*

Lauriol, Jules. Transport electrique de la Force. Les experiences de Creil. *Paris, 1886.*

Memorial de l'Officer du Génie. No. 21. *Paris, 1875.*

Thiroux, M. Essai dur les projectiles allongés. *Paris, 1857.*

GIFT OF CARL HERING

L'Alternateur, systéme Boucherot, de 1000 HP exposé par la Maison Breguet et accouple avec la machine a vapeur Delaunay-Belleville.

Armature of Elphinstone & Vincent Machine (Drawings).

Brown Single Phase Induction Motor Curves. 1900 (Blue Print).

Discussion of series dynamo-electric machines. By Carl Kinsley, 1898.

Starting Gear on an Induction Motor. 1900 (Drawing).

Sur le Calcul de Machines electriques. Ateliers de Construction Oerlikon. 1900.

System of Control for Electric Motors, Ward Leonard.

Theory of Commutation, C. C. Hawkins.

Unipolar Dynamo. 1891. (Description and blue print.)

Die Verausberechnung der Dynamomaschinen.

TRADE CATALOGUES

American Blower Company. *Detroit, Mich.* Sirocco Service, vol. 5, no. 11.

Coen Company, Inc. *San Francisco, Cal.* Catalog Two. The Coen System of Mechanical Oil Burning. *1916.*

Columbian Brass Foundry. *Freeport, L. I.* Propellers in a Nut Shell.

Du Pont de Nemours, E. I. & Co. *Wilmington, Del.* Du Pont Magazine. *August* and *September, 1916.*

Engberg's Electric & Mechanical Works. *St. Joseph, Mich.* Apparatus designed on good, sound engineering principles.

Goldschmidt Thermit Company. *New York City.* Reactions. Second quarter, 1916. vol. 9, no. 2.

Koven, L. O. & Bro. *New York City.* Marine Catalogue.

Marine Oil Engine Co., Inc. *New York City.* Bulletin 101. Skandia Marine Oil Engines for crude or fuel oils.

Milburn, Alexander Co. *Baltimore, Md.* Oxy-Acetylene Welding and Cutting Apparatus.

Motor Compressor Co. *Newark, N. J.* The Perfect Starter.

Pelton Water Wheel Co. *New York, N. Y.* Bulletin no. 9. Pelton Doble Centrifugal Pumps.

Pyrene Manufacturing Co. *New York City.* Ten reasons why Pyrene is superior to the three gallon chemical extinguisher. Pyrene Extinguisher for motion picture theatres.

Robertson-Cataract Electric Co. *Buffalo, N. Y.* Illustrated brochure of buildings of company. 21 pp.

Samson Electric Co. *Canton, Mass.* "Perfex" waterproof ignition for motor boats. *1916.*

Smith, H. Collier. *Detroit, Mich.* Catalog no. 50. Quickwork machinery.

Snow & Petrelli Mfg. Co. *New Haven, Conn.* Joe's high power reverse gears. *1916.*

Sparta Iron Works Co. *Sparta, Wis.* Sludge bucket. *Aug., 1916.*

The Sperry Gyroscope Co. *Brooklyn, N. Y.* Neptune foiled by the Sperry ship's stabilizer.

Talbot Boiler Co. *New York City.* Talbot crude oil burning steamers.

Texas Company. *New York, N. Y.* Lubrication, vol. 2, no. 3; vol. 3, nos. 1-10. *Nov., 1914; Nov., 1915-Aug., 1916.*

Toomey, Frank. *Philadelphia, Pa.* Machinery house of the East.

Under-Feed Stoker Company of America. *Chicago, Ill.* Publicity Magazine. *July, 1916.*

Under-Feed Stoker Co. of America. *Chicago, Ill.* Publicity magazine. *Aug., 1916.*

United Shoe Machinery Co. *Boston, Mass.* Pamphlets relating to conditions at factory at Beverly, Mass., together with illustrations.

Westinghouse Electric & Mfg. Co. *East Pittsburgh, Pa.* Special publication no. 7064. Cut your repair costs with Westinghouse arc welding equipment. *1916.*

——— Leaflet 1356. Motors for driving ventilating and heating apparatus.

Wheeler & Schebler. *Indianapolis, Ind.* The Model "R" Schebler carburetor.

Wynkoop-Hallenbeck-Crawford Co. *New York City.* Description of plant.

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY.

AERONAUTICAL ENGINES.
WIRING ON AEROPLANES.
BREAKAGE OF MAGNETOS.
AIRCRAFT ENGINE BEDS.
AIRCRAFT ENGINE RADIATORS.
VIBRATION IN AIRCRAFT ENGINES.
SIX, EIGHT AND TWELVE CYLINDER ENGINES FOR AIRCRAFT.
HORSE POWER OF AERONAUTICAL UNITS.
STANDARDIZATION IN AVIATION ENGINES.
ROTARY MOTORS FOR AVIATION.
CAST-IRON DROP-FORGE DIES.
PATTERN MAKING FOR CAST IRON DIES.
PLASTER PATTERNS FOR CAST IRON DROP-FORGE DIES.
TRIMMING DIES OF CAST IRON.
CORROSION AND DUCTILITY OF BRASS.
CORROSION AND STRENGTH OF BRASS.
PORCELAIN, CONSTITUTION AND MICROSTRUCTURE.
PORCELAIN, PETROGRAPHIC MICROSCOPIC STUDY.
PORCELAIN, MEANS OF ESTIMATING THE BURNING TEMPERATURE.
BEHAVIOR OF REFRACTORIES.
TEMPERATURE—VISCOSITY RELATIONS IN REFRACTORIES.
DEFORMATION UNDER LOAD AND REFRACTORINESS OF FIRE BRICK.
BURNING-IN MANGANESE BRONZE.
PULVERIZED COAL ON RAILROAD STATIONARY BOILERS.
PULVERIZED COAL COSTS.
SURFACE COMBUSTION ANNEALING FURNACE.
REINFORCED CONCRETE COALING PLANT.
DIESEL ENGINES WITH LOW COMPRESSION.
PUMP LEATHERS.
PARALLEL DEPTH BEVEL GEARS.
LIQUID MEASURING PUMPS.
GASOLINE MEASURING PUMPS.
UNITED STATES MUNITIONS.
SPRINGFIELD MODEL 1903 SERVICE RIFLE.
LOCOMOTIVE PROBLEMS THAT DEMAND SOLUTION.
TILLING-STEVENS GASOLINE ELECTRIC RAILROAD CAR.
STARTING TORQUE ON ORDINARY GEAR TRANSMISSION.
STARTING TORQUE OF INDIRECT ELECTRIC TRANSMISSION.
INITIAL STRAINS IN STEEL RAILS.
THERMAL INSULATORS.
THERMODYNAMIC TERMS DEFINED.
TRANSMISSION OF COMPOUND WALLS.
CONDUCTION THROUGH AIR SPACES.
SMALL COOPER SYSTEM COLD STORAGE PLANT.
FLOW OF SUPERHEATED AMMONIA GAS IN PIPES.
PURE SCIENCE AND INDUSTRIAL RESEARCH.
FRENCH ACADEMY OF SCIENCES AND ENGINEERING.
NATIONAL PHYSICAL LABORATORY, ENGLAND.
IDEAL PHYSICAL LABORATORY.
DYNAMIC AND STATIC TENSILE TESTS.
ALTERNATING STRESS TEST.
NOTCH TEST WITH ALTERNATING HAMMER BLOWS.
PLASTIC DEFORMATION AND FAILURE OF MATERIAL.
BOILER EXPANSION.
RELATIVE MOVEMENTS OF FIREBOX SHEETS.
RELATIVE MOVEMENTS OF TUBES.
BREAKAGE OF LOCOMOTIVE STAYBOLTS.
FAILURE OF BACK AND FRONT TUBE SHEET.
PROSSERING OF NEW TUBES.
PATCHING TOP OF TUBE SHEET.

In this issue of the Engineering Survey will be found two groups of articles related not inherently but by their bearing on the existing situation. Howard E. Coffin's article on munitions manufacture on the one hand and several articles on scientific research in relation to industries on the other would have been regarded three years ago as relating to entirely independent subjects. Today military preparedness for the defense of the country against armed aggression, and industrial preparedness vitally necessary to assure a country its due place in the world's market, have brought them into essentially the same class.

It is, however, more and more fully realized that no industrial progress, which is the corner stone of industrial preparedness, is possible without the closest correlation between the developments of science and their application to industrial engineering. Unless the achievements attained today in the laboratory in any country are transferred to the shop, it is fairly certain that some other country will avail itself of them and secure a hold on the market.

Events of the last two years have taught this lesson in a very striking manner. The world's industries have suddenly found themselves lacking not only sources of supply of some staple materials, but even, in many instances, knowledge of how these staples are produced. No country intends to repeat this error, and the papers by Coffin and Carty prove conclusively that in this country there is a full realization of this fact.

Those interested in the present industrial problems here will also be interested in how matters stand abroad, and in this issue will be found two highly authoritative statements on the situation in France by A. Blondel, Member of the French Academy of Sciences, and on the work and prospects of the National Physical Laboratory in England by Walter Rosenhain, chief of one of the departments and a metallurgist of note. Bearing on this same subject, is a paper by Charles P. Steinmetz, chief consulting engineer of the General Electric Co., read on October 18, 1916, before The Franklin Institute at Philadelphia, delivered too late to be abstracted in the Survey. The speaker said that since established research institutions have not been able to furnish all the information desired for use in the industries, industrial establishments have recently gone into scientific research themselves with vastly extended facilities, with the result that of late the largest number of scientific advances have been made in industrial research laboratories. Germany was first to realize that the establishment of the industrial research laboratory was one of the most profitable investments which could be made by the large industries, but in the last few years American corporations have also fully awakened to a realization of this fact, and the research laboratories established in this country by industrial corporations are doing scientific work of the highest order in chemistry, physics and mechanics.

THIS MONTH'S ARTICLES

In the section Aeronautics will be found an interesting report of a session of the Executive Committee of the National Advisory Committee for Aeronautics, devoted mainly to the discussion of means for securing satisfactory motors for American aircraft. The discussion brought out several highly important points. It showed that the details of design and construction are far from receiving a proper amount of attention. The wiring is in many cases defective. Installation of magnetos is such as has been long ago abandoned, for example, on racing cars. Another important point brought out is the growing conviction of designers as to the influence of

engine vibration on the general factor of reliability of the machine. Discussion has also confirmed the prevailing impression that big motors of 200, 300 and perhaps higher horsepower, will be especially demanded in the near future.

A. R. Braden describes a method of making cast-iron drop-forge dies which proved successful on shoe-machine forgings. The main improvements appeared to be in the method of producing the patterns.

In the section Engineering Materials will be found two advance abstracts of technologic papers of the Bureau of Standards, published by courtesy of the Bureau. One of these abstracts is devoted to an investigation of a homogeneous alpha brass, presenting an interesting explanation of the decrease in strength and ductility of brasses when corroded while under stress.

The other Bureau of Standards' investigation covers a petrographic study of various porcelains, as well as combinations of the raw materials which enter into porcelain manufacture. It is found that the constitution and microstructure of porcelain depend upon the temperature of burning, the time of burning factor being only of secondary importance. The petrographic and microscopic study of porcelain of the type carried out at the Bureau is of high importance, in that it places the chemical and physical properties involved in the formation of porcelain on a more quantitative thermal basis. Furthermore, it offers a means of estimation of burning temperature of a ware from the examination of a fragment much too small in size to be satisfactory for even a chemical analysis.

Data on stresses produced by burning-in manganese bronze are presented by D. Merica and C. P. Karr from an investigation made in connection with some work on manganese bronze valve castings used in the Catskill viaduct.

Data on the testing of refractories are presented by A. V. Bleininger from work done at the Bureau of Standards.

Several years ago the Missouri, Kansas & Texas Railroad decided to install pulverized coal firing for some of their stationary boilers. For various reasons the installation was not put into operation until this year. Since then various tests have been made with different fuels and all of them burned with entire success and without troublesome deposits of ash. The abstract in the section Fuels gives a brief description of this installation and cost data from some of the tests.

Annealing furnaces operating on the surface combustion principle are described in the section Furnaces. One of their advantages is that they give a neutral or reducing atmosphere which makes it possible to treat forgings without packing.

Prof. W. H. Watkinson's paper presented to the Newcastle meeting of the British Association in September, 1916, will come as somewhat of a surprise to Diesel engineers. The author claims that it should be as easy to obtain ignition temperature by compression to 2 atmospheres as it is to obtain it in the ordinary way by compression to 34 atmospheres, and he shows that it is entirely unnecessary to permit starting period pressures running as high as 800 lb. per square inch.

William C. Glass describes a method of producing parallel depth bevel gears on a universal gear cutter requiring only two settings to complete the gear.

The precision of liquid-measuring pumps is discussed by F. J. Schlink in a paper before the Annual Conference of Weights and Measures of the United States. The conclusion of the author is that nearly all of the defects of construction and installation of gasoline-measuring pumps tend to produce errors in the one direction of under-measurement.

In the section Railroad Engineering will be found a general paper by George M. Basford on electric problems that demand solution, as well as a paper on the Tilling-Stevens gasoline-electric cars to run on standard track. In the same section will be found an abstract of a report made by James E. Howard, engineer physicist of the Interstate Commerce Commission, covering the subject of initial stress in steel rails.

The testing of thermal insulators is the subject of a paper based on the work done at the Bureau of Standards by H. C. Dickinson and M. S. VanDusen. Among other things the paper contains definitions of several terms used in refrigerating engineering and thermodynamics.

Interesting experiments on boiler expansion and certain boiler troubles made on the New York Central lines are described in a paper by D. R. MacBain in the section Steam Engineering.

Aeronautics

Aeronautical Engines

Abstract of a report of a session of the Executive Committee of the National Advisory Committee for Aeronautics held at the Smithsonian Institution, June 8, 1916.

The meeting was held in the very rooms where Dr. Langley first developed his idea of the physics of the air and the art of flying.

Henry Souther, Mem.Am.Soc.M.E., Consulting Engineer of the War Department, stated that we in this country are in a fair way to obtain a satisfactory motor for aircraft within a reasonable length of time, but the only way of arriving at anything of this nature is by a slow process of evolution or use. What is demanded of an aeronautical motor is, in the first place, reliability, which does not, however, necessarily mean anything unusually strong, but means thoroughness in all details of which reliable wiring is an example; accidents may come from an accumulation of gasoline in the shape of a puddle somewhere in the structure, hence the piping is as important as anything, etc.

Next come dependability and durability. Of exceeding importance is also simplicity of design. Adaptability of the motors is a quality that will change as fast as the art changes, and what is considered adaptable today may be viewed as bad practice ten years from now.

Lieut. W. G. Child, U. S. N., in discussing the experience of the Navy with motors, pointed out some matters of considerable practical importance. One is the question of interchangeability of motors. At present beds built for one motor are often not adaptable to another motor of the same horsepower because of the difference in the brackets. One way of overcoming this without changing the design is to make the brackets wider, say 4 in., and not drill bolt holes, so that any motor can be installed on foundations that would take the width of that bracket.

For motors of higher horsepower, the speaker advocated generator ignition because of the necessity of having starters and of the need for a hot spark at low speed. As between having a large lower crank case to keep the oil or of having separate tanks, the preference of the speaker was for separate tanks which would lighten the engine, give an extra oil supply, help cool the oil and permit of installing the tank at any convenient place. In addition, with only a little oil in the motor, there would be no danger of flooding the cylinders in gliding.

One of the greatest problems in aviation is the design of a suitable radiator. The resistance of the radiator means a tremendous loss in lifting capacity, and the Navy found ex-

perimentally that one type of radiator had a very low resistance and was about five times as effective as another type in very general use.

Lieut.-Col. George O. Squier, U. S. A., in charge of the Aviation Section, War Department, stated, in answer to questions, that the Green engine is the one which the British are widely using. It is built in sizes as large as 250 h.p., and two of these are put on an aeroplane. In all the belligerent countries they are doing wonderful things every day, things we have never done here.

Capt. Mark L. Bristol, U. S. N., Commander of the Navy Air Service, believes that we have not a motor in this country suitable for aeronautic use. The principal fault with our motors is that they are unreliable. Another is that we cannot get enough power out of them for naval use. The aeroplane that will be taken to sea must not weigh less than 6000 lb. and must have 300 or 400 h.p. at least. This can be obtained from two motors of from 150 to 200 h.p. each, but there is not such a motor in the United States at present that is reliable.

Charles M. Manly (Curtiss Aeroplane and Motor Corporation) discussed the manner of approach in the matter of developing the best aviation motor. There are two main ways of approaching the subject; one is to start with your motor light weight, and by a process of evolution make it more and more reliable; the other is to start with the motor very reliable and decrease the weight. The speaker personally believes that the better plan is to start with the motor light.

Howard E. Coffin, Mem.Am.Soc.M.E., of the Naval Consulting Board, expressed his opinion that the whole development of aviation has been thus far an experimental proposition only, and that there has been practically no real quantity or commercial production in that line. So far an attempt has been made to build motors which are so near the ragged edge in strength of parts, reliability, lightness, and so forth, that we have got into a lot of trouble that we should be able to avoid. A great deal of the trouble was because of the magneto not being properly mounted on the motor, although we learned in racing cars as early as 1906 that no magneto should carry a gear directly on its shaft. The wiring in the average aeroplane is a joke. All wiring must be carried in metal conduits. In fact, the speaker believes that the wiring of either an automobile or an aeroplane should pass an examination similar to the underwriters' examination by the insurance companies. If a $500 garage is not built without the underwriters passing on the wiring installation, there is no reason why an aeroplane costing $10,000, in which one risks his life, should escape such inspection.

The speaker strongly emphasized the question of the elimination of vibration, which in his belief is the real cause of possibly nine-tenths of the trouble with any apparatus, whether it is a motor car or an aeroplane. The vibration in a gas engine is dependent upon certain fundamentals of its design, and the six- and twelve-cylinder machines are the only two types of engines that in a practical way can be freed from vibration.

It is surprising to find that a six-cylinder engine, if driven by an electric motor so that the engine itself is not running under its own power at speeds up to 2000 to 3000 r.p.m., can be stripped of everything down to the crankshaft without appreciably reducing the noise, which indicates that the principal difficulties in the gas engine are connected in some way with the crankshaft. It makes no difference how heavy the crankshaft is, in fact, adding weight to it will probably make the trouble worse. No couples of any kind may be permitted to develop within the crankshaft; every unbalanced effect must be compensated, and that not somewhere else in the shaft, but immediately in the plane of rotation of the part causing this unbalanced effect. This holds also in the aircraft end. If the engines be made so that they do not vibrate when run at 2000 r.p.m., there will be wiped out nine-tenths of the other troubles, such as the breaking of pipe connections, of the wiring on the plane itself, and so forth, which all goes back to vibration of these parts.

On the other hand, H. M. Crane (Wright Aeroplane Co.), with respect to the question of vibration, called attention to the fact that the conditions in an aviation motor are different from those in an automobile motor. There you have to cover every speed up to 2000 or 3000, or even higher, revolutions per minute, while an aviation motor has mainly to run at full power at a certain fixed speed. Hence the eight can meet in an aeroplane the conditions for which a six or twelve cylinder engine is required in a motor car.

William R. McCulla (Packard Motor Car Co.) in describing his trip to Europe during the present war said that in Europe the lowest power with which they want to go up is 250 or 300 h.p. They had one motor of 600 h.p. which had been built in advance for a warplane, but this motor was put in a very fast motorboat for discovering submarines. Then they went to the geared-down motor (such as the Sunbeam) and had no trouble with gear reduction. These large motors use successfully four-bladed 14 ft. propellers. The specifications of the British Government now call for a disconnecting test of propellers to make sure that if the propeller becomes loose in the air or is shot away it will not smash the motor. As to trouble with magnetos, the speaker ascribed it to general lack of thoroughness in design and construction. He saw an aeroplane motor taken down to be overhauled. The motor was considered to be first-class, and still the closest any one of its pistons came to another was within 1¼ oz., that is, no two pistons were of the same weight. It hardly can be expected that any magneto could stand that.

Several of the speakers, especially those who have been in Europe, expressed dissatisfaction with rotary motors. Statements were made that the use of the Gnome motor, which was so popular in French aviation at the beginning of the war, has been now practically abandoned. (*Abstract of a stenographic report of the meeting of the Executive Committee of the National Advisory Committee for Aeronautics held at the Smithsonian Institution,* June 8, 1916, 58 typewritten pages.)

Dies

Cast-Iron Drop-Forge Dies, A. R. Braden

Description of a method of making cast-iron drop-forge dies which has proved successful on a large variety of shoe-machine forgings in the Beverly factory of the United Shoe Machinery Co.

The possibility of using cast-iron dies instead of steel dies not only opens an opportunity to effect a large saving in the cost of new dies, but eliminates the necessity which exists on orders of between five and ten thousand pieces of repairing the steel dies, and often of planing off the old impressions and "sinking" new ones, a costly operation, and one which, in addition, delays the work of forging. Also, a common requirement is the changing over of steel dies to agree with a change in design of the forging, which is nearly as expensive as making new dies.

The method of making cast-iron dies is said to have been

perfected now to the highest point. The most important part of this process appears to be the production of the patterns. The original pattern proved to be defective and several improvements had to be made. A pattern was originated that made it possible to cast the die block and the shank with both draft and dowel holes, doing away entirely with machine work. To accomplish this the pattern for the shank was made in three parts—a wide rectangular centerpiece and two smaller strips, on each of which were cut the draft and dowel holes. Then, when in molding the pattern was ready to be drawn from the sand, the pins connecting the small pieces to the centerpiece were removed and the main part of the tongue drawn, making it possible to draw the small strips.

It was found that the correctness of the pattern was spoiled by the warping of the wood frames. This trouble was overcome by securing a casting of the pattern and using the latter as a model for molding the first die and for filing for future use. Further, an aluminum block pattern was provided to replace the old wooden one, thus giving a completely indestructible die pattern, with the exception of the pattern for the tongue, which it has not as yet been necessary to replace by metal.

The latest improvement is a pattern made entirely of plaster. A special frame similar in shape to the old wooden one is made of cast iron, and is adjustable by means of pegs and dowel holes to any one of the eight standard die sizes. This frame is placed flat on a surface plate, the wood model of the forging being held in the proper position relative to the frame by means of four clamps that bear on the parting line. The patterns for the break-down, anvil, sprue and cut-off are sawed out of wood and placed in their proper positions inside the frame. The plaster is then run into the frame and allowed to set. When hard, the frame is removed together with the model and patterns, leaving a complete plaster impression ready for molding.

In addition to discarding the stock of expensive wooden frames which had to be kept, a great deal of time is saved in that the break-downs, anvils, sprues and cut-offs can be cast with the impression of the forging by simply cutting out the necessary patterns from waste stock on a band saw. These plaster patterns made with the adjustable frame may be filed away without danger of warping. If they break they can be replaced in an hour's time.

The maximum time required to turn out cast-iron dies ready for the hammer is four days. (The average time for steel dies is from one to four weeks.) On one order a pair of cast-iron dies produced 5000 forgings. This record will not hold for all cast-iron dies, but in many cases their life nearly equals the life of steel dies.

Concerning trimming dies, it is stated that actual trials have proved them to be as successful in their line of work as the drop-forged dies are in theirs. Excellent results have been obtained both in hot- and cold-trimming work; for instance, one die, ground once, and one punch trimmed a thousand forgings through a flash fully 3/16 in. thick. (*American Machinist*, vol. 45, no. 15, p. 621, October 12, 1916, 5 pp., 22 figs. *d.*)

Engineering Materials

The Failure of Brass.—2. The Effect of Corrosion on the Ductility and Strength of Brass, Paul D. Merica.

Results of an investigation made on a homogeneous alpha brass have shown that the electrolytic solution potential of this material is increased by the application of a tensile stress. This increase, as measured, amounts to approximately 0.1 millivolt for a stress of 10,000 lb. per sq. in.

Using this fact as a basis, an explanation can be given of the decrease in strength and ductility of brasses when corroded while under stress. Over a roughened surface of a bar under tensile stress this stress will vary in value, being greatest at the bottom of furrows and depressions and least, almost zero indeed, at the tops of the ridges. The EMF will therefore, other things being equal, be greater; i. e., more electropositive, at the bottom of these furrows than elsewhere; corrosion will set in here most rapidly forming a crack, which will grow narrower and sharper, its rate of growth being greater the sharper it is. In time the cross-section of such a bar is so reduced by these cracks that fracture occurs, the brass failing apparently at a stress value less than the ultimate strength, and exhibiting only light elongation (ductility).

This explanation is borne out by the examination of a number of brass failures, which have occurred under such conditions. (*Bureau of Standards* Technologic Paper No. 83, advance abstract.)

The Constitution and Microstructure of Porcelain, A. A. Klein

A petrographic microscopical study of porcelains prepared in the laboratory of the Bureau of Standards and of commercial porcelain as well as of various combinations of the raw materials which enter into porcelain, has led to results which are interesting and important both scientifically and technically.

Bodies and mixtures of the following types were examined: kaolin, feldspar-kaolin, feldspar-quartz and feldspar-clay-quartz. These were burned to various known temperatures. The commercial bodies investigated represented the practices of the following countries: United States, England, Germany, France, Austria, Denmark and Japan. The end in view was to obtain data concerning the changes involved by burning porcelain at various temperatures, and it was found possible to correlate to a certain degree the constitution and microstructure with the burning temperature of bodies whose composition lay within the limits of whiteware and hard fired porcelains.

The result of this investigation leads to the following conclusions: Kaolin appears homogenous microscopically when heated up to 1200°. At about this temperature a trace of dissociation occurs. As the temperature is raised above 1200° the dissociation increases very slowly at first, then at an increasing rate until at 1400° it seems to be complete. The products of dissociation are silica and aluminum silicate. The latter compound has been identified as an amorphous phase of sillimanite from the following facts: It shows no crystalline form, has an index of refraction approximately above 1.60, and by heating at a higher temperature (about 1450°) it inverts to minute needle crystallites corresponding to sillimanite in all determinable optical properties.

Up to 1340° in mixtures of quartz and feldspar, the quartz dissolved to only a small extent in the feldspar glass. At 1460° the quartz practically completely dissolved in specimens having as high a quartz content as fifty per cent quartz to fifty per cent feldspar.

At 1340°, in specimens containing kaolin and feldspar, the kaolin dissociates entirely. The amount of crystallized and amorphous sillimanite increases with an increased content of kaolin at least to a concentration of fifty per cent kaolin to fifty per cent feldspar.

At 1460° apparently ten per cent kaolin is entirely soluble in the feldspar glass. With higher concentrations of kaolin the amount of crystallized sillimanite increases. The needle crystals are well developed and comparatively large.

At 1310° in quartz-clay-feldspar bodies, the feldspar is present as a glass; the clay shows almost complete dissociation, with the formation of amorphous sillimanite mainly and but little crystallized sillimanite, while the quartz is undissolved and the grains may still be of considerable size, up to 0.2 mm. or more, depending upon the fineness of grinding.

By burning these bodies at 1380°-1400°, the feldspar glass dissolves considerable quartz, there being only a comparatively small amount of residual quartz remaining. The quartz grains are much rounded and etched, and they seldom show a length over 0.06 mm. The clay is dissociated with the formation of crystallized sillimanite, although an extremely small amount of amorphous sillimanite may be present.

The changes involved by burning commercial bodies are identical with those of laboratory-prepared bodies. Commercial ware ranges from a low-burned porous whiteware in which, except for the dehydration of the clay, only the feldspar is changed, to very-high-fired porcelain which consists of glass, sillimanite crystallites and more or less of residual quartz. The quartz grains observed in the whiteware and in the low-fired vitreous ware are large and angular, showing a size of .2 mm. or more, whereas in the hard porcelain, due to solution, the quartz grains are rounded and etched, and seldom exceed .05 mm. in length.

The constitution and the microstructure of porcelain depend upon the temperature of burning and change as this temperature changes. This has served as a basis for the estimation of the probable burning temperatures of the commercial bodies, a fact which was accomplished with success, the error involved being within twenty-five degrees. It appears that the time-of-burning factor is by no means as important as that of the burning temperature in determining the constitution and microstructure of the ware.

No cristobalite or tridymite has been definitely observed in any of the laboratory or commercial bodies examined. It appears that the quartz dissolves in the feldspar glass more readily than it inverts to the other modifications of silica.

In conclusion it may be stated that the petrographic microscopic study of porcelain led to interesting and, it is to be hoped, important technical results. It has placed the chemical and physical processes involved in the formation of porcelain on a more quantitative thermal basis. Furthermore it has offered a means of estimating the burning temperature of a ware from the examination of a fragment much too small in size to be satisfactory for even a chemical analysis. (*Bureau of Standards,* Technologic Paper, No. 80, advance abstract.)

Some Aspects of the Testing of Refractories, A. V. Bleininger

Data on the behavior under various conditions of clay, silica, magnesite, aluminous, carbon and other refractories. In particular clay refractories have been investigated with respect to porosity, and the diagram Fig. 1 has been obtained showing the behavior of one open and four dense burning clays. This diagram represents five well-known European fireclays imported to this country in considerable quantities.

With increasing temperature the viscosity of refractories decreases, and this softening is the greater the larger the amount of fluxes present. It had been suggested, therefore, that the deformation at certain temperatures and under given load be used as a criterion of the refractoriness of firebricks. From the data recently obtained by the Bureau of Standards (Technologic paper, No. 7), it follows that the softening of the bricks becomes clearly manifest at 1350 deg. cent., which seems a suitable temperature for this test. The load to be supplied should not be greater than 40 lb. per sq. in., and not less than 25 lb. The relation between the deformation temperature T and the load W in pounds per square inch is expressed by Mellor's equation

$$T = Ce^{-KW}$$

where C = deformation temperature of specimen without load; K = a constant the numerical value of which depends upon the particular clay, and e = exponential constant.

It was found that the more silicious the clay the less the difference between the deformation temperatures with and without load. On the other hand, the more the composition of

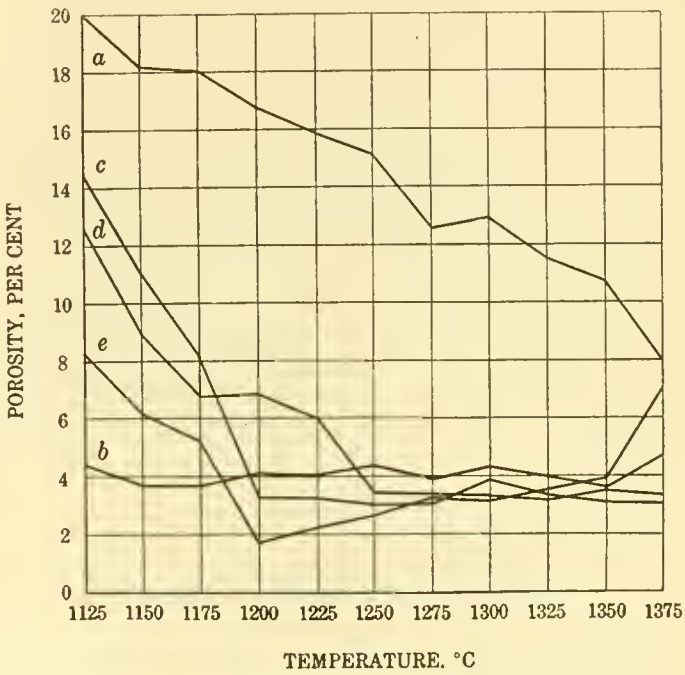


Fig. 1 Diagram Showing Behavior of One Open and Four Dense Burning Clays

the material approaches that of the pure clay substances the greater is the difference between the deformation temperatures with and without load. It is possible, however, to produce high-clay firebrick showing excellent resistance to load conditions by using a mixture containing as high a percentage as possible of calcined No. 1 fireclay and a very refractory bond clay. Such bricks have been made under the direction of the writer and were found to possess an exceedingly small contraction with a load of 50 lb. per sq. in. and at temperatures of 1350 to 1400 deg. cent. (*Proceedings of the Engineers' Society of Western Pennsylvania,* vol. 32, no. 7, p. 612, October, 1916, 34 pp., 14 figs., *e A.*)

Stress Produced by Burning-In Manganese-Bronze, Paul D. Merica and C. P. Karr

An investigation of the initial stresses produced by the burning-in of manganese-bronze made in connection with the failure of a number of manganese-bronze valve castings used in the Catskill aqueduct.

In that work experience has shown that large castings of this material after some months of service have developed fissures through which leakage takes place under only a few pounds of pressure. Nearly all these cracks appear to be close to or in a repair made by the method of burning-in. It was assumed that, after the burning-in, stresses remained in the casting particularly severe near or within the burning-in area, and that these stresses were responsible for the subsequent failure at these points.

An experimental investigation was carried out to determine the presence and magnitude of these stresses. It was found that actually after the burning-in there result stresses greater than the elastic limit of the material and the material yields thenceforth, the stress following (with probably some time lag) the elastic limit of the material, so that the stress as measured one or two days after burning-in represents the true elastic limit of the material.

The experiments have indicated how readily severe stresses may be introduced into a casting by the burning-in or welding of a strained area or part of it. These stresses may be modified in complicated shapes by the added influence of distortion. For instance, in the spherical shell or dome-shaped valve casting of the New York Board of Water Supply burning-in would tend to flatten the shell and in so doing partly relieve these stresses. The authors believe that even in these castings, however, local stresses equal to the true elastic limit must have been produced. Hence such castings should be either preheated carefully for welding so that all parts of the casting cool down together from a dull red heat or the casting should be subsequently annealed. Experience indicates that a low temperature anneal is sufficient for this purpose, say from 400 to 500 deg. cent. from for one to two hours. (*The Foundry*, vol. 44, no. 290, page 431, October 1916, 3 pp., 4 figs. *ed.*)

Fuels

Stationary Boilers Fired by Pulverized Coal on the Missouri, Kansas & Texas Railroad

The equipment for pulverizing and drying fuel is contained in a separate building, the coal being dumped from the cars directly into a concrete track-hopper of 50 tons capacity adjoining the building. The plant is designed to handle either mine run or slack coal, and immediately below the track-hopper is placed a set of Jeffrey double spike-tooth rolls which will reduce lumps up to 12 in. by 18 in. to 5 in. cubes or less in one operation.

The equipment throughout the pulverizer plant is operated by electric motors. The capacity of the pulverizer plant is 180 tons per day of 24 hours.

The boilers in the power house are arranged in pairs, and for pulverized fuel are provided with a Dutch-oven furnace built on the front of the boiler setting. Each pair of boilers is provided with a blower driven by a 10 h.p. constant-speed direct-current motor, a blast pipe from this blower entering the rear end of an induction tube passing through the wall of each furnace. The fuel from the feeders is led by gravity through a pipe entering the top of the induction tube near the front of the furnace. The action of the high velocity jet from the blast pipe induces a large volume of air at lower velocity through the induction tube; the fuel is caught by this current, is thoroughly mixed and enters the furnace at a low velocity, burning with a lazy flame, which practically fills the combustion chamber. The boilers were formerly provided with 3-pass horizontal baffles. In the pulverized fuel fire boilers these baffles are being replaced by a vertical 3-pass arrangement from which excellent results have been obtained.

Various tests have been made with the different fuels mentioned, and all of them were burned with entire success. An effective distribution of the heat throughout the heating surface of the boiler was obtained and the stack temperatures were low. No deposit of ash that could not readily be dislodged with an ordinary air blast settled anywhere in the boiler.

With Texas lignite and a boiler output of 110 per cent of rated capacity, an equivalent evaporation of 8.81 lb. of water per pound of combustible was obtained. The coal, as fired, had a heating value of 11,250 B.t.u. and contained 7 per cent moisture, the dryer not being arranged to handle this class of fuel regularly. At about 92 per cent of rated capacity an equivalent evaporation of 10.9 lb. of water per lb. of combustible was obtained with Mineral slack (Cherokee County, Kansas), the fuel as fired containing 1 per cent moisture. Including the cost of pulverizing, 35 cents per ton, the cost of this coal delivered to the bin was $1.795 per ton. The cost of evaporating 1000 lb. of water was 11.6 cents, while with natural gas, of heating value about 940 B.t.u. per cu. ft. and costing 12.5 cents per 1000 cu. ft., the cost of evaporating 1000 lb. of water was 16 cents.

The normal coal feed is arranged to develop about the rated capacity of the boiler. At maximum feed, however, the boilers may be forced to 142 per cent of rated capacity. No difficulty has been experienced from abnormal furnace temperatures which would tend to destroy the furnace walls. Even under forced conditions the furnace temperature does not exceed 2350 deg. fahr., and under normal conditions it is about 2100 deg. fahr. (*Railway Age Gazette*, vol. 61, no. 13, page 549, September 29, 1916, 3 pp., 2 figs. *de.*)

Furnaces

New Annealing Furnace

At the plant of the Remington Arms Company, Eddystone, Pa., there are now in operation two annealing furnaces employing the surface combustion principle and giving a neutral or reducing atmosphere which makes it possible to treat the forgings without packing or otherwise protecting them against possible oxidation.

The furnaces were provided for annealing rifle parts immediately after forging. They are of the car-bottom type, 20 ft. long, 12 ft. wide and 9 ft. high. The charge to each furnace varies from 20,000 lb. to 40,000 lb., depending upon the parts handled. A mixture of water and coal gas is used, averaging 580 B.t.u. per cu. ft. The gas is delivered and metered under a pressure of 25 lb.

During the heating-up period, each furnace consumes about 10,000 cu. ft. of gas per hour. When the temperature has been reached this is dropped to about 5000 cu. ft. per hour. For a maximum weight charge, approximately 72,000 cu. ft. of gas is used by each furnace. Two charges per furnace can be secured in a 24-hr. day.

The annealing temperature is 1550 deg. fahr.

The furnaces are of the heavy-rail buck-stave type, with red brick outside. The firebrick lining is backed by cork-brick insulation. To prevent in-leakage of cold air, giving an oxidizing atmosphere and lowering the furnace efficiency, a furnace back pressure is carried, the flue openings being small enough to cause this condition.

Both furnaces are controlled from a central point by a

single valve, which regulates the pressure supplied. It takes only little of a man's time to hold the furnaces to the exact temperature called for. To maintain a proper reducing atmosphere, the mixture is adjusted to give a flue-gas reading of about 1.2 per cent carbon monoxide.

The article is illustrated by a section of the furnace showing the refractory material kept at incandescence by the high-pressure gas burners. (*The Iron Age,* vol. 98, no. 12, p. 636, September 21, 1916, 2 pp., 2 figs. *d.*)

Handling Materials

A Large Reinforced-Concrete Coaling Plant

Description of the new station for the Duluth, Missabe & Northern Railroad, at Proctor, Minn., having a storage capacity of 1000 tons of coal. Of interest because it represents recent developments in equipment for handling coal and sand.

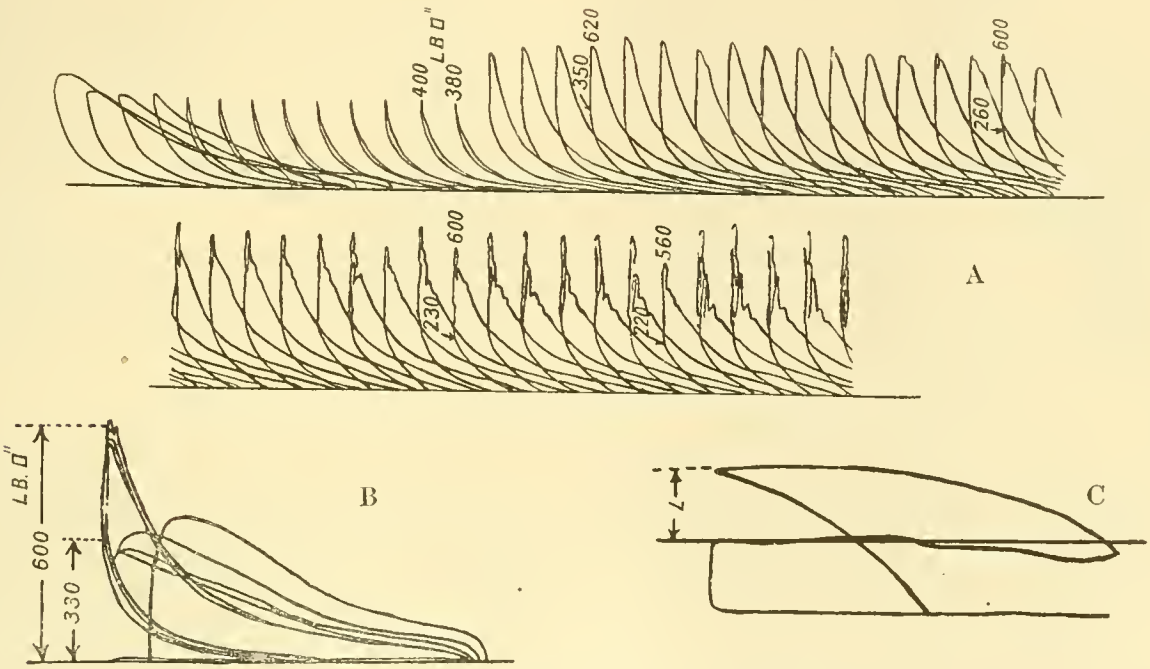


Fig. 2 Starting Diagrams with Reduced Compression

The design of the superstructure of the station structure is simple. The bins are supported on two rows of concrete columns along the two sides of the building, six 2 ft. by 2 ft. 6 in. columns in each row. Transverse girders of the same width as the columns span between opposite sides of the building over each pair of columns and support the floor of the bin. The sides of the bins are 7 in. thick and span horizontally between pilasters which are 18 in. wide and project 11 in. into the bin. These pilasters are located directly over each column along the two sides of the building and at a spacing of about 10 ft. center to center at the two ends. They distribute the lateral pressure of the coal to the top and bottom of the bin, the pressure being absorbed at the bottom by the floor system and at the top by a horizontal girder; the latter is continuous on all four sides and is braced at each corner by a diagonal tie or horizontal knee-brace which connects the nearest pilasters in adjoining walls.

The coal delivered to the track hopper in bottom-dump cars is fed by a Schraeder measuring feeder into the elevating bucket. This feeder has a capacity of 2½ tons, and is actuated by the ascent and descent of the elevating bucket, being arranged in such a manner that 2½ tons of coal are discharged into the bucket each time the latter passes by the feeder in its descent.

The coal is retained in the bucket by means of an apron at the bottom. The apron is equipped with a 6-in. roller traveling on a continuous steel guide from the bottom of the pit to the bucket discharge point. This insures the retention of the coal except when the roller guide permits the apron to open up at the top of the tower to discharge the coal into the bin.

The operation of the bucket when handling sand is exactly the same. The sides of the track hopper have a slope of 50 deg. to insure the ready flow of the wet sand. Deflectors are provided in the chute at the top of the shaft to deflect the sand into the sand chute as well as to control the flow of coal into either one of the bins.

A brief description of the sand-drying plant is given. It is of the Beamer steam type, and is so designed that the steam pipes themselves act as retaining walls for the green sand, permitting the moisture to escape immediately into the atmosphere. The spaces between the coils are such that they readily hold the green sand but permit dry sand to slip through and fall onto a gravity sand screen which removes all foreign matter and particles of sand of too large a size. From the screen the sand passes into a hopper of an automatic air drum, from which it is blown by compressed air into the dry sand storage pocket. (*Railway Age Gazette,* vol. 61, no. 13, p. 542, September 29, 1916, 3 pp., 6 figs., *d.*)

Internal Combustion Engineering

Diesel Engines with Low Compression, Prof. W. H. Watkinson

Abstract of a paper presented to the Newcastle meeting of the British Association, September, 1916. In order that the temperature of the air in Diesel engines may be raised during

compression to the ignition temperature of the oil, the compression pressure is about 460 to 500 lb. per sq. in., and it has hitherto been believed that this high compression pressure was necessary to effect self-ignition of the oil sprayed into the compressed air.

While during the normal working of these engines the compression pressure is approximately the maximum pressure of the cycle during the starting period explosions occur within the engine cylinder and the pressure attained during these explosions may amount to 800 lb. per sq. in. or more. Because of these and other pressures which are liable to be developed under certain abnormal conditions, it is necessary to make various principal parts of the engine much stronger than would be necessary for the normal maximum working pressure. The author has found, however, that it is possible in several different ways to obtain ignition temperatures during compression without the use of high compression pressures.

Fig. 2A shows a number of continuous diagrams from the engine after these additions have been made to it. In all these diagrams the compression pressure is very much lower than the minimum pressure hitherto believed to be necessary for self-ignition. In the second row of these diagrams the ignitions are shown to be taking place quite regularly with a compression pressure of 220 lb. per sq. in. Fig. B shows a diagram for the starting air and explosion due to self-ignition with a compression pressure of 330 lb. and a maximum explosion pressure of 600 lb. per sq. in. and different atmospheric pressure, these diagrams being the first to be taken on a certain morning when the engine was first started from all cold.

Fig. C shows a light spring diagram and indicates one way by which it has been possible to obtain ignition temperatures without a high compression pressure.

The equation of the compression curve shows that the temperature at the end of compression in any given case depends on the ratio of compression and not on the magnitude of the pressure at the end of compression. Further, the experiments of the late Dr. Joule indicate that the temperature is not sensibly reduced by wire-drawing, and therefore the temperature at the beginning of compression is independent of the pressure of the air, while the temperature of the air at the end of compression is independent of the compression pressure. Hence, it should be as easy to obtain ignition temperature by compression to two atmospheres as it is to obtain it in the ordinary way by compression to 34 atmospheres. (The author has not yet, however, made any experiments with such low compression pressures.) To avoid the very high pressures obtained during the starting of the engine it is only necessary to throw the mechanism operating the air-admission valve out of action, and then the spring of the valve spindle will automatically control the wire-drawing of the air admitted to the cylinder and the maximum explosion pressure during the starting of the engine will then be limited to about the normal compression pressure instead of its being 800 lb. per sq. in. or more. (*The Engineer*, vol. 122, no. 3169, p. 266, September 22, 1916, 2 pp., 7 figs., *d e.*)

Leather Articles

Manufacture of Pump Leathers

Description of the production of pump leathers at the plant of W. & B. Douglas Co., Middletown, Conn. Leather cups are produced by a process analogous to the drawing-up process of working brass and other sheet metal which imposes upon the material a particular set of conditions. As numerous kinds of leather articles, such as cup leathers, valve leathers, head packing, coupling packing rings, etc., have to be produced, the elementary stages are usually identical throughout the complete list of shapes. The starting point is shaving the leather to the desired thickness, after which the work is cut out to the desired size and shape by special punches and dies. These dies are made in hundreds of sizes and in scores of patterns.

The forming operation is accomplished in the pneumatic press. In this machine, operated by air under 60 lb. pressure, the work is pushed down to a steam-heated die. The actual die surface is about 1 ft. deep and each cup leather is pushed and formed up and punches the one below it down through the bottom of the die. The die is heated by steam. If the die or sleeve in which the work is formed gets too hot, the leather is likely to crack, so cold water is turned on, when the operator can tell by touch that the die has become too highly heated. It is, however, just as important that the die should not get too cold, for if it does the cup leather will wrinkle in the drawing-up process.

This drawing-up of cup leathers is an operation requiring considerable skill and judgment on the part of the workman. Certain conditions obtained are quite similar to the drawing-up of brass. A slight wrinkle in the form of the die leathers actually produces a shallow channel in the outer surface of the cup. While the cup material is flexible enough to take care of a certain degree of irregularity, it is not desirable that a depression or crease extending across the face should result from this forming process.

The article is illustrated by views of the pump leather department, dies, machinery and finished product. (*American Machinist*, vol. 45, no. 15, p. 631, October 12, 1916, 3 pp., 5 figs. *d.*)

Machine Shop

Parallel-Depth Bevel Gears, William C. Glass

Since the particular shape of the teeth of bevel gears is non-essential, provided the teeth in the mating gear are conjugates in so far as action is concerned, the ideal condition would be to have the teeth of such a form that exactly the same procedure and kind of cutter would be required to produce both. Still further advantage could be derived from producing such a form of tooth with rotary cutters on an automatic machine that can be set up by an ordinary machinist. This has been accomplished in a simple manner by a method by which hundreds of gears have been cut. So far they have been cut on a universal gear cutter requiring two settings to complete the gear, but the author claims that it would not be difficult to make the operation fully automatic.

The process admits of two general designs, (1) the stub-tooth form used preferably in new designs on account of its greater strength; and (2) the standard-depth form for gears to mesh with others cut by one of the generating processes.

It is necessary to have for each gear a gage for setting the gear cutter and a thickness gage equal to 1.157 ÷ diametral pitch for obtaining the proper depth of cut. It is also well to have a testing fixture for trying the gears in pairs.

Fig. 3A gives the particular data required in this process. X represents a bevel gear and Y its setting gage. For the stub-tooth form is used a standard involute spur-gear cutter, and for the standard-depth form an involute bevel-gear cutter. The writer gives the following formulae and data:

Known W = center and cut angles, diametral pitch (in the stub-tooth form W is the center, cut and face angles.

In the standard-depth form W is the center and cut angles, while the face angle is formed by a line Z, Fig. A, from the corner of the gear to the apex of the pitch cone as in the regular bevel gear)

N = number of teeth

T = thickness of cutter at a depth of $1.157 \div$ diametral pitch

Required $2C$ = diameter of setting gage

V = set-over angle

D = diameter from which to choose cutter

$$C = T/(2\sin 90/N)$$

$$R = C/\sin W$$

$$D = 2R \tan W$$

$$\sin V = T/2R$$

The cutter is set central in relation to and in line with the spindle and brought to the gage, as shown in Fig. B. The cutter is drawn back (see Fig. C) and replaced by a height gage that is centered over the swiveling stud in the gear cutter. A thickness gage equal to $1.157 \div$ diametral pitch in thickness $= B$ is placed between the point of the height gage and the gear gage. The slide is then tipped up to the cut angle and moved out until the point of the height gage is brought to the corner of the gage Y, as shown in Fig. D. The gear gage Y is then replaced by the gear blank X. The slide is next turned about the swiveling stud the amount of the set-over angle V (cp. Fig. E) and a cut taken around the gear. The slide is then set over the opposite side of the center line the amount of the set-over angle V and a final cut taken around the gear.

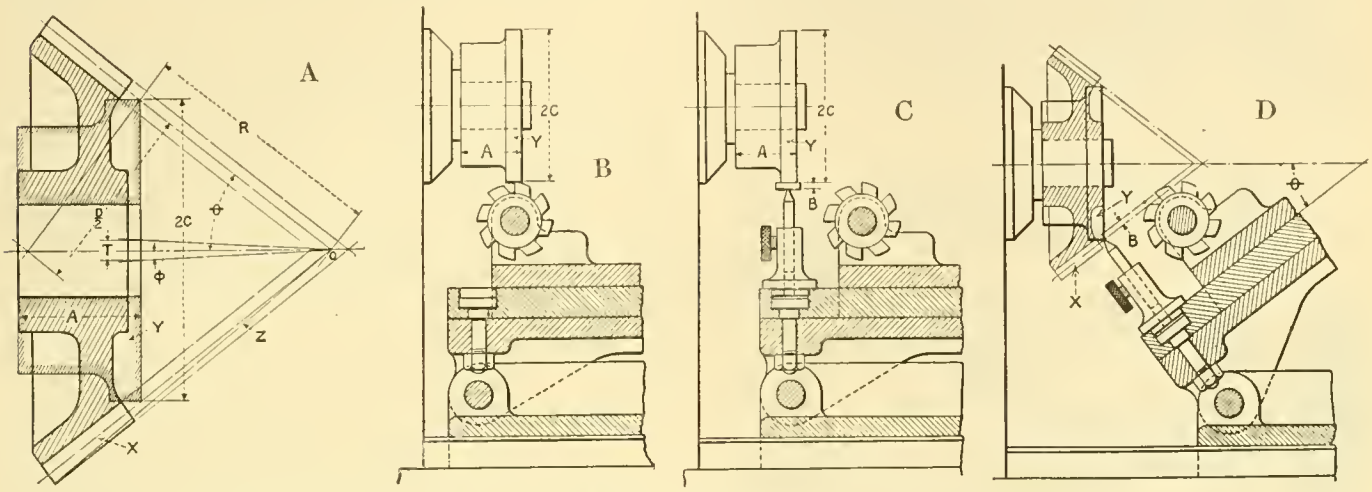


Fig. 3, A, B, C, D Layout and Method of Cutting Parallel-Depth Bevel Gears

This process has been developed by Frank C. Stevens. (*American Machinist*, vol. 45, no. 15, p. 633, October 12, 1916, 2 pp., 6 figs. *d.*)

Measuring Apparatus

Liquid Measuring Pumps, F. J. Schlink

The importance of the measuring pump is principally due to the large quantities of gasoline sold as fuel for motor cars through its various forms. About 27 firms are now engaged in the manufacture of the various measuring pumps and liquid dispensing systems.

The main types of measuring pumps are the piston pump, which is in principle the usual plunger pump with stops that act to define accurately the limits of the piston stroke and consequently the volume generated by the piston on each cycle; and the meter pumps in which the measurement is performed by passing the liquid through a meter, commonly of the nutating-piston type, the discharge of liquid through the meter being produced either by displacement of the oil over water, by pneumatic pressure or by mechanical pumping.

A third type of measuring system is founded upon the principle of overfilling a measuring chamber and then removing the excess by abstraction to a definite level. In a modification of this type the measurement is obtained by direct reading of the height of the liquid column on a graduated scale at the beginning and end of the withdrawal of the liquid from a tank or cylinder.

A portable apparatus is also in use comprising a small storage tank and a measuring pump. The precision of such devices is usually higher than that of most stationary tanks, as the suction lift can be kept a minimum and the danger of vaporization and leakage below the piston is much reduced.

In the testing and inspection of measuring pumps it is essential to determine whether the installation is free from inward leaks of air and outward leaks of gasoline.

The principal causes of short delivery of pumps of the piston type are leakage of foot valves and formation of vapor or air spaces under the piston. It appears that a total vertical suction lift greater than 7 ft. may be excessive with the ordinary commercial (not "blended" or "casing-head") gasoline. "Casing-head" or "blended" gasoline should not be lifted any appreciable vertical distance on the suction side in pumps in which the pistons and cylinder form the measuring elements, on account of the vaporization difficulty before-mentioned.

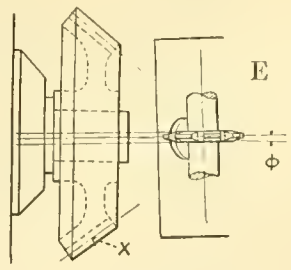
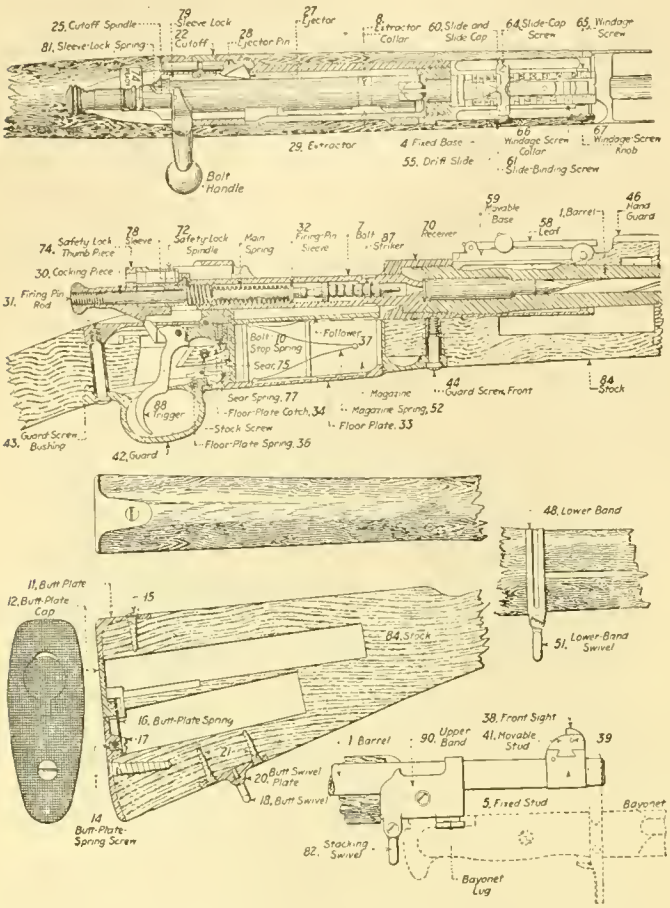


Fig. 3, E Final Cut

The writer discusses several other sources of error, among which is the possibility of short deliveries consequent upon operating the piston at less than full stroke. It is noteworthy that nearly all of the defects of construction and installation



Barrel:
- 1 Barrel
- 2 Base pin
- 3 Base spline
- 4 Fixed base
- 5 Fixed stud
- 6 Stud pin

Bolt:
- 7 Bolt
- 8 Extractor collar

Bolt Stop:
- 9 Bolt-stop pin
- 10 Bolt-stop spring

Butt Plate:
- 11 Butt plate
- 12 Butt-plate cap
- 13 Butt-plate pin
- 14 Butt-plate screw, large
- 15 Butt-plate screw, small
- 16 Butt-plate spring
- 17 Butt-plate screw

Butt Swivel:
- 18 Butt swivel
- 19 Butt-swivel pin
- 20 Butt-swivel plate
- 21 Butt-swivel screws (2)

Cutoff:
- 22 Cutoff
- 23 Cutoff plunger
- 24 Cutoff screw
- 25 Cutoff spindle
- 26 Cutoff spring
- 27 Ejector
- 28 Ejector pin
- 29 Extractor

Firing Pin:
- 30 Cocking piece
- 31 Firing-pin rod
- 32 Firing-pin sleeve
- 33 Floor plate
- 34 Floor-plate catch
- 35 Floor-plate pin
- 36 Floor-plate spring
- 37 Follower

Front Sight:
- 38 Front sight
- 39 Front-sight pin
- 40 Front-sight screw
- 41 Movable stud
- 42 Guard
- 43 Guard-screw bushing
- 44 Guard screw, front
- 45 Guard screw, rear
- 46 Hand guard
- 47 Hand-guard clips (2)
- 48 Lower band
- 49 Lower-band screw
- 50 Lower-band spring
- 51 Lower-band swivel
- 52 Magazine spring
- 53 Mainspring

Rear Sight:
- 54 Base spring
- 55 Drift slide, 0.05 peep
- 56 Drift-slide pin
- 57 Joint pin
- 58 Leaf
- 59 Movable base
- 60 Slide

Rear Sight (Continued):
- 61 Slide binding screw
- 62 Slide cap
- 63 Slide-cap pin
- 64 Slide-cap screw
- 65 Windage screw
- 66 Windage-screw collar
- 67 Windage-screw knob
- 68 Windage-screw pin
- 69 Windage-screw spring
- 70 Receiver

Safety Lock:
- 71 Safety-lock plunger
- 72 Safety-lock spindle
- 73 Safety-lock spring
- 74 Safety-lock thumb piece
- 75 Sear
- 76 Sear pin
- 77 Sear spring

Sleeve:
- 78 Sleeve
- 79 Sleeve lock
- 80 Sleeve-lock pin
- 81 Sleeve-lock spring
- 82 Stacking swivel
- 83 Stacking-swivel screw
- 84 Stock
- 85 Stock screw
- 86 Stock-screw nut
- 87 Striker
- 88 Trigger
- 89 Trigger pin
- 90 Upper band
- 91 Upper-band screw

Fig. 4 Sections of Springfield Model 1903 Service Rifle

(leakage of air and liquid, retention of liquid by the hose, vapor formation consequent on excessive suction head, failure to complete the full stroke, and slippage of liquid past valves and piston) tend to produce errors in the one direction of undermeasurement. (*Abstract of paper read at the Annual Conference of Weights and Measures of the United States,* May 23, 1916.)

Munitions

United States Munitions. A Springfield Model 1903 Service Rifle. General Specifications and Barrel Operations

With this article begins a complete description of the manufacture of the Springfield rifle, showing each operation of each component part and illustrating the machines, tools, jigs, fixtures and production methods. The major part of the article, notwithstanding its high interest, is unsuitable for abstracting.

There are 93 component parts in this rifle. The names are listed under Fig. 4, which shows the important parts by numbers.

The steel used in the rifle is divided into seven classes. These are music wire and screw stock of commercial grade; three classes of steel made by the open-hearth or crucible process and two classes of steel made by either open-hearth or Bessemer process. The proportions of carbon, manganese and silicon may be varied, but the maximum limits given for manganese, sulphur and phosphorus must not be exceeded. No nickel or other alloys shall be used in any of the grades. Data are given on an annealing of the forgings used in the manufacture of the rifle. (*American Machinist,* vol. 45, no. 15, p. 635, October 12, 1916, 12 p., 69 figs., *d A.*)

Teaching the Manufacture of United States Munitions, Howard E. Coffin

Introduction to a series of articles on the manufacture of munitions for the United States Government. The author emphasizes anew the need of organizing and educating the industries of the United States in the manufacture of munitions. He points out the vital need for a text-book dealing with this work.

The experience on orders for foreign governments has taught American manufacturers that the making of materials of modern warfare is a new art, in which we have had little or no previous experience and in which our workmen are unskilled.

There are in the United States vast resources in manufacturing and producing equipment, but they are unorganized and uneducated for the national service. European experience teaches, however, that it is upon organized industry that all plans of military defense must be based, and in case of trouble with any first class power from 80 and 90 per cent of our industrial activities would be centered upon the making of supplies for the Government.

Industrial preparedness is strictly in keeping with the natural tendencies and abilities of the American people. The necessary resources are present, but to make them available in time of emergency most careful methods of organization and education are essential.

The article proceeds to a discussion of the work of the Naval Consulting Board, in particular that of the Committee on Industrial Preparedness. The work accomplished by this Committee will in due time be turned over to the newly authorized Council of National Defense, which will carry forward the work of education and organization of our resources for national emergency service.

The writer expresses in strong terms his appreciation of the work done by the editor-in-chief and staff of the *American*

Machinist in this direction of education in the manufacture of munitions. (*American Machinist*, vol. 45, no. 15, p. 617, October 12, 1916, 1 p. *g.*)

Railroad Engineering

Locomotive Problems That Demand Solution, George M. Basford

Discussion of a few of the more important phases of design and operation which are greatly in need of attention.

The author claims that very little positive information is available upon the circulation of water in the boiler.

Much attention is being devoted to grate design. Conditions requiring maximum power lead to the conclusion that air openings through the grates should be as large as the character of the coal used will permit. Thirty per cent is aimed at. A vital factor in the production of heat is the design of the ash pan, a difficult problem, as the speed of gases in a big fire-box working hard may be as high as 200 miles per hour. It is no easy matter to provide air openings in the ash pan sufficient to maintain their atmospheric pressure at maximum rate of power development.

To attain, with all fuels, the highest degree of heat intensity per unit of fire-box volume is a problem in which, according to the writer, important developments are almost ready to be announced.

Another big problem is that of burning the gases completely before they reach the flues. The tendency seems to be in the direction of larger fire-boxes, larger grates, larger combustion chambers, and new developments in the mixing of the burning gases by improvements in brick arches.

A promising field is that of front air-draft appliances, such as pump action necessary for draft with minimum back-pressure load on the cylinders. The author asks why a front-end construction that itself consumes 33 per cent of the draft produced should be perpetuated.

Improved valve motion and improvements in superheating are two fields where great progress has been made and still greater possibilities exist.

Of equal importance is the matter of feed-water heating. Successful feed-water heating will permit of modernizing existing boilers of outclassed locomotives to render them in many cases again available for service which has outgrown them. Locomotive boilers should be relieved of the duty of heating water; it should come to them hot, leaving only the evaporation to be effected in the boiler.

The matter of water purification is becoming more important every day.

The compounding principle is coming into its own. No locomotive improvement fills its natural field so well, when properly fitted into the general scheme of locomotive design.

Regarding the use of alloy steels, the author states: "If you could see confidential figures now in the desk of your speaker some of you would jump to the task of improving locomotive design with respect to lightening reciprocating and revolving parts of locomotives."

Best locomotive records reflecting up-to-date developments show a water rate of 14.6 lb. per i.h.p.-hr. What may be termed unimproved locomotives produced this unit on about 24 to 30 lb., and between these figures lie great possibilities, especially as the majority of locomotives are in or near the 24-lb. class.

(*Railway Age Gazette*, vol. 61, No. 13, p. 539, September 29, 1916, 3 pp., *g.*)

Commercial Motor Vehicles for Railway and Industrial Purposes

Description of the Tilling-Stevens gasoline-electric vehicles, particularly the type designated by the makers as TS-3, 40 h.p.

The wheel base is 13 ft. 6 in., with a wheel track of 5 ft. 6½ in. and an overall length of 23 ft. 9 in. The load, including body, is rated up to 4 tons 15 cwt.

The frame is of pressed steel throughout, braced by cross-members having large gussets formed solid with them. Each of the main side members is pressed from one solid steel plate and is long enough to take the longest type truck body. The engine is of the 4-cylinder enclosed vertical type, 4.75 in. bore and 5.5 in. stroke. Cylinders are cast in pairs with the inlet and exhaust valves (interchangeable) placed on the near side and operated by a single cam shaft. Oil is circulated by means of a gear pump situated in the oil sump formed in the bottom half of the crankcase. The connecting rods are provided with dippers which pick up the oil from the troughs and distribute it to the working parts of the engine. The lubrication is entirely automatic.

The radiator is of the plain tubular type with large water tanks, and the whole of the system is free from pockets in which steam or air might collect. The fan is driven by a Whittle belt.

Electric transmission consists of a generator driven directly by the engine through a flexible coupling, a series-wound electric motor direct coupled to the cardan shaft and the controller box. The generator is capable of an output of from 1 to 30 kw. at a speed varying from 350 to 1400 r.p.m. and voltage from 0 to 300, and has been designed with a falling characteristic so that any increase in demand for current when the engine is fully loaded is accompanied by a corresponding reduction in voltage. The output in kilowatts at any speed is proportional to the power exerted by the engine, but the volts and amperes may vary over a large range according to the gradient, speed or degree of acceleration required. The controller and speed regulator are carried in separate aluminum cases. The controller is of the tramway type with screw adjustment to the contact fingers. The speed regulator is of the multiple-contact type and operates by varying the resistance in the shunt field of the generator and by shunting the series field of the motor. On level roads and ordinary gradients the whole of the control is effected by a gas throttle pedal operated by the right foot of the driver. On stiff gradients the shunt resistance has to be employed to allow of increased engine speed.

The electric equipment cannot be burned out, as the maximum effort of the prime mover, namely, the engine, is limited. The drive from electric motor to back axle is by means of a propeller shaft fitted with universal joints at each end. The back axle is worm-driven, the worm being placed above the worm wheel. The steering is of the irreversible Ackermann type; it is fully described and illustrated in the article.

One of the advantages claimed for the gasoline-electric car is the elimination of gear changing. It has been calculated that the average number of gear changes in an omnibus in London public service amounts to 800 a day. The strains on transmission and chassis during starting are at least twice as great as with an indirect gasoline-electric drive, and may be considerably more than this, as illustrated in the diagram, Fig. 5, in which Curve 1 indicates the strains due to the starting up of a gear-driven omnibus of the latest type, and Curve 2 is due to an electric transmission of the same capacity. In the first case the starting is effected by three successive im-

pulses with intervals of no load due to the disengagement of the clutch between each change of speed, the maximum strains being limited by the condition of the clutch and the personal element of each driver. It must be further borne in mind that a tired driver may at any time let his clutch in with practically the effect of engaging a dog clutch, causing extremely heavy strains on the transmission and all parts of the vehicle, as indicated by the dotted lines on Curve 1.

In Curve 2 it will be seen that the same amount of energy applied to the road wheels by an indirect electric drive will not require half the maximum torque demanded in the case of clutch-and-gear transmission, as the impulse is continuous, increasing gradually with the excitation of the generator, and it is not in the power of the driver to increase this torque otherwise than gradually. (*The Railway Gazette*, vol. 25, no. 10, p. 255, September 8, 1916, 6 pp., 11 figs. *d.*)

Initial Strains in Steel Rails

Abstract of a report made by James E. Howard, engineer-physicist of the Interstate Commerce Commission, on the ex-

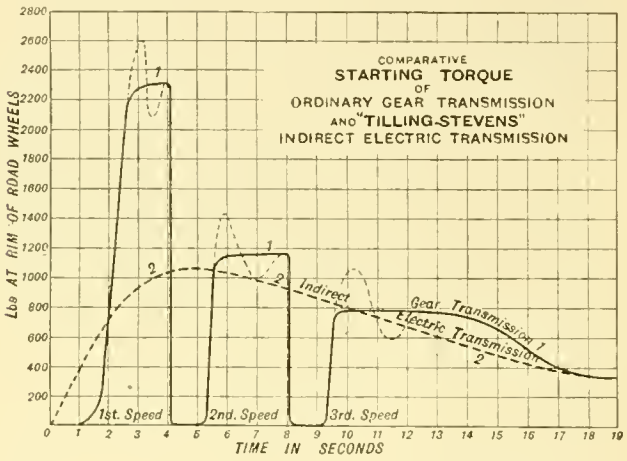


Fig. 5 Comparative Starting Torque of Gear and Electric Transmissions

amination of the rail the failure of which caused a derailment of a passenger train on the Western Maryland Railroad (Jan. 7, 1916).

According to the report, the investigation showed that the rail that caused the derailment failed by the head splitting, from lack of structural soundness of the steel.

The writer traces this latter to the state of the metal in the ingot that produces seaminess, and it is this seaminess, rather than segregation, that apparently constitutes the real danger.

As a mill question it is, therefore, important to remove the causes of this seaminess, and until this is done reliance must be placed on track inspection for the detection and removal of rails having split heads.

The report discusses further the effect of initial strains in the rail. Such initial strains, due to cooling during fabrication and to the cold-rolling action of the wheels on the running surface of the head, increase the total stresses of the rails when the wheels are in certain positions. These initial strains should, therefore, be taken into consideration in judging the strength and ability of the rails to endure the loads imposed upon them in the track.

The report discusses further the effect of initial strains in rails under normal conditions of cooling when the rate of cooling was accelerated and when it was retarded, and of the strains present in annealed sections. As to the effects of gagging, it is stated that the magnitudes of the initial strains in the gagged sections were found to be lower than those in the corresponding sections which cooled normally. In the head, the normal condition of a state of compression was reversed and initial strains of tension were introduced. The report insists upon a distinction between the permanent sets of tension or compression that are given the rail by the process of gagging, and the initial strains that result therefrom.

The effects of sudden heating have a bearing upon the strains momentarily introduced in rails when "wheel-burns" occur, as well as influence the strains in brake shoes and the rims and plates of wheels. (*The Iron Age*, vol. 98, no. 12, p. 654, September 21, 1916, 1 p. *e.*)

Refrigeration

The Testing of Thermal Insulators, H. C. Dickinson and M. S. VanDusen

Data of work done at the Bureau of Standards, communicated by H. C. Dickinson to the Annual Meeting of the American Society of Refrigerating Engineers, New York, December, 1915.

The writers point out that between the simple mathematical and physical problem of heat transfer through a homogeneous solid material, or even several such materials combined, and the practical engineering problem of heat transfer, there is a long step which neither the experimental physicist nor the engineer has generally been inclined to take. This led to two distinct groups of experimental investigations, one of which offers an immense quantity of data on the internal conductivity of many materials, while the other offers a large number of determinations of the apparent heat transmission of various simple and compound walls, often under ill-defined conditions of surface temperature. The writers give certain definitions which are of interest, since the terms defined are not always used in the same sense in technical literature.

Conductivity is equivalent to specific conductivity or internal conductivity (*i. e.*, the amount of heat passing per unit time through a unit area of the material when the temperature gradient is 1 deg. per unit thickness.

Gradient is the space rate at which temperature changes in passing through the material.

Conduction is the amount of heat per unit area which will pass in unit time between the surfaces of the wall when the temperature difference between them is 1 degree.

Transmission is the amount of heat which will pass (unit time, unit area) through a given layer of insulating material when the temperature difference between the medium (air, brine, etc.) on one side of it and that on the other side is 1 degree.

Thermal *resistance* is the reciprocal of conduction.

The paper discusses the computation of transmission of compound walls and analyzes the air-conduction problem. From this the writers pass to a description of the investigation of the apparent conduction of air spaces as part of the study of the problem of insulation. A description is given of the apparatus used which consists essentially of a pair of copper heater plates enclosing a uniform electric heating element and two water-cooled outside plates. The heat supplied is determined by measuring the electric energy delivered to the plate. When used for air-conduction measurements, bottomless boxes of soft wood or other suitable material are

made of various thicknesses to afford different widths of air space. They are inserted between the heater plate and the water-cooled plates just as a solid insulation sample would be.

Important variations of the apparent conduction through air spaces occur with change of width, although it has often been assumed that all air spaces have about the same conduction. Actually for very narrow spaces, that is, less than ⅜ in., the *resistance* to the passage of heat increases almost in proportion to the thickness. Beyond this the resistance increases less rapidly, until it reaches a maximum above which a *greater* thickness offers *less* resistance to the passage of heat. It is plain that convection plays no appreciable part in the conduction of air spaces of less than ⅜ in. width when 8 in. high. Fig. 6 shows the manner in which the resistance of air spaces is affected by temperature difference. The curves are plotted for resistance corresponding to conduction per degree difference in temperature. The less the temperature difference the greater the resistance. The conductivities and conductions of air spaces of various widths for various differences of temperature are tabulated in the original article. The effect of varying heat upon the resistance of air spaces of various widths is shown by curves. A curve showing variation of conductivity of vertical air spaces with height when the temperature differences are small and the widths not greater than the width of maximum resistance for each particular height seems to indicate that for heights greater than 2 ft. (width of space remaining the same) the conduction changes very little. However, this conclusion is an extrapolation not yet verified by experiment.

A knowledge of the conduction of air spaces and rigid insulators enables one to compute the conduction of almost any compound wall by adding the reciprocals of the conductions, *i. e.*, the resistances of the various parts. It is true that the conduction of a wall containing air spaces depends upon the temperature difference, unless the air spaces be less than ½ in. wide. But the variation of conduction with temperature difference is not large enough to prevent the computation of wall conductions for usual conditions to within reasonably close limits. The data presented above explain some apparent contradictions. For instance, it has long been assumed that for practical purposes all air spaces in wall construction have about the same conduction. This has been approximately true for air spaces less than ⅞ in., but the suggestion has been made that increasing the number of air spaces at the expense of their width would give any desired amount of insulation in a given space. This is not true because the conduction is no longer the same for spaces below ½ in. in width, and increases almost in proportion to the decrease in width below this figure, so that practically nothing is gained by making air spaces narrower than this.

The writers show that, in the construction of walls such as those of refrigerator cars in which air spaces are employed, when the total air space available is 1 in. or more in width, a decided advantage is gained by so distributing the material that it splits this air space into two or more parts.

The paper briefly discusses the conductivity of rigid insulators and the methods of testing such insulators. The Bureau of Standards expects in the course of a few months to have secured and tested samples of the important commercial insulators. In fact, data of tests of some of these insulators are given in a table in the appendix. (*A. S. R. E. Journal*, vol. 3, no. 2, page 5, September, 1916, 21 pp., 5 figs. *ex.*)

The Smallest Cooper System Cold-Storage Plant

Description of a plant installed by the Iowa State Agricultural College at Ames, Ia., for experimental purposes, especially in connection with fruit research work. The refrigerated space is quite small. As it was desired to secure several different temperatures, small chambers controlled by thermostats were placed within the cooling chamber. These small chambers are so arranged that by maintaining the cooling chamber at the maximum low point required, heat may be applied in the small chambers and thereby any higher temperature desired may be maintained therein.

It is stated that in addition to experiments on the respiration of fruits at various temperatures, experiments have also been made on germination. In these latter experiments seeds which require a low temperature for germination have been placed within the small chambers controlled by thermostats, the aim being to determine the minimum, maximum and optimum temperatures required for germination. (*Cold*, vol. 7, No. 12, page 135, October 1916, 2 pp., 3 figs. *d.*)

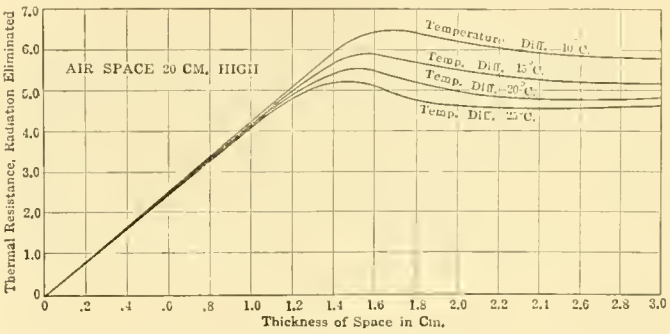


Fig. 6 Thermal Resistance of an Air Space of Constant Height, in cal. per hr. cm² per deg. cent. (ordinates)

The Flow of Superheated Ammonia Gas in Pipes, Edward F. Miller

The paper gives in condensed form the results of an investigation made by Edward A. Whiting and Edward H. Williams, class of 1916, Massachusetts Institute of Technology, and presented by them as their thesis.

The tests from which the data referred to in the paper were compiled were undertaken to obtain sufficient data on the flow of superheated ammonia in a pipe open to the air, from which, taking into account the length of the pipe, the necessary size of the discharge of a safety valve might be determined.

The experiments were all made on Beyers pipe 1.5 in. in diameter. The orifice used for measuring the flow was 0.5 in. diameter with the curve 0.25 in. radius at entrance, the straight part of the orifice being 0.75 in. long. The pressure in the orifice was obtained through an opening 1/32 in. diameter drilled at right angles to the straight part of the orifice. Experiments were run with the head pressure varying by 25 lb. from 50 lb. gage through 200 lb. gage, with pressures at the entrance to the 1.5-in. pipe varying from 31 lb. absolute to 67 lb. absolute and temperatures from 141 to 171 deg. fahr. The results are given in the form of two capacity drop curves, one for a pipe with tees and the other with no tees.

A formula deduced to fit the experiments on 1½-in. pipe with tees in the line was given as

$$W = 1.6\ D \left(\frac{100\ d}{L}\right)^{.318}$$

where D = density at entrance,
d = pressure drop in pounds for length L,
L = length of pipe in feet,
W = weight per second in lb.

Probably there will be but little error if this formula is put into the form given below, so as to make it apply to pipes from 1 in. to 2 in. diameter.

$$W = 1.6\ D \left(\frac{100\ d}{L}\right)^{.318} \frac{b^2}{2.25}$$

where b = diameter of pipe in inches.

The Babcock formula with a constant deduced from these experiments becomes

$$W = 2.37 \left\{\frac{d\ D\ b^6}{\left(1 + \frac{3.6}{b}\right) L}\right\}^{1/2}$$

These formulæ, if applied in figuring the discharge capacity of 100 ft. of pipe on the outlet of a safety valve having inlet and outlet pipes of the size called for by the refrigeration regulations in force in Massachusetts, show that in every case the pipe has a discharging capacity at least 50 per cent greater than the rated capacity of the valve. (*A.S.R.E. Journal*, vol. 3, no. 2, p. 26, September 1916, 3 pp., 1 fig. *et.*)

Research

The Relation of Pure Science to Industrial Research, J. J. Carty

President's address delivered at the Annual Convention of the American Institute of Electrical Engineers at Cleveland, Ohio, June, 1916.

The writer traces the growing appreciation of the importance of industrial scientific research primarily to the events in Europe, and the recognition of the unpreparedness of our own country to defend itself against attack. Industrial research conducted in accordance with the principles of science is no new thing in America. The Engineering Department of the American Telephone and Telegraph Company, under the charge of the speaker, was founded nearly forty years ago to develop, with the aid of scientific men, the telephone art, and has grown from small beginnings to a great institution employing hundreds of scientists and engineers. It is generally acknowledged that to industrial research thus conducted we are largely indebted for the telephone achievements in America being so greatly above those of other countries.

The same applies to the development of electric light, electric power and electric traction. Vast sums are being spent annually upon industrial research by some of the larger electrical manufacturing concerns, but the speaker says with authority that these laboratories return to the industries each year improvements in the art which taken all together have a value many times greater than the total cost of their production. Money expended in properly directed industrial research conducted on scientific principles is sure to bring to the industries a most generous return.

Industrial scientific research departments can reach their highest development in those concerns doing the largest amount of business, and small concerns without coöperation among themselves cannot have the full benefit of industrial research, for no one among them is sufficiently strong to maintain the necessary staff and laboratories. But once the vital importance of this subject is appreciated by the small manufacturers, many solutions of the problem will promptly appear. One of these is for the manufacturer to take his problem to one of the industrial research laboratories already established for the purpose of serving those who cannot afford a laboratory of their own. There are now under consideration many plans for the establishment of industrial laboratories to serve concerns which cannot afford laboratories of their own, and in some cases the possible relation of these laboratories to our technical and engineering schools is being earnestly studied.

But until the manufacturers themselves are aroused to the necessity of action in the matter of industrial research, no plan can be devised that will result in the general establishment of research laboratories for the industries.

In the present state of the world's development there is nothing which can do more to advance American industries than the adoption by our manufacturers generally of industrial research conducted on scientific principles. In the minds of many there is confusion between industrial scientific research and purely scientific research, particularly as the industrial research involves the use of advanced scientific methods and calls for the highest degree of scientific attainment. The distinction lies not in the subject-matter of the research but in the motive. Industrial research is always conducted with the purpose of accomplishing some utilitarian end. Pure scientific research is conducted with a philosophical purpose for the discovery of truth and for the advancement of the boundaries of human knowledge. At the same time, while a single discovery in pure science when considered with reference to any particular branch of industry may not appear to be of appreciable benefit, yet when interpreted by the industrial scientist, with whom may be classed the engineer and the industrial chemist, and when adapted to practical uses by them, the contributions of pure science as a whole become of incalculable value to all the industries.

But who is to support the researches of the pure scientist, to furnish the laboratories and the funds for apparatus, traveling and foreign study? It has been suggested that perhaps the theater of scientific research might be shifted from the university to the great industrial laboratories which have already grown up, or to the even greater ones which the future is bound to bring forth. The speaker does not agree with this. Organizations and institutions of all kinds engaged in pure scientific research should receive every encouragement, but the natural home of pure science and of pure scientific research is to be found in the universities, from which it cannot pass. Instead of abdicating in their favor, our universities, stimulated by the wonderful achievements of these industrial laboratories, should find a way to advance the conduct of their own pure scientific research.

The universities, however, are not money-making institutions. Well, there is much that can be done without money. The most important and most fundamental factor in scientific research is the mind of a man suitably endowed by nature, and responsible university authorities should apply their judgment so that when the man with the required mental attributes does appear he may be appreciated as early in his career as possible.

While, however, there are many things and most important things which the universities can do to aid pure science without the employment of large sums of money, there are, nevertheless, a great many things required in the conduct of pure scientific research which can be done only with the aid of money, and the first of these is to provide a master scientist,

when he does appear, with all the resources and facilities and assistance, so as to afford a full freedom of development to the range of his genius.

Workers in pure science should be located not only in our great universities, but also at our technical schools, where the influence of a discoverer in science would serve as a balance to the practical curriculum and familiarize the student with the high ideals of the pure scientist and with his rigorous methods of investigation.

The engineering student should be taught to appreciate the ultimate great practical importance of the results of pure scientific investigation and to realize that pure science furnishes to engineering the raw material, so to speak, which must be worked into useful forms. A better understanding is required of the relation between the pure scientist and the applied scientist, and this understanding would be greatly helped by a closer association between the pure scientist and the student in the technical schools. (*Proceedings of the American Institute of Electrical Engineers,* vol. 35, no. 10, p. 1411, October, 1916, 10 pp., *g.*)

Concerning Efficient Means for Establishing a Connection Between Science and Industry, A. Blondel

In a recent sitting of the French Academy of Sciences a member, Le Chatelier, presented a paper on the necessity of establishing in France a closer relation between the work of pure scientists and the industrial activities of the country.

It appears that in France the prevailing tendency is for savants to keep aloof from practical activities, and the Academy of Sciences has no section devoted to practical engineering of today.

The author of the present article, A. Blondel, chief engineer of the Department of Bridges and Roads, and also member of the Academy of Sciences, emphasizes still more the necessity of such a coöperation.

He points out that the French Academy even now includes such sections as geography and navigation and medicine, which points to the desire of the founders to include in the scope of the activities of the Academy practical engineering, at least practical engineering of those days. Since then, however, engineering has developed without a corresponding growth in the scope of the work of the Academy.

He therefore suggests the creation of sections of industrial engineering, applied and constructive mechanics, applied chemistry and industrial physics. It appears that the part of the Academy of Sciences in bringing together the pure scientist and the engineer is particularly important in France. There are certain technical societies such as the Society for the Encouragement of National Industry, the Society of Electricity, the Aeronautical League and the Society of Civil Engineers, but the first three of these societies admit members practically on their payment of dues, that is, without imposing effectively strict qualifications of admission, while the Society of Civil Engineers excludes from its membership engineers in the employment of the government. Hence, the higher class of engineers in France has really no common body to work out the larger aspects of engineering activity. (*Sur un moyen efficace d'établir la liaison entre la science et l' industrie,* A. Blondel, *Le Génie Civil,* vol. 69, no. 11, p. 169, September 9, 1916, 3 pp. *g.*)

The National Physical Laboratory—Its Work and Aims, Walter Rosenhain

The writer begins with a discussion of the relation between science and industries, with special reference to conditions existing in Great Britain.

Broadly speaking, scientific activities, from the point of view of their relation to industries, may be divided into three groups or phases which, while they necessarily overlap, yet afford a convenient and rational means of classification. In the first place the application of science to industry cannot be cultivated until we possess the "science" we are to apply. While even the existing body of scientific knowledge, as laid down in scientific publications, is in most fields considerably in advance of technical practice, one cannot rest content with merely this ready-made knowledge. If the application of science is to be fruitful and progressive science itself must also be progressive,—it must be living, growing science. It is as vital to keep abreast, and if possible ahead, of our rivals in pure scientific investigation and discovery as in the practical application of its results.

Experimental Plant

The next phase is the transition from purely scientific to practical work. In order to make experiments which give intelligible results or to obtain data which lend themselves to accurate calculations, the scientific worker is obliged to simplify the phenomena as far as he can. In the laboratory he uses for that particular purpose experimental devices intended to eliminate as far as possible all those disturbing factors in which he is not interested, but when one comes to applying the results obtained by the pure science worker to practical ends an entirely different set of conditions is encountered. For practical purposes we have to deal with natural phenomena as we find them, and have to produce the desired result in an approximate but efficient manner; in other words, we have to translate laboratory results into shop language.

To make this somewhat clearer the author employs a metallurgical example. Suppose an investigator is studying the constitution and properties of a system of alloys of two metals. The proper course for him is to work with the chemically pure metals, or with the nearest approach to them he can obtain. But after the investigation is completed and the technical worker is asked to render the alloy obtained in the laboratory available for practical use, he is probably immediately confronted with the fact that he cannot obtain on the market his metals of the the degree of purity employed by the investigator. Hence, an alloy which proved in the laboratory to be ductile and workable might easily prove brittle and useless when made in the works. In reality both results would be true but both must be more fully understood to be brought into mutual agreement. Further research is required to meet the difficulties which hamper proper application. Either means must be found to eliminate the injurious impurities, or methods of working must be adopted whereby the influence of the impurities is in some way overcome. This part of the work must be done on a proper scale and may entail a much longer series of experiments, requiring elaborate appliances as well as numerous assistants. The erection of such "experimental plants" and their running expenses entail very considerable financial demands.

Industrial Works Organization

The third step or phase in the application of science to industry lies in the industrial works themselves, where the men trained in pure and applied science should find room for their

useful activities. The first step for securing for science its proper status in the industries must be the creation of an adequate appreciation of science and its possibilities among those who control the industries, and the author calls attention in this connection to the fact that in Germany it was quite usual to elect scientific men to the boards of directors of great enterprises.

IDEAL NATIONAL LABORATORY

From this the author proceeds to a discussion of what he calls the Ideal National Laboratory. Such a laboratory would be an institution for research, additional and supplementary to the work of universities and colleges, but one in which the educational bias is entirely absent and whose activities can, therefore, be directed in an entirely untrammelled manner to the solution of problems suggested by public utility, scientific importance, or industrial demand. Such an institution would possess a more or less permanent staff of investigators and their highly trained assistants, thus affording opportunities for long-continued researches which can scarcely be undertaken by a professor working with successive generations of young students. The equipment of such an institution could be designed on lines free from educational considerations; apparatus and experimental plant could be set up, involving, if necessary, the permanent employment of skilled labor as well as scientific supervision. If only one or a very few such institutions were set up in the country, equipment could be carried out on a scale of cost which could not be reproduced at any considerable number of colleges, whereas appliances could be used which it would be unsafe to place in the hands or even within the reach of students.

Such an establishment should occupy a unique position as a central national institution which would naturally undertake certain duties of a scientific or technical nature required by the government. In another direction, where certain industries required national aid on account of their vital nature as "key" industries, the national central institution would provide the government with the means of affording the scientific assistance demanded. The Ideal National Laboratory would be in the closest possible touch with the most advanced scientific thought and would, if it fulfilled its functions properly, contribute largely to the advancement of pure science by utilizing its experimental resources to that end. At the same time, the institution would also be in useful touch with industry, helping, advising, assisting, testing, taking up the special investigations proposed by industry and dealing with them in the laboratory and the experimental plant.

NATIONAL PHYSICAL LABORATORY

An ideal somewhat on these lines has actually been recognized by most of the great nations and each of them has worked out its own institution on characteristic lines. In the United States, as the speaker stated, we see the Bureau of Standards developing into an institution of very great size and of steadily increasing importance. In Britain the National Physical Laboratory was opened in 1901, making a very small and modest beginning at a time when the German national laboratories had already attained great size and reputation.

The National Physical Laboratory is thus not yet 15 years old. At its inception the work was begun in a very tentative way and extensions have been made in a hesitating and guarded manner due to the difficulty with which the Laboratory authorities have obtained the requisite funds from the treasury. The Laboratory is not actually a government institution. It is managed by a committee appointed by the Royal Society, and members of the staff of the Laboratory are employees of the Royal Society and not civil servants. The treasury makes a grant of £7000 to the Royal Society per annum towards the cost of the Laboratory and in return exacts certain conditions in regard to the work. This grant is entirely inadequate for the maintenance of the Laboratory, which is mainly supported by fees earned by itself (a large part of these fees are, however, derived from government sources). Further, technical institutions like the Institution of Mechanical Engineers, Institute of Civil Engineers, Institute of Naval Architects and others have contributed to the Laboratory budget, in some cases by simple donations and more frequently by grants in aid of some definite scheme of research.

The management of the Laboratory rests with an executive committee selected from the general board. On the latter are represented the scientific and technical institutions as well as certain government departments. The Laboratory itself is divided into four great departments dealing with Physics, Engineering, Metallurgy and Metallurgical Chemistry and the National Experimental Tank.

The Laboratory serves also as the official laboratory of the Advisory Committee on Aeronautics, and the aeronautical work carried out in the Engineering and Metallurgy departments constitutes an important separate division in each.

Besides the director, superintendents (prominent engineers and scientists) and principal assistants, there is a large staff of scientific assistants of various grades, as well as a large staff of others less highly trained but often of very great value and experience who are classed as "observers," and in addition to this there is a complement of skilled workmen. Quite recently the policy of employing women on both the "scientific" and "observer" staffs has been initiated, and so far the result promises to be eminently satisfactory, although in the majority of cases women have merely been appointed to temporary posts during the absence of men on military service.

ENGINEERING RESEARCH

Naturally the section most interesting to engineers is the Engineering Department, which comprises practically four sections devoted respectively to testing materials; testing and standardization of engineering apparatus, appliances, and machines; testing and investigation of road materials and roads, and aeronautics. All these sections work in close conjunction with the metallurgical department and which deals with all *materials* as such.

One important result of the work in the Section of Testing of Materials has been the development of whole series of machines for the application of various mechanical tests to metals, and recently some of these have been extended to concrete and timber. Among these methods of testing those known as "dynamic" in contradistinction to the ordinary so-called "static" tensile test have received the most attention. One of the first dynamic tests studied was the alternating stress test, in connection with which a machine has been developed for applying alternate tension and compression to small test pieces, thus exposing them to alternations of direct stress in place of the alternate bend action which occurs in the original Woehler test. This led to an increased use of testing by means of direct alternating stresses, and incidentally it

has been shown that the time occupied by tests can be very much reduced as it has been found that an increase in the speed of alternations up to 2200 per minute does not affect the results of the tests.

Another form of test developed in the Laboratory is that in which a notched test piece is exposed to blows of a hammer of known weight falling from a known height and alternately striking the test piece on opposite sides.

Results obtained from alternating stress tests of various kinds have led to the view that so long as a material is only exposed to stresses which nowhere exceed the true elastic limit, the material will resist an indefinite number of alternations; but so soon as plastic deformation is produced, even in a few isolated crystals, then failure will sooner or later occur under a sufficiently long-continued repetition of stresses. This led to an extremely interesting investigation on the subject of elastic limit.

The work of the Aeronautical Section has been touched upon only very slightly because of the secrecy covering all developments since the beginning of the European war. In general the work may be described as being of two kinds, first, a series of continued investigations for the purpose of establishing the fundamental principal data and formulæ which must govern aircraft design, and second, testing actual models with a view of ascertaining their properties and behavior in the air.

Both lines of aeronautical work are pursued by means of scale models and the equipment of the Laboratory consists largely in appliances for measuring the forces acted upon or exerted by these models when in motion relative to the air at known speeds.

The development of aeronautics has practically created what has become known as the chemistry of aeronautics, which has already assumed a very high degree of importance. Apparatus had to be designed, for example, for testing balloon or airship fabrics for the power of retaining hydrogen gas. (*The Journal of the West of Scotland Iron and Steel Institute*, vol. 23, No. 6, p. 213, April, 1916, 66 pp., 32 figs. *dA.*)

Steam Engineering

Boiler Expansion Experiments, D. R. MacBain

Data of tests made on the New York Central Railroad system to determine relative movements of firebox sheets and tubes under working conditions.

From experiments made at various times it was found that the expansion of the outer sheets was greater in every case than that of the inner sheets, which would seem to account for the breakage of the back head and throat sheets along the outer row of staybolts, also for the vertical cracks in the side sheets as well as the cracks extending from the arch tube holes.

It was also found by means of a needle connected with the inner throat sheet and passing through the outer throat sheeet that the inner tube sheet moved outward 3/32 in. when the fire was first started and before the circulation was fully established, and later, when steam pressure began to rise, backward about 1/16 in. The first movement throws some light on the cause of the side sheet cropping out along the fire line, as it does sometimes.

Another source of trouble was found with the breakage of staybolts in some of the wide firebox engines.

It was believed previously that the cause of these bolts breaking was the same as that which was responsible for the leaky side sheet seams, and further that the elimination of excessive staybolt breakage would result in a cure for these leaky seams. With rigid bolts it was quite common to find anywhere from three to five or more bolts broken. An experiment was therefore tried on an Atlantic-type engine while it was undergoing repairs. A heavy template was fitted from the side of the boiler when the boiler was cold and was firmly clamped at its center to the boiler. The fit was very carefully made. The engine was then fired up and the effect of

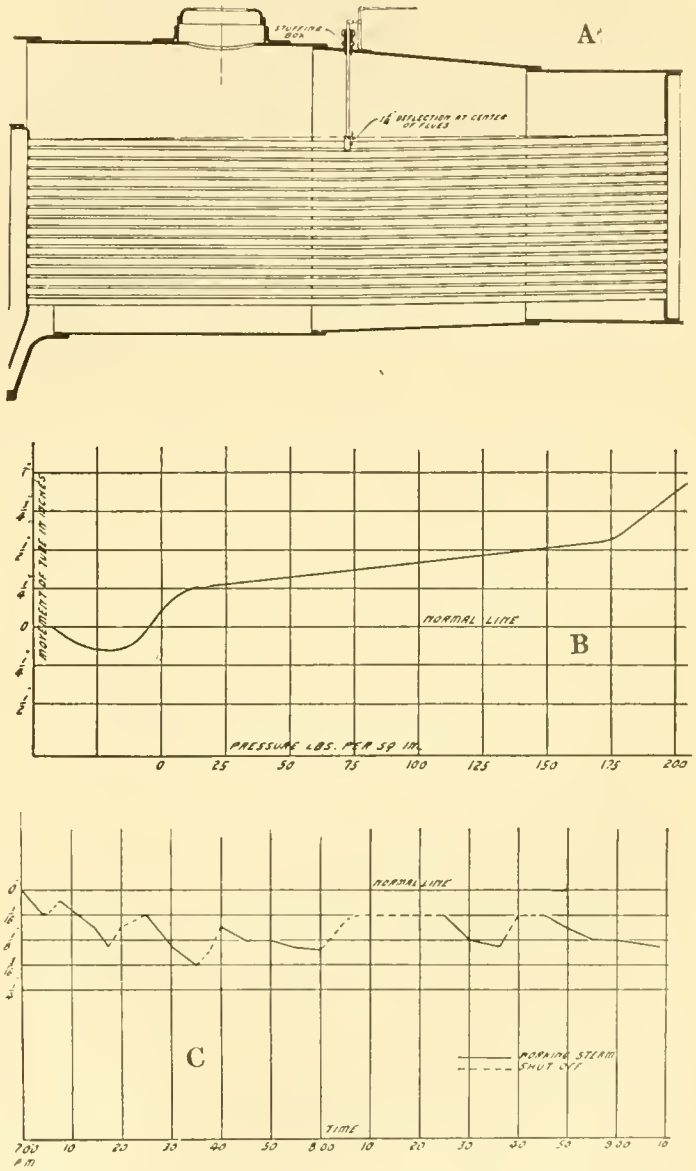


Fig. 7 Arrangement of Pointer in Boiler Tube Deflecting Test. Curves Showing Movement of Tube: B. Boiler Fired up without Blower; C. Road Service, West Albany to Rotterdam Junction

heating up the boiler to the point where 200 lb. of steam was obtained caused the wrapper sheet to bulge out so that there was 3/32 in. opening between the template and the wrapper sheet at both ends of the template. This apparently explains the cause of the breakage of the staybolts.

In order to determine whether this distortion of the boiler was caused by the pressure or the heat, the template was carefully refitted and a pressure of 225 lb. of cold water put on the boiler. The template retained its shape, which proved conclusively that the distortion was due to the temperature and

not to the pressure. The application of three rows of flexible stayholts stopped the trouble and cured the leaky seams.

The New York Central has also made experiments to determine why the back and front tube sheets become deflected or distorted. It was believed that while the boiler was working and had a hot fire the expansion in the boiler proper, that is, between the tube sheets, was greater than in the tubes. An experimental set of tubes was installed in a large Pacific-type locomotive, each tube being given a drop of 15/16 in. at the center, but fastened at each end. A rod was fastened to one of the top tubes at the center and extended up through a stuffing box in the boiler shell, as shown in Fig. 7A, the outer end being attached to a recording device which would register the movements of the tube. Fig. B shows the result of a standing test from the time the fire was started until 200 lb. pressure in the boiler was obtained. Almost immediately after the fire was started the tube deflected still more until it had reached 1/8 in. It remained in this position for a short time and then it rose and was about 1/8 in. above its normal position when the steam pressure began to rise. It rose gradually until 175 lb. pressure, and then rose rather abruptly. This rapid rise may have been due to the needle sticking a little in the stuffing box. Fig. C is the record of another test, namely, on a road trip from West Albany to Rotterdam Junction. The solid lines are readings taken when the throttle was open, and the dotted lines with the throttle closed and the engine drifting. It is seen that immediately upon starting the tubes began to deflect, and rose when the engine was not working steam.

An investigation was also made to determine the direction and extent of expansion in a tube sheet resulting from prossering a set of new tubes. A circle of as large diameter as possible was described on the tube sheet, and after the tubes had been set it was found that this circle had increased or had widened out 1/32 in. at the side and bottom and 3/32 in. at the top. It has been the experience there that the 3-in. radius for the tube-sheet flange will give better results than the 2-in.

Data on the relative movements of the back tube sheet to the throat sheet are given for the time from the moment the boiler is heated up and raised to 200 lb. pressure and released back to zero pressure. It was found that it is necessary to allow some freedom to the sheets longitudinally in order to avoid excessive strains being set up.

A process is shown for patching the top of a tube sheet that had been cracked from the top of the tube holes up to the flange. (*Railway Mechanical Engineer*, vol. 90, no. 10, p. 496, October, 1916, 41 pp., 13 figs. *e.*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

SELECTED TITLES OF ENGINEERING ARTICLES

AERONAUTICS

Diagramme logarithmique d'ensemble applicable au choix d'une hélice, G. Eiffel. L'Aérophile, vol. 24, no. 15-16, August 1-15, 1916, 4 pp.
Logarithmic diagram for use in the selection of a propeller.

L'Etat actuel de l'aérodynamique, L. Marchis. L'Aérophile, vol. 24, no. 15-16, August 1-15, 1916, 4½ pp., 2 figs.
The present state of aerodynamics, aerial article.

Faut-il construire des zeppelins? A. Poidloué. L'Aérophile, vol. 24, no. 15-16, August 1-15, 1916, 1½ pp.
Is it necessary to build Zeppelins?

Les bi-moteurs allemands A. E. G., Jean Lagorgette. L'Aérophile, vol. 24, no. 15-16, August 1-15, 1916, 1½ pp., 5 figs.
Twin-engine German aeroplanes.

Aviation Engine Design, J. G. Vincent. Automotive Engineering, vol. 1, no. 1, September 1916, 3½ pp.

La Similitudine Meccanica, Letterio Laboccetta. Rivista di Aeronautica, vol. 10, no. 5-6, December 31, 1915, 6½ pp.
Mechanical similitude in aircraft design.

Relazione Fra La Velocità Del Vento, Giuseppe Crestani. Rivista di Aeronautica, vol. 10, no. 5-6, December 31, 1915, 3 pp., 2 figs.
Velocity of wind phenomena.

Esperienze Di Idrodinamica, Giulio Costanzi. Rivista di Aeronautica, vol. 10, no. 5-6, December 31, 1915, 16 pp., 10 figs.
Hydrodynamic experimeuts.

Ricerca di un propulsore aereo. Rivista di Aeronautica, vol. 11, no. 1-2, April 30, 1916, 5 pp., illustrated.
Aerial propeller research.

AIR ENGINEERING

Temperature, Relative Moisture and Movement of Air Essential Features in Ventilation of Rooms. American Gas Light Journal, vol. 105, no. 16, October 16, 1916, ¼ p.

Coefficient of Friction of Air Flowing in Round Galvanized Iron Ducts, J. E. Emswiler. Journal of the American Society of Heating and Ventilating Engineers, vol. 22, no. 4, July 1916, 4½ pp., 4 figs.

AUTOMOBILES

Automobile Cushion Springs, E. F. Lake. Machinery, vol. 8, no. 208, September 21 1916, 6 pp., 11 figs.

Running on Town Gas, Shortage of Gasoline Drives Omnibus Proprietors in England to Try Gas as Fuel—Essential Things to be Observed in Engine Testing—British Patent Covers Device for Pre-Heating Fuel Going to Carbureter, A. Ludlow Clayden. The Automobile, vol. 35, no. 15, October 12, 1916, 3½ pp., 5 figs.

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The Protection of Iron by Electroplating, Oliver P. Watts and Paul L. DeVerter. A paper presented at the Thirtieth General

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The Influence of Heat Treatment on the Thermo-Electric Properties and Specific Resistance of Carbon Steels, Edward D. Campbell. Iron and Steel Institute, paper read at Autumn Meeting, September 21-22, 1916, 18 pp., 8 figs.

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Making an Eight-Ton Kettle Casting in a Dry Sand Mould. Canadian Foundryman, vol. 7, no. 2, February 1916, 2 pp., 6 figs

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Calculation of Scale Members, Eugene Motchman. Railway Review, vol. 59, no. 13, September 23, 1916, 2 pp., 7 figs.

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Charts showing constants for 5-inch sine bar, p. 121 and also p. 123.

Diagramme logarithmique d'ensemble applicable au choix d'une hélice. L'Aérophile, vol. 24, no. 15-16, August 1-15, 1916.

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Chart for figuring ability of motor truck in tractive effort.

ANNUAL MEETING PAPERS

Continuation of Comprehensive Abstracts of Papers to be Presented and Discussed at the Thirty-Seventh Annual Meeting of the Society, New York, December 5 to 8, 1916

COMPREHENSIVE abstracts of the papers to be presented and discussed at the forthcoming thirty-seventh Annual Meeting of The American Society of Mechanical Engineers, to be held in the Engineering Societies Building, New York City, December 5 to 8, 1916, are given below. This publication of abstracts is continued from the November issue of The Journal.

These abridgments have been prepared with the collaboration of authors, and are therefore authoritative presentations of the subject-matter of the papers. In many cases the abstract comprises practically the entire paper, with the omission of only such sections as mathematical derivation of formulæ, minute descriptions of apparatus, and logs of tests.

Engineers—members of the Society and others—are invited to contribute discussion to these papers. Such discussion will be read at the meeting and be published in The Journal.

All the papers printed below are also being printed in unabridged form in pamphlet size, and members of the Society desiring a pamphlet copy of any particular paper may obtain it gratis upon application to the Secretary.

The order of presentation of papers is given in the program included in the Society Affairs section of this issue. The first papers below are to be presented at the Miscellaneous Sessions.

Two of the papers to be presented at the Railroad Session were published last month, as also was the Safety Code on Cranes to be discussed at the Industrial Safety Session, two of the papers to be presented at the Valuation Session, two of the Gas Power Session papers and one of the Textile Session papers.

GRAPHIC METHODS OF ANALYSIS IN THE DESIGN AND OPERATION OF STEAM POWER PLANTS

By R. J. S. PIGOTT, BRIDGEPORT, CONN.

Associate-Member

THIS paper considers the application of graphic methods of analysis of steam power plant design and operation to:

a The 90,000-kw. addition to the 74th Street Station of the Interborough Rapid Transit Company, New York City, where the entire output is electrical energy from three 30,000-kw. turbine-driven units, and

b The power plant of the Remington Arms and Ammunition Company, Bridgeport, Conn., where there is a variable output of electrical energy from five turbine-driven units of different capacities, and steam for industrial purposes and heating, this latter output fluctuating, naturally, with the seasons.

This abstract contains the essential facts and conclusions in those paragraphs in the paper dealing with the Interborough addition. The Remington Company's plant is omitted.

THE INTERBOROUGH ADDITION

Individual water rates. The Willans input-output lines have been employed considerably in connection with the performance of steam turbines and steam engines, but for a complete analysis it is necessary also to have input-output lines for:

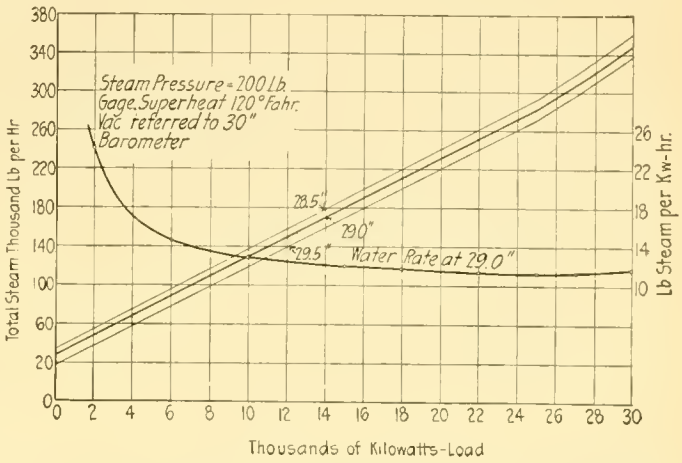

FIG. 1 WILLANS LINES AND WATER RATE, 30,000-KW. WESTINGHOUSE TURBINE UNIT

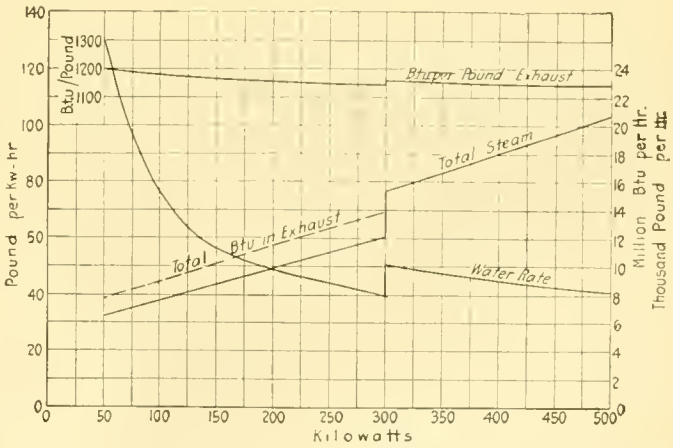

FIG. 2 INPUT-OUTPUT LINE AND ECONOMY, 300-KW. EXCITERS

a main units, *b* exciters, *c* boiler-feed pumps, *d* forced-draft fans, *e* stoker drive, *f* boilers.

Main units. The Willans lines and water-rate curves for the 30,000- kw. Interborough steam turbines are shown in Fig. 1. Here it will be seen that the effect of variation in vacuum is a practically constant variation in the amount of total steam required over the entire range of operation. The percentage increase in economy is greater at light than at heavy loads.

Exciters. In Fig. 2 will be found the Willans line and water-rate curves of a 300-kw. turbine-driven, geared, exciter set. The machine is arranged with a special oversize generator and overload valve, so that, in the event of the failure of one of the two exciters to operate, the remaining one can carry the

For presentation at the Annual Meeting, December, 1916, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

entire load for a convenient length of time. It is not intended to use the range from 300 to 500 kw. in regular service.

Boiler-feed pumps. Willans lines for a 1000-gal.-per-min. turbine-driven boiler-feed pump are given in Fig. 3. The high no-output steam consumption is characteristic of all constant-pressure, turbine-driven centrifugal pumps, in which the efficiency drops off rapidly at the lower loads. Most boiler-feed centrifugal pumps show from 40 to 45 per cent full-load brake horsepower at no load, and from 50 to 60 per cent full-load steam consumption. The Willans lines for most turbine-driven centrifugal pumps show a greater curvature than those of Fig. 3.

Forced-draft fans. The curve in Fig. 4 is the input-output

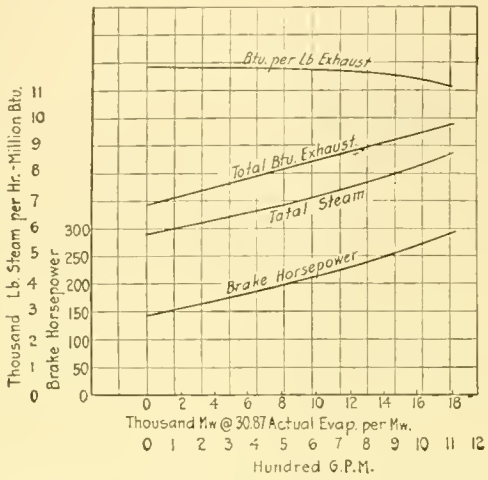

FIG. 3 INPUT-OUTPUT LINE AND BRAKE HORSEPOWER, 1000-G.P.M. BOILER-FEED PUMP

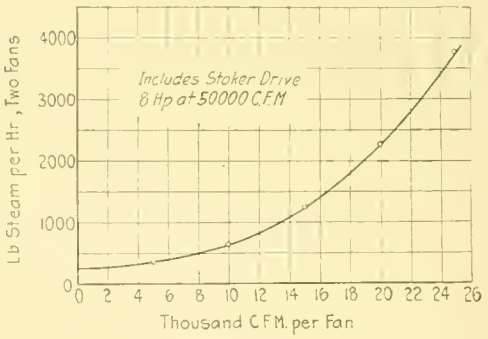

FIG. 4 STEAM CONSUMPTION AND AIR DELIVERED, FORCED-DRAFT BLOWERS

curve of the forced-draft fans. The units are arranged so that two multivane fans are driven by a single turbine. One unit serves a battery of two boilers through short air ducts. The sharp curvature is due to the fact that both pressure and volume of air increase with the speed. The curve is drawn on the basis of the steam consumed by both fans, and the air delivered by each. The mechanical stokers are driven from the fan shaft, requiring about 8 h.p. per pair at 50,000 cu. ft. per min. air delivery; this value is from tests.

The volume, static pressure and brake horsepower required by fans for the 520-myriawatt[1] B. and W. boiler using the Taylor stoker are given in Fig. 5, on a basis of 17 lb. of air per pound of coal. The results of numerous tests show that the CO_2 content, and consequently the air per pound of fuel, is substantially independent of the rate of driving with underfeed stokers.

From Figs. 4 and 5, Fig. 6 has been constructed, showing

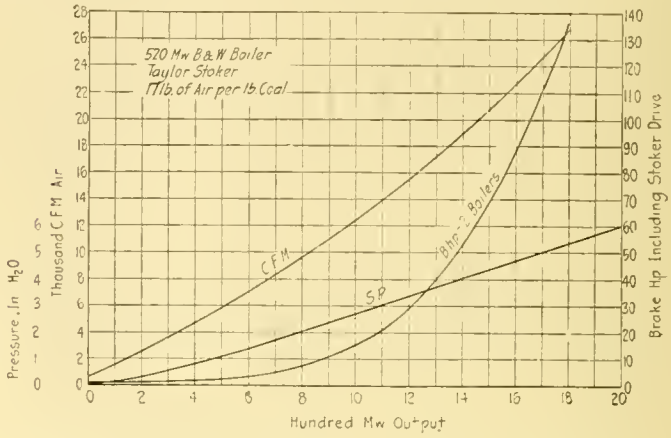

FIG. 5 AIR, BLAST PRESSURE AND BRAKE HORSEPOWER, FORCED-DRAFT FAN

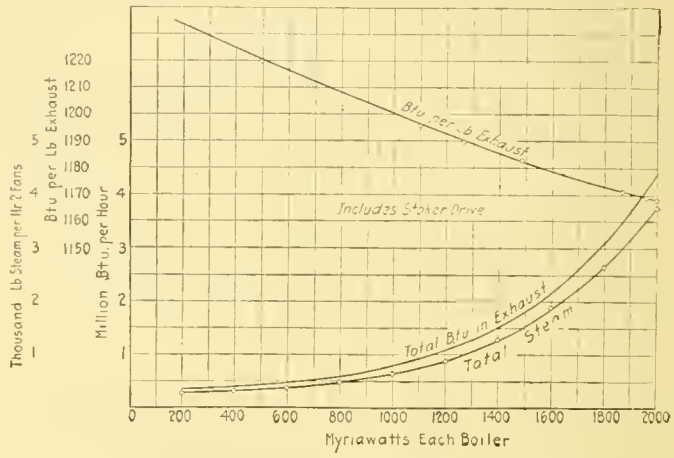

FIG. 6 STEAM CONSUMPTION AND BOILER OUTPUT, FORCED-DRAFT BLOWERS

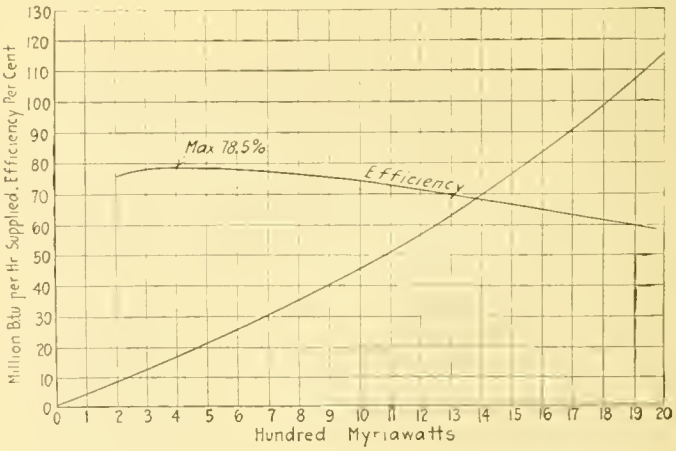

FIG. 7 BOILER INPUT-OUTPUT CURVE AND EFFICIENCY, FROM TESTS

the relation between the steam consumed by the fans and the boiler output in myriawatts.

Boilers. In Fig. 7, the input-output curve of a single boiler

[1] The unit called "myriawatt" has been suggested by some engineers as a unit of boiler capacity. It is 2 per cent greater than the "boiler horsepower" and is equivalent to 34,150 B.t.u. per hour, the "boiler horsepower" being 33,479 B.t.u. per hour.

is plotted from data obtained from actual tests. The efficiency at different rates of output is also shown, the maximum being 78.5 per cent; higher efficiencies are frequently obtained in single tests, but the values given represent the average of the best results obtainable in practice.

Condensers. The Willans lines for the condenser auxiliaries are not essential, as the condenser operates at practically full

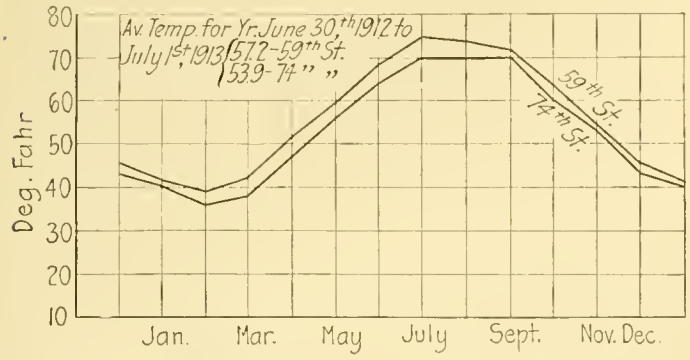

Fig. 8 Circulating-Water Injection Temperature

load, once it is started. The variation in cooling-water temperature is shown in Fig. 8. The average for the year, June 30, 1912, to July 1, 1913, at the 74th Street Station of the Interborough Rapid Transit Company, was 53.9 deg. fahr.

Construction of the combined curves. Fig. 9 shows the heat input per hour plotted against myriawatt output of 30 active boilers, 520 myriawatts rated capacity each. Theoretically, the most economical method is to reduce to zero load with all

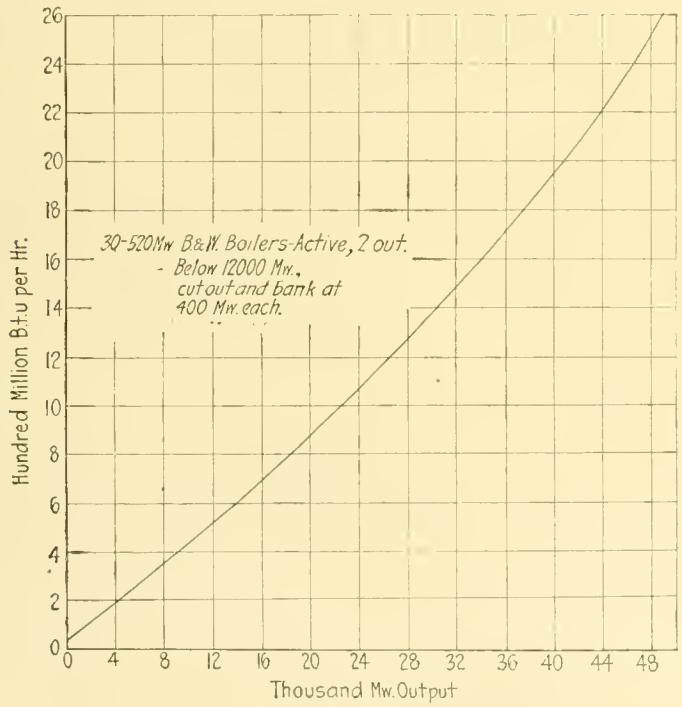

Fig. 9 Boiler-Room Input-Output Line

boilers active, banking none. It is not feasible to operate in this manner, however, because of the difficulties of operating the underfeed stoker at loads less than 80 per cent of capacity and the question of labor costs. Fig 9 is therefore drawn on a basis of cutting out and banking as the load drops from 12,000 myriawatts at a rate of one boiler for every 400-myriawatt drop. This method is only slightly less efficient than continuous operation of all boilers.

Combined boiler-room auxiliaries, input-output lines. In Fig. 10 are combined the curves of Figs. 3 and 6 to give the total steam consumed by boiler-feed pumps, fans and stoker drives against gross output of the boilers in myriawatts, and the total B.t.u. available in the exhaust steam from these auxiliaries. It will be noticed that, for normal loads, the steam consumption of the boiler-room auxiliaries varies but little

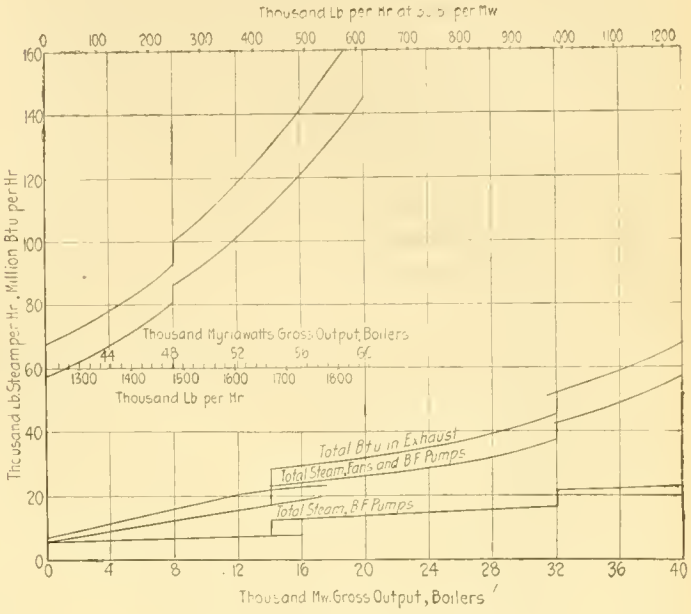

Fig. 10 Boiler-Room Auxiliary Input-Output Lines

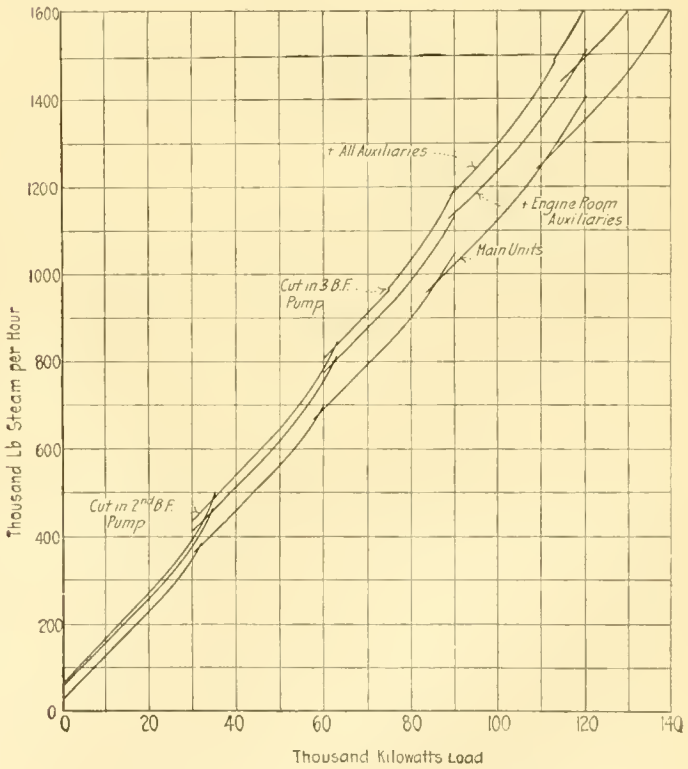

Fig. 11 Engine-Room Steam Demand

from 4.6 per cent of the total steam generated. All except about 3 per cent of the losses in a steam turbine reappear as heat in the exhaust. Therefore, *Heat in exhaust = Total heat in steam supplied — (3 to 4.5 per cent) — Brake horsepower* $\times$ 2547 — 3,200,000 *B.t.u.* The 3,200,000 B.t.u. covers radiation and leakage from the exhaust system. This radiation loss

is figured, if possible, from area of pipe-line surface; but for quick figures, 2 per cent of the heat of steam passing at full load will amply cover this loss, both on high-pressure and exhaust steam. Usually it does not actually exceed 1 to 1.5 per cent.

Total steam demand. The total steam demand for the main turbine units in pounds per kilowatt-hour developed is shown in one of the curves of Fig. 11, marked "main units." All curves on this sheet are based upon a 29-in. vacuum, and the circulating water is assumed to be at a constant temperature from May 1 to November 1, and at another temperature for the rest of the year. In Fig. 11, the curve marked "main units" is obtained directly from Fig. 1. Adding 21,620 lb. of steam per hour per unit for the condenser auxiliaries, which comprise two 37,500-gal.-per-min. circulating pumps, two 800-gal.-per-min. hot-well pumps, and one dry vacuum pump for each unit, gives the curve "engine-room auxiliaries." Adding the boiler-room-auxiliary steam demand, gives "all auxiliaries." There are also added 3 per cent for starting, warming up, and losses dependent upon load; and 25,000 lb. of steam per hour for pipe radiation, boiler dusting and leakage. These last are substantially independent of the load. From Figs. 10 and 11 the heat demand is drawn in Fig. 13, heat units of input being plotted against kilowatts output.

Bleeding. The curves at the bottom of Fig. 13 show the heat units required in the feed-water heater and the heat units available from the exhaust from auxiliaries per kilowatt of output.

Effect of bleeding. The effects of introducing or removing steam from a compound turbine are shown in Fig. 12. Here are shown the Willans lines of the high- and low-pressure turbines and entire unit, with and without bleeding.

It will be noticed that the straight Willans line for the low-pressure turbine is represented by the equation

$$W = 45{,}000 + 20.26\,L$$

in which W = total pounds steam consumed
L = kilowatt output of low-pressure turbine only
45,000 = no-load steam consumption, pounds.

Therefore, the addition of steam in any reasonable quantity at any load will produce the same kilowatt increase in output of the low-pressure turbine, at a water rate of 20.26 lb. of steam per kw-hr. The decrease of output of the high-pressure turbine, due to increased back pressure, is practically in the ratio of the adiabatic heat drop.

Balanced input-output curve. From the anticipated load curve, Fig. 14, and from Figs. 9 and 13, the B.t.u. consumption for the two conditions is obtained. The data are: 40,739 kw. average load, 71,900 maximum hours, 977,735 kw-hr. per day total output. From Fig. 13, without heat balancing, the total input, at 40,739 kw. output, is 19,823,300,000 B.t.u. per day, while with heat balancing this amount is 19,636,800,000 B.t.u. per day. With coal at $0.10 per million B.t.u. and such labor as is affected, which brings the cost up to $0.11, the saving due to heat balancing is $204.00 per day.

Effect of changing operating conditions. The Interborough installation considered in this paper is capable of peak loads of 90,000 kw. because there is adequate reserve in reciprocating-engine units.

The Interborough station is now running 22,500 B.t.u. per net kilowatt-hour, or 91 per cent of what is possible with the equipment. The effect of vacuum improvement can be obtained readily by shifting the heat- and steam-consumption scales of Fig. 13 up or down as required.

The correction for superheat can be applied as a direct

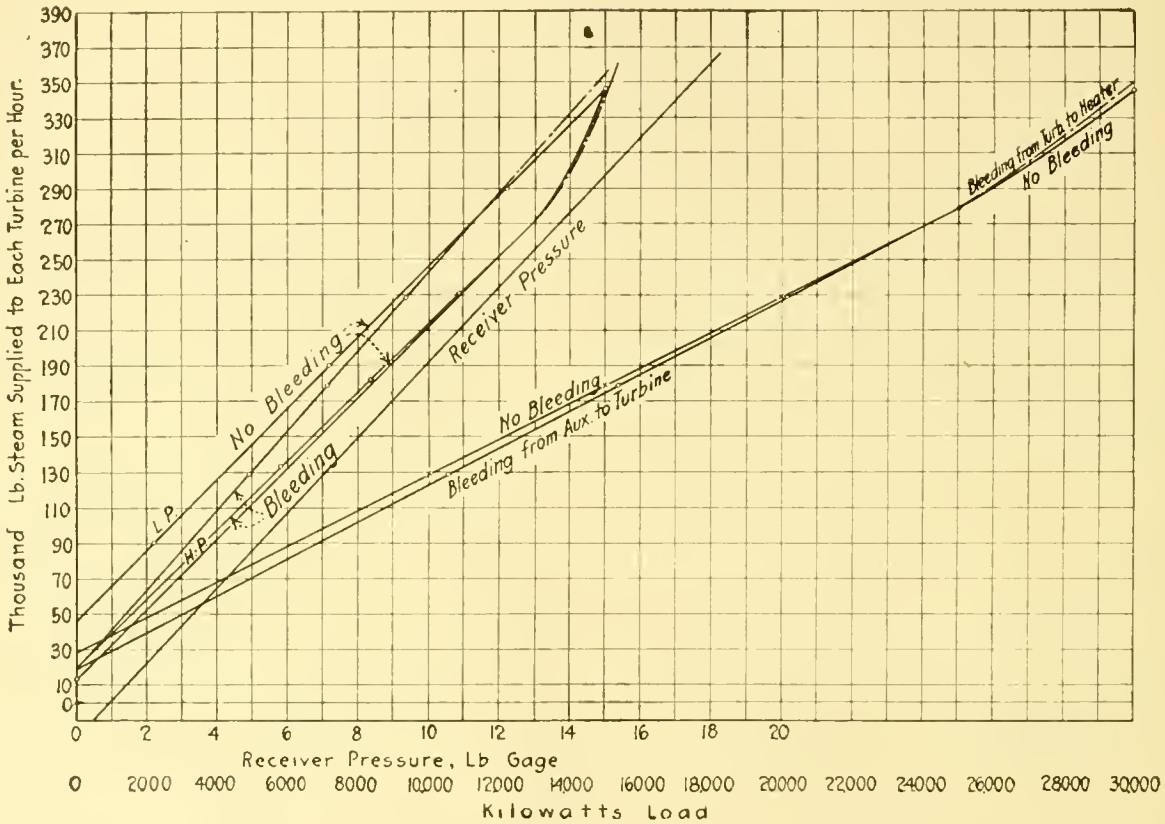

FIG. 12 CORRECTED WILLANS LINES FOR HEAT BALANCING

percentage correction to the total figures obtained from the load curve.

Electric-driven auxiliaries. Fig. 15 shows conclusively that this arrangement is thermally less economical than the steam-driven. The cost of the steam auxiliary station per effective installed kilowatt is $65.00 against $69.10 for the electric auxiliary station.

Consider a separate turbine-driven generating equipment for serving motor-driven auxiliaries and exhausting its steam into the feed-water heater and an economizer.

A load of 50,000 kw. will give about the best economy for both steam and electric drive. The data are: Main steam units, 561,200 lb. of steam, auxiliary power requirements, 1989 kw., 52,140 lb. of steam, including induced-draft fans and economizer-scraper drive. In the steam-electric units the temperature of the feed water would be raised from 70 to 155 deg. fahr. by the exhaust from the auxiliary turbines, and the possible rise in the economizer would be 147 deg. fahr. (flue-gas temperature cannot be brought lower than 150 deg. fahr. above water temperature). The use of the economizer will lower the B.t.u. per kilowatt-hour to 18,000, as against 19,250 without it, or about 6.5 per cent. Economizers could be used with the all-steam units, but on account of the feed-water temperature, 208 deg. fahr., the saving would be only 4.1 per cent, making the B.t.u. per kilowatt-hour for this type of plant 18,540. The steam-electric plant, therefore, shows an improvement of 2.9 per cent. The investment cost per kilowatt, however, is increased from $65.00 to $70.31. Whether or not it would pay to use the steam-electric combination, viewing it from the point of view of cost of power only, would depend upon the load factor. Reliability, certainly, is not as good with the electric-driven units, as two additional links have been added to the auxiliary system. In the writer's

Fig. 14 Anticipated Load Curve and Heat Input, Balanced

opinion, electric-driven auxiliaries should never be used for boiler feed, and only with steam support for excitation.

Another method is to use part steam and part electric

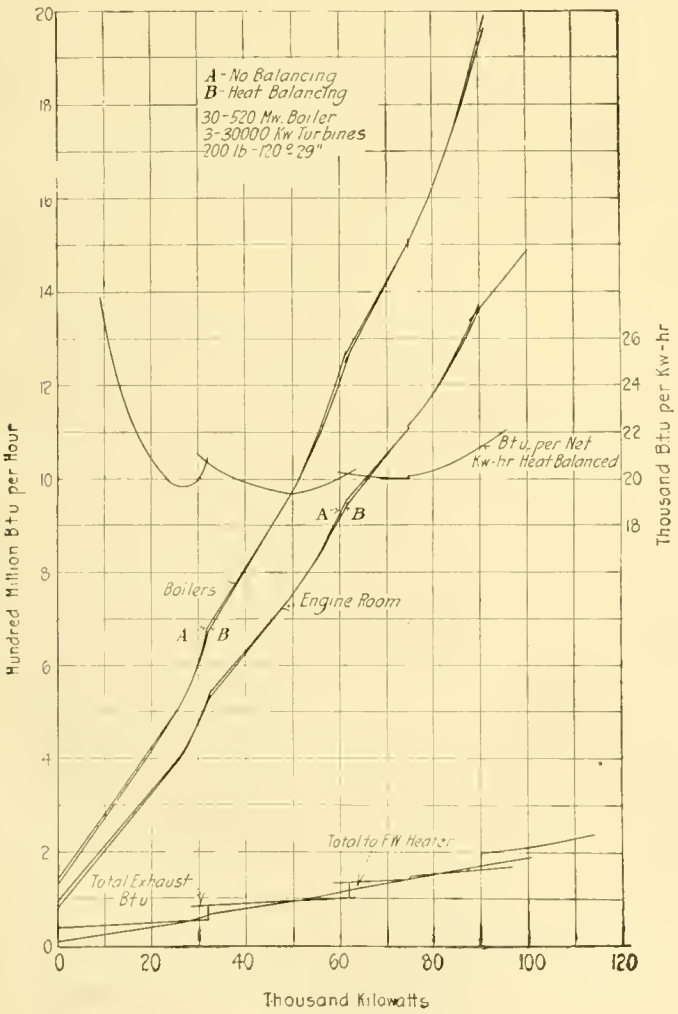

Fig. 13 Plant Input-output Lines

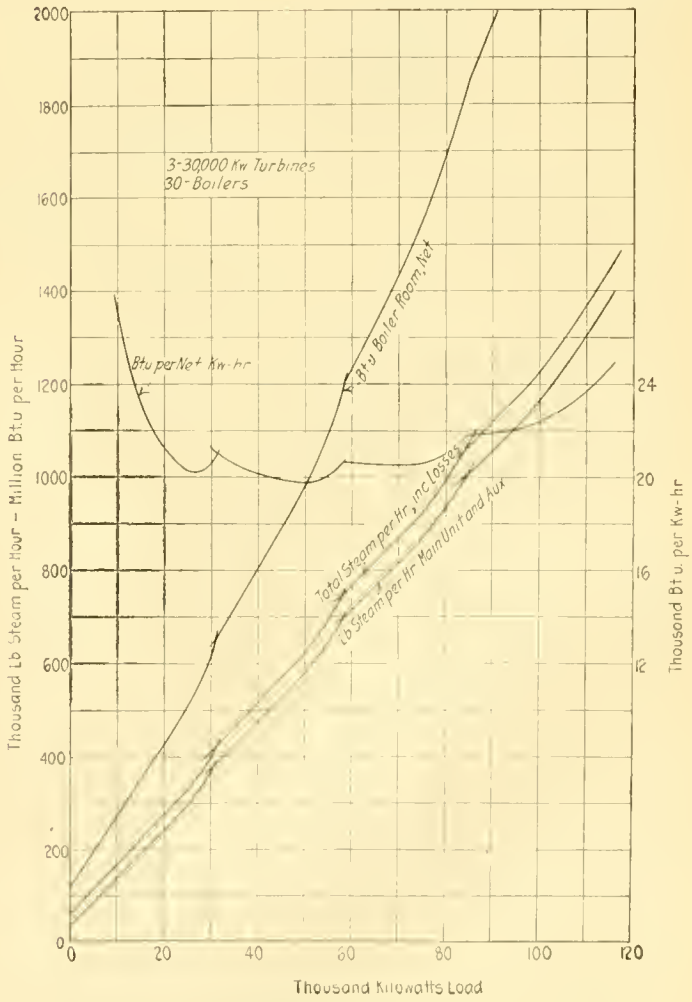

Fig. 15 Plant Input-output Lines, All-Electric Auxiliaries

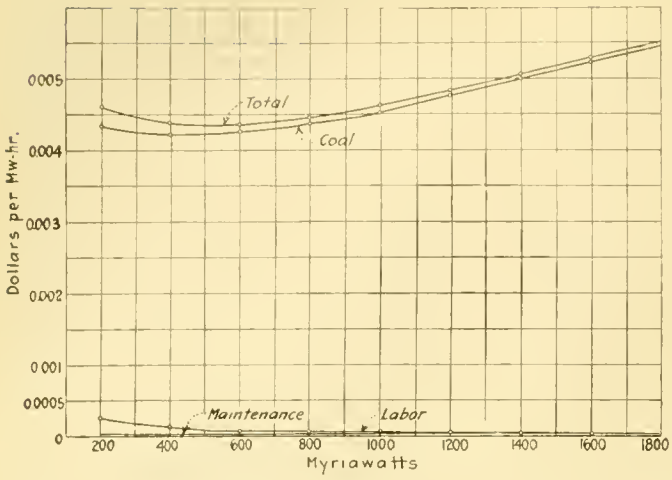

Fig. 16 Cost of Operation per Myriawatt-Hour, Boilers

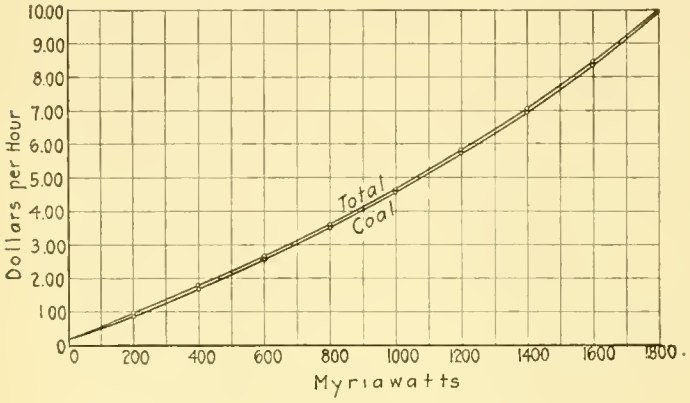

Fig. 17 Total Operating Cost per Hour, Boilers

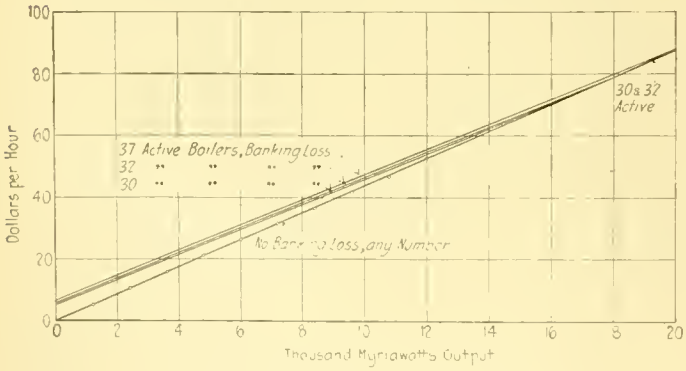

Fig. 18 Cost per Hour, Boiler Plant

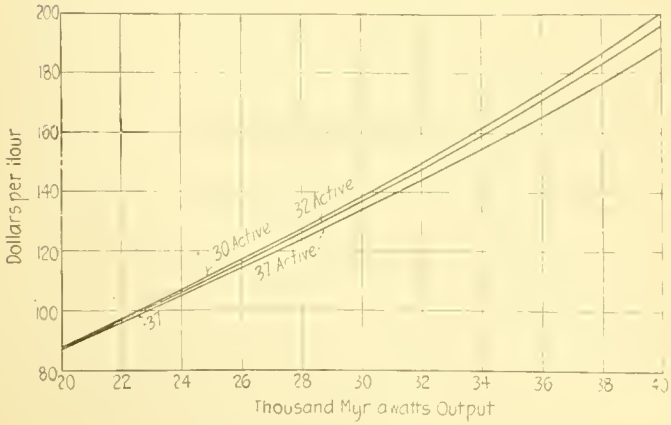

Fig. 19 Cost per Hour, Boiler Plant

auxiliaries, as is done in many plants, but the limits of this paper will not permit the analysis of all possible combinations. The above reasons show why the slightly more economical combination steam-electric auxiliary was not considered for the Interborough plant; reliability was paramount.

Number of boilers to install. The best number of boilers and stokers to install for a given load curve can be determined readily. The cost per myriawatt-hour to operate a boiler and stoker is given in Fig. 16. The curves are based

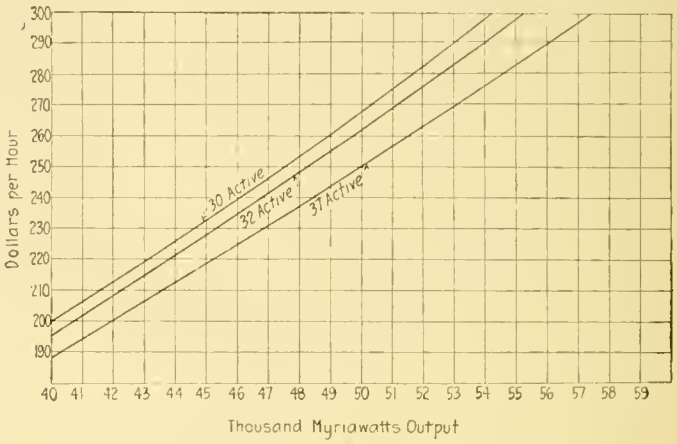

Fig. 20 Cost per Hour, Boiler Plant

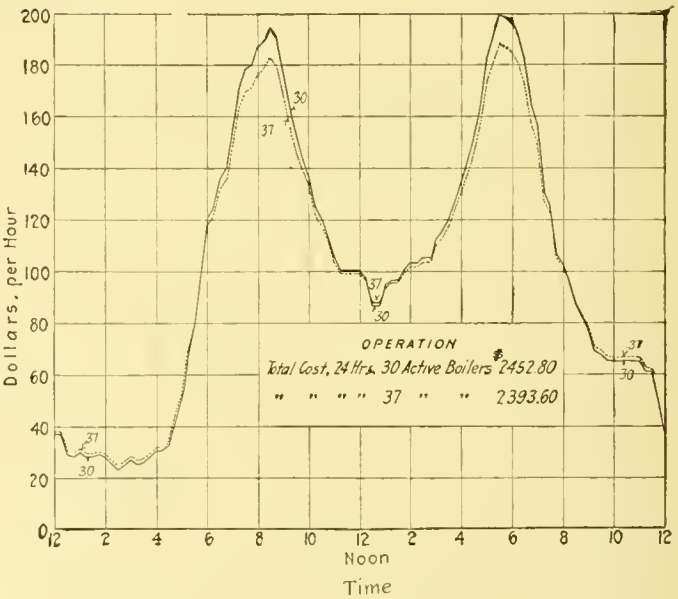

Fig. 21 Hourly Variation of Boiler-Room Operating Cost, Anticipated Winter Load

on the following data: Coal at $0.103 per million B.t.u. ($3.30 per ton, heat value 14,250 per pound of dry coal), maintenance at $0.03 per ton of coal fired, labor, one operator at $0.40 per hour and one helper at $0.20 per hour for every twelve stokers. Fig. 17 shows the total operating cost per hour per myriawatt load, and the total cost of coal. The total cost plainly follows the heat input-output line. Figs. 18, 19 and 20 show the boiler-room cost lines in dollars per myriawatt-hour for different numbers of boilers in operation.

Using the total heat demand as before, but separately for different numbers of boilers, Fig. 21 is obtained. This shows 30 boilers more economical at light loads and 37 more economical at heavy loads, and for a typical day shows a net

saving of $59.20 by the large number of boilers. In a new plant, unquestionably the greater number of boilers would not pay, as the fixed charges more than offset the operating saving. The actual case in question required stokers and equipment, but not boilers, as these were already installed. The saving would not pay the fixed charges on the greater number of boilers even in this case. It is evident that the load factor is the controlling item.

CONCLUSION

For rapid estimates it is evident that the curves presented in this paper will give some useful relations for analyzing operating records. For instance, the engine-room steam demand with all-steam auxiliaries, in Fig. 13, balanced, might be represented with fair accuracy by the straight line $H = a + bL$,

where a = the no-load losses in the engine room = 60,000,000 B.t.u. per hr.

b = the intrinsic B.t.u. rate of the engine room = 14,000 B.t.u. per hr.

L = the kilowatt load on the plant

H = steam demand, B.t.u. per hour.

This average curve smooths out the humps in the original line. It is found, by investigating eight cases, that the total heat input-output amounts between 0.30 and 0.80 load factor will lie on the curve of total B.t.u. plotted from the above straight-line engine-room demand and by use of Fig. 9, for any load curve. Variations of peak load within 15 or 20 per cent are also found to agree. In short, the average heat consumption for any load curve can be taken from this chart as the amount corresponding to the average load without correction.

The writer has indicated only a few of the valuable features of the graphic method of analysis in steam power plants, which not only shorten the labor in power plant design, but reduce the chances of error and encourage a rigorous heat analysis. It is hoped that these curves will prove of value to others investigating similar problems.

THE FLOW OF AIR AND STEAM THROUGH ORIFICES

By Herbert B. Reynolds, New York

Junior Member

This paper is in two parts, the first covering the flow of air through orifices, including a study of pitot and venturi tubes for measuring compressed air, and the second the flow of steam through orifices at low pressures. Both investigations were undertaken for the want of available data on these subjects under the particular conditions mentioned.

Thin-plate orifices were used in both the air and steam measurements. From the data of both the air and the steam tests empirical equations were derived for computing the flow. Both equations were proved out by checking computations for the quantities of air and steam passed against actual measurement of the quantities, and curves were plotted to show the close agreement between computed and test results.

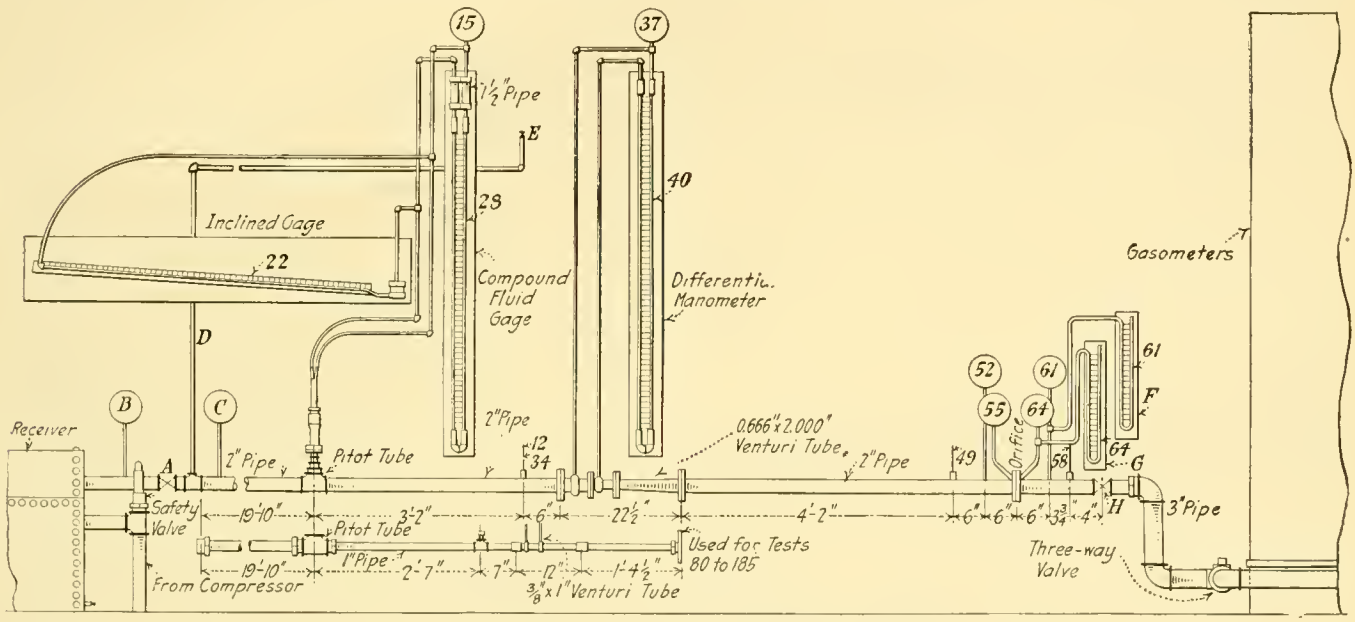

Fig. 1 Layout of Apparatus for Air Tests

In connection with the air-flow investigation the coefficients of two venturi tubes and one Taylor pitot tube were also experimentally worked out, as there are occasions where these means of measuring air flow are preferable to orifice measurement because they do not cause any drop in pressure.

DESCRIPTION OF THE APPARATUS

The apparatus for the experiments was set up in the mechanical laboratories of Sibley College, Cornell University, in the Spring of 1913. The compressed air was furnished by a two-stage steam-driven compressor of about 150 cu. ft. capacity. A slight additional capacity was obtained by using a Westinghouse locomotive compressor. These two

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

compressors discharged into a common receiver of about 12 cu. ft. capacity.

The rest of the layout of the apparatus can be understood from Fig. 1. The air passed from the receiver through a 2-in. pipe line to a valve *A*, Fig. 1, that was used to regu-

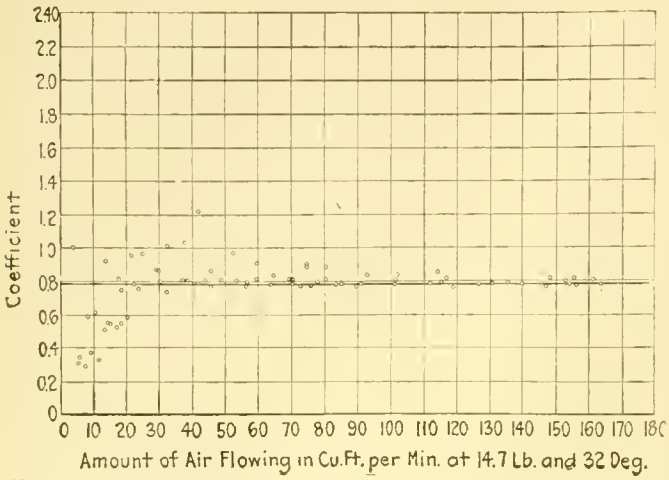

FIG. 2 COEFFICIENT OF TAYLOR PITOT TUBE IN A 2-IN. PIPE

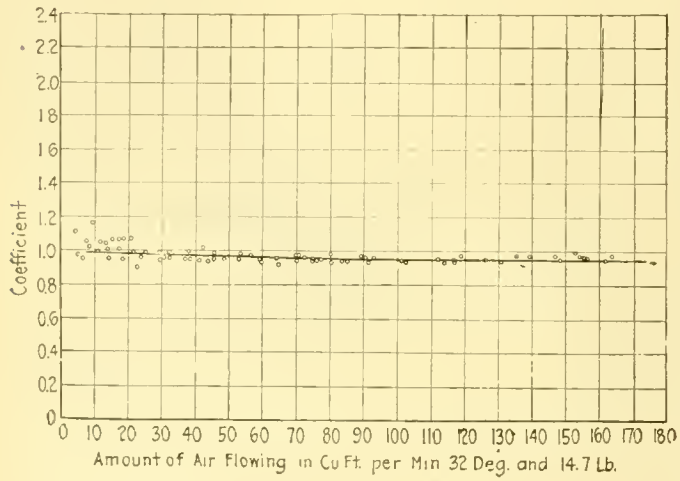

FIG. 3 COEFFICIENT OF THE 2-IN. × 0.666-IN. VENTURI TUBE

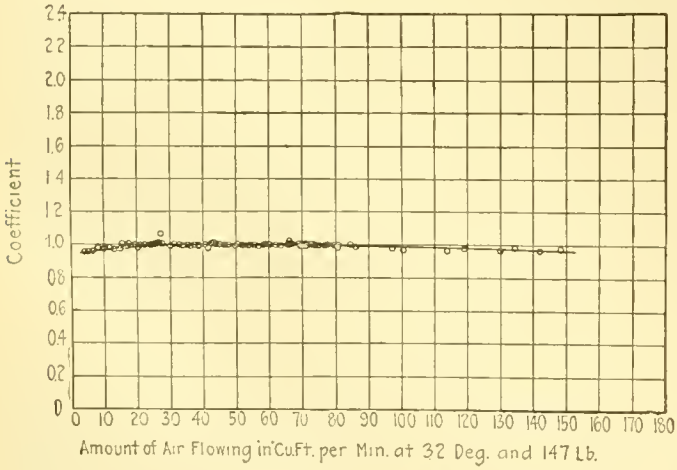

FIG. 4 COEFFICIENT OF THE 1-IN. × 3/8-IN. VENTURI TUBE

late the pressure on the apparatus, a gage each side of it showing the pressures. To obtain a still closer adjustment of the pressure a small pipe was tapped into the line, *D*, Fig. 1, at the end of which a small valve *E* was attached.

With the apparatus arranged for tests Nos. 1 to 79, the air, after passing the throttle valve *A*, flowed through a 2-in. pipe at the end of which a standard Taylor pitot tube was inserted through a pipe tee. The tube extended up into the pipe, so that the tee did not interfere with the motion of the air until after the pitot tube had been passed. The stem of the tube passed through a stuffing box which prevented leakage. This stuffing box also had a ball-and-socket joint, so that the tube could be adjusted in its position in the pipe line. With the stuffing box a traverse of the pipe could have been made, but as time did not permit, the tube was kept always in the center of the pipe.

To determine the velocity head from the pitot tube, two forms of manometers were used. One was the familiar form of compound fluid manometer with water as the heavier and olive oil as the lighter fluid. As constructed, and by using the above fluids, the readings were multiplied about ten times. In addition an inclined gage of the ordinary draft-reading type was used that could be set at different angles, to give any multiplier. In its lowest position the readings were multiplied about forty times.

After the air passed the pitot tube it flowed through a short 2-in. pipe and then through a venturi tube. Just before the air passed into the venturi tube its temperature was taken by a thermometer in a well tapped into the pipe. An ordinary differential manometer determined the difference of pressure between the mouth and throat of the venturi tube. A pressure gage was attached, as shown, from which the total pressure of the air at the mouth was obtained.

After flowing through the venturi tube, the air continued through a 2-in. pipe and then through a square-cornered orifice in a thin plate inserted in the line between two standard pipe flanges. The pressure was obtained on each side of the orifice in two places. One gage was tapped into the side of the pipe 6 in. from the orifice, while the other gage was tapped into the flange on an angle, so that the pressure was obtained right at the face of the orifice. Different orifices were used during the tests, which were made by drilling a brass plate and not rounding the corners except to remove the burr formed by the drilling. After leaving the orifice the air passed through the valve *H*, which was used for adjusting the final pressure.

Thence, the air flowed through a 3-in. pipe to a three-way cock, by which it could be discharged into either of two gasometer tanks, each of about 100 cu. ft. volume. Thus an absolute measure of the volume of air flowing was obtained, the rise of each tank being determined by a scale reading to tenths of inches. The pressure of the air in the tanks, which varied from 2 to 4 in. of water, was obtained from a water manometer on top of each tank. The air temperature in the gasometer tanks was determined by thermometers inserted through their tops.

As the tests were very short and the air in the tanks was kept in motion by the inflowing air, it is believed that representative temperature readings were obtained. Through large quick-opening valves on top of the tanks they were emptied after the readings were taken.

The arrangement of the apparatus for tests Nos. 80 to 185 was somewhat different. After passing through the throttle valve *A* the air passed through a 1½-in. pipe and then past the same Taylor pitot tube as in the first tests. This time the pitot tube was in the center of the 1½-in. pipe. The same manometers were used as before for obtaining the velocity head. Beyond the pitot tube the air passed a thermometer registering its temperature, and then through a 1 × 3/8-in. venturi tube. This tube is in one piece and

not of exactly the same form as the larger tube used before. From this point on, the layout of the apparatus was the same as for the other tests.

DESCRIPTION OF THE TESTS

A leakage test was run on each tank to determine the necessary correction for leakage. The actual volume of each gasometer was computed from the average diameter found by measuring the diameter of the inside tank at a great many points (four diameters at every foot throughout the length).

The compound fluid manometer and the inclined manometer used in connection with the pitot tube were calibrated by connecting to a U-tube manometer, and taking readings at several points. All pressure gages were calibrated by a dead-weight gage tester. All thermometers were calibrated by reference to a standard thermometer.

The tests were run as follows: An orifice was selected and placed in the line; both gasometer tanks were emptied, the exhaust valve on one tank was left open while that on the other was closed, the three-way valve was then turned so that the air could enter the gasometer that was open to the atmosphere; the throttle valve A, Fig. 1, was then opened until the gage C indicated a pressure slightly in excess of that desired; the pressure was then adjusted by the valve E and gage 37; then the three-way valve was quickly turned so that the air discharged into the gasometer that was closed. When this gasometer was full the three-way valve was turned back to its original position so that the air flowed into the other gasometer, which in the meantime had been closed.

The rise of the first tank and the pressure and temperature of the air in it were then recorded while the second tank was filling. After the readings had been taken the exhaust valve was opened allowing the tank to empty. After a length of time equal to that taken to fill the first gasometer, the three-way valve was quickly turned, so that the air could flow to the atmosphere through the first gasometer. The rise, temperature, and pressure were then recorded for the second gasometer. The pressure in the pipe line was maintained constant during the entire operation. The various gages and thermometers along the pipe line were read every 5 min. during the long tests, and as often as possible during the short tests.

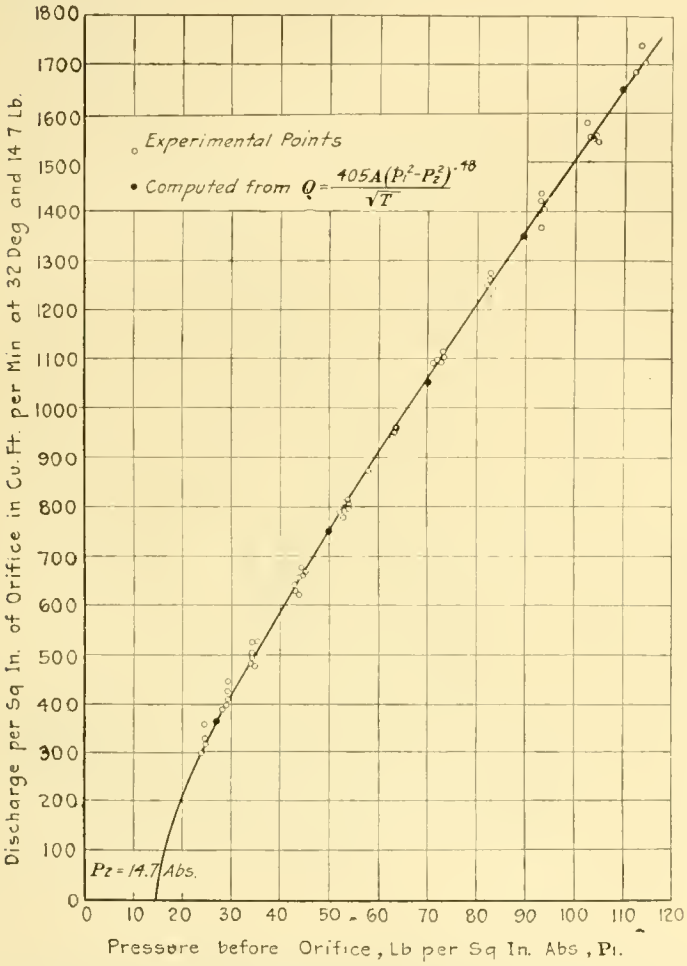

Fig. 5 Initial Pressure-Quantity Curve. Final Pressure = 14.7 lb.

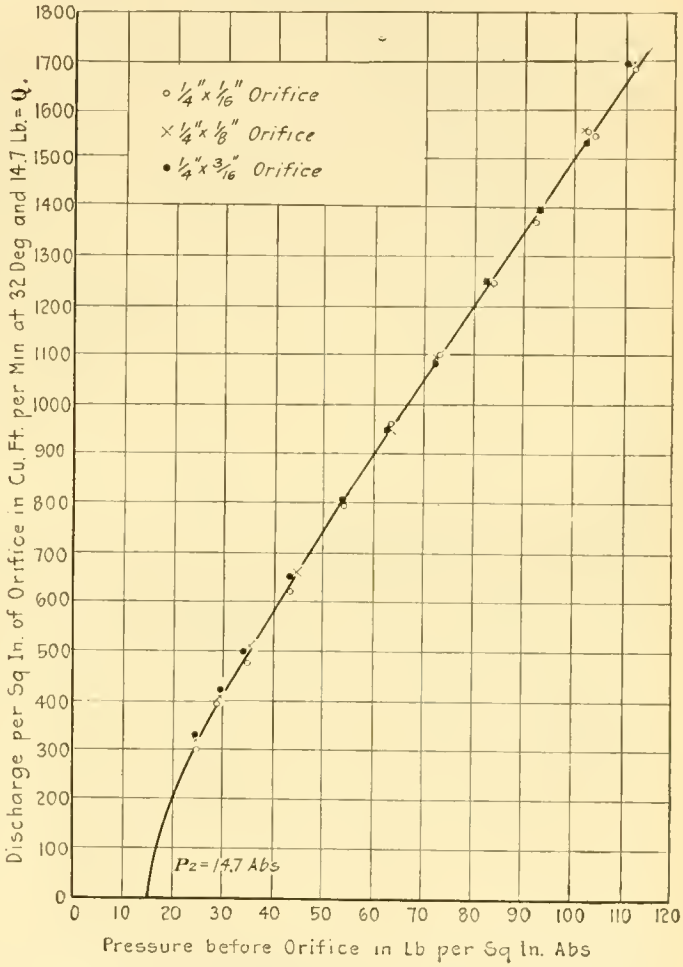

Fig. 6 Initial Pressure-Quantity Curve. Orifices of Different Thicknesses

Tests were made on each orifice at pressures of 10, 15, 20, 30, etc., up to 100 lb. per sq. in. gage. During most of the tests the final pressure on the discharge side of the orifice was kept constant at 14.7 lb. per sq. in. abs. However, a few tests were run with final pressures as high as 90 lb. per sq. in. gage. If during any test the rise of the two gasometer tanks did not check each other within one inch, the test was repeated.

To test the pitot and venturi tubes for large volumes and low pressures, a few tests were run without any orifice in the line. The flow during these tests was adjusted by the back-pressure valve H.

During most of the tests, water was the fluid used in the venturi manometer, but, during some the readings were so high that it was necessary to use mercury.

COMPUTATIONS

All of the computations are simple and need no explanation. However, the equations used for the pitot tube, venturi tube, and the orifice will be given.

The equation for the pitot tube was taken from a paper by Thomas R. Weymouth on the Measurement of Natural Gas.[1]

$$V = \sqrt{\frac{2\,gh\delta w\,14.7\,T}{12\,\delta a\,492\,PG}}$$

where V = velocity of flowing gas, ft. per sec.
g = acceleration of gravity = 32.2 ft. per sec.
h = velocity head, in. of water.
δw = weight of water, lb. per cu. ft.
T = absolute temperance of flowing gas, deg. fahr.
δa = weight of 1 cu. ft. of air at 32 deg. fahr. and 14.7 lb. per sq. in. abs. = 0.08073 lb.
P = absolute pressure of flowing gas, lb. per sq. in.
G = specific gravity of flowing gas, air = 1.000.

The equation which was used for the venturi was taken from the same paper by Weymouth and is as follows:

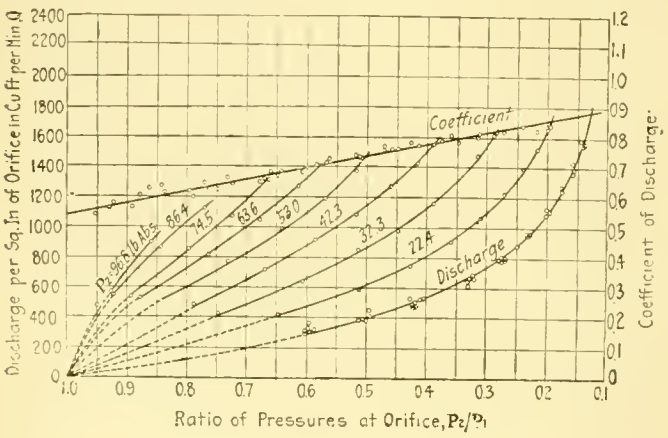

FIG. 7 COEFFICIENT OF DISCHARGE FOR ORIFICES IN 1/16-IN. PLATE

$$Q = \frac{3514\,A_1T_s}{P_s}\sqrt{\frac{n}{(n-1)\,G}\,\frac{P_1}{\sqrt{T_1}}\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}}\frac{1-\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}}}{1-\left(\frac{A_2}{A_1}\right)^2\left(\frac{P_2}{P_1}\right)^{\frac{2}{n}}}}$$

where Q = quantity of air per minute at 32 deg. and 14.7 lb. abs., cu. ft.
A_2 = area of throat, sq. ft.
A_1 = area of entrance, sq. ft.
T_s = absolute temperance of standard air = 492 deg. fahr.
P_s = absolute pressure of standard air = 14.7 lb, per sq. in.
n = a constant, for air = 1.402.
G = specific gravity of gas, air = 1.000.
P_1 = pressure of air at entrance, lb. per sq. in. abs.
P_2 = pressure of air in throat, lb. per sq. in. abs.
T_1 = temperature of air at entrance, deg. fahr. abs.

The equation which was used for the orifice was taken from Hirshfeld and Barnard's Elements of Heat Power Engineering, and is as follows:

$$Q = \frac{1522\,P_1A}{\sqrt{T_1}}\sqrt{\left(\frac{P_2}{P_1}\right)^{1.42}-\left(\frac{P_2}{P_1}\right)^{1.71}}$$

where Q = quantity of air per minute at 32 deg. and 14.7 lb. abs., cu. ft.
P_1 = initial pressure, lb. per sq. in. abs.
P_2 = final pressure, lb. per sq. in. abs.

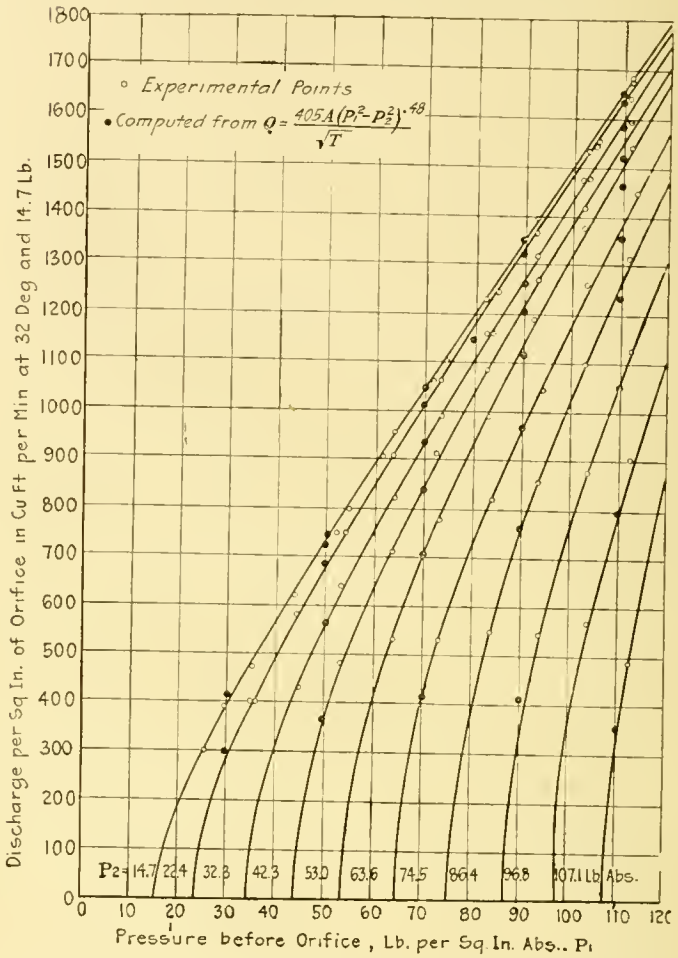

FIG. 8 INITIAL PRESSURE-QUANTITY CURVES. VARIOUS FINAL PRESSURES

A = area of orifice, sq. in.
T_1 = initial temperature of air, deg. fahr. abs.

Using the foregoing three theoretical equations, coefficients were computed for the pitot tube, venturi tube, and the orifices. The actual volume of the air flowing during the tests was computed from the known dimensions of the gasometers. Corrections were made for temperature, pressure, leakage, zero reading of scale, etc.

PITOT AND VENTURI TUBES

Fig. 2 gives a curve of coefficients for the Taylor pitot tube when in the center of a 2-in. pipe. The coefficients were computed using the readings from the inclined gage, as it was impossible to obtain satisfactory readings from the compound fluid gage. This figure shows that the pitot tube is uncertain when used in a 2-in. pipe if the amount of air flowing is less than 40 or 50 cu. ft. per min. while the coefficient becomes fairly steady when the discharge is greater than 80 cu. ft. per min.

[1] Trans. Am.Soc.M.E., vol. 34, p. 1639.

A similar curve, not shown, was plotted of coefficients for the same tube when in the center of a 1½-in. pipe, the velocity head being obtained with the inclined gage as before. This curve showed that below 30 cu. ft. per min. the results are not very reliable and that the coefficient increases with increase in velocity until at about 90 cu. ft. per min., after which it is constant.

The curve in Fig. 3 of coefficients for the 2 × 0.666-in. venturi tube, shows that the average is about 0.95. It also shows that this size of venturi tube is not accurate when the flow is less than 25 cu. ft. of free air per minute, and that the coefficient decreases slightly as the flow increases.

The curve of coefficients for the 1 × ⅜-in. venturi tube is shown in Fig. 4. This curve differs slightly from that for the larger tube, and the average coefficient is higher, being about 0.99 over most of the range of the tests. The reason for this difference in the curves, and the coefficients is that the converging section of the larger tube continues up to where the throat pressure is taken. This tends to contract the stream at the throat, and so to give a lower pressure reading here than should be. This causes the reading to be high. In the smaller tube the converging section stops before the point where the pressure is taken so that the stream completely fills the throat at that point. The contraction effect is greater at the high velocities which explains the decrease in the coefficient at the high rates of flow.

ORIFICES

A number of tests were run on various-sized orifices from ⅛ to ½-in. increasing in size by 1-16 in. These orifices were all formed in 1-16-in. brass plate. The actual results of these tests are shown in Fig. 5.

As has been mentioned the pressure was taken near the orifice at two points. However, it was impossible to detect any difference between the pressures taken at these two points with the gages used, which could be read to the nearest pound, the smallest division on the scale being 5 lb.

It was impossible to keep the temperature of the air constant during the tests, so the actual discharge has been corrected to 32 deg. fahr. by multiplying the actual discharge by the factor $\sqrt{\frac{T}{492}}$, in which T is the absolute temperature of the air flowing.

Judging from the results the size of the orifice has no effect upon the coefficient of discharge.

The open circles in Fig. 5 are the experimental points obtained from all the orifices in the 1-16-in. plates. The solid circles will be mentioned later.

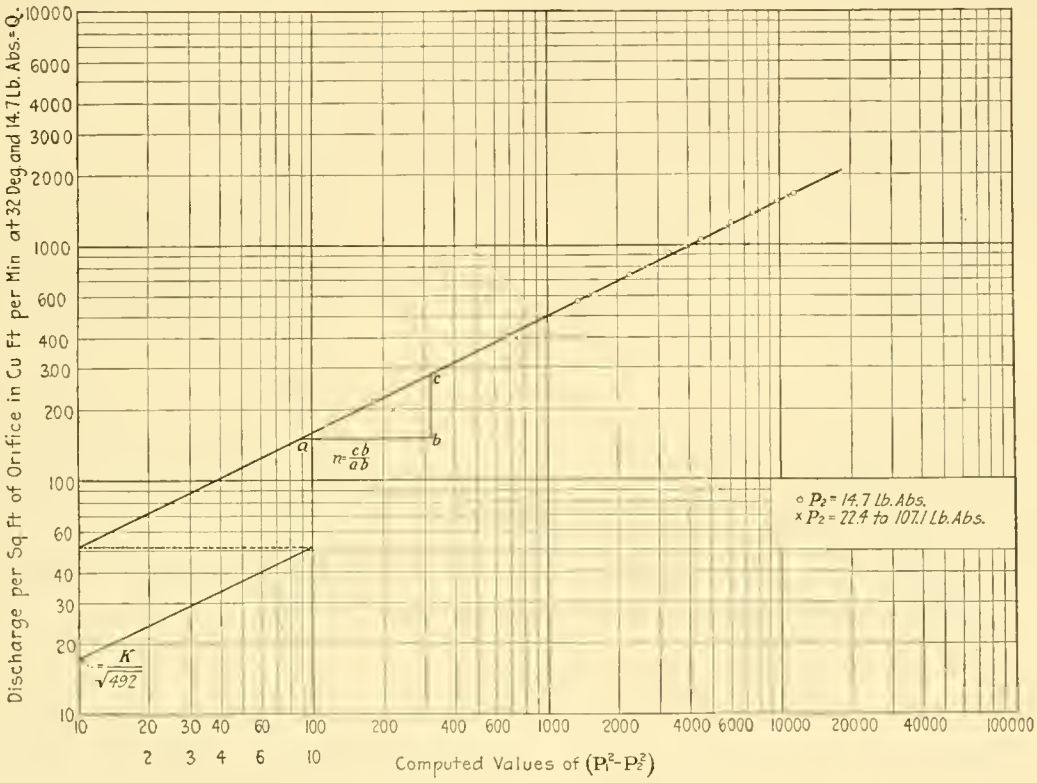

Fig. 9 Quantity-$(P_1^2 - P_2^2)$ Curves

To compare orifices of the same size but in different thicknesses of plate, tests were run on three orifices ¼-in. diameter. The first was in 1-16-in. plate, the second in ⅛-in. plate, and the third was in 3-16-in. plate. The curve and points in Fig. 6 show that very nearly the same result was obtained in each case.

Fig. 7 shows how the coefficient of discharge and the actual discharge vary with the ratio of pressure at the orifice, when the final pressure is constant at 14.7 lb. per sq. in. abs.

A number of tests were run on the ¼ × 1-16-in. orifice with various back pressures from atmospheric pressure up to about ninety pounds gage. The results of these tests are shown in Fig. 8.

Fig. 7 also shows the coefficient of discharge and the discharge plotted against the ratio of pressures at the orifice, for the tests when the final pressure was greater than atmospheric pressure.

FLOW OF AIR THROUGH A THIN-PLATE ORIFICE

For a given orifice the flow of air involves three variables the quantity discharged, the initial pressure, and the final

TYPICAL RESULTS SELECTED FROM TESTS ON THE TAYLOR PITOT TUBE IN A 2-IN. PIPE

	General Data				Pitot Tube				
No.	Barometer, in. Hg at 32 deg. fahr.	Length of test in minutes	Cu. ft. of air per min. at 32 deg., 14.7 lb. abs.	Temp. of room, deg. fahr.	Temp. of air, deg. fahr.	Pres. of air, lb. abs.	Actual velocity in pipe, ft. sec.	Velocity head, in. water	Coefficient of tube
12	29.44	20.00	8.6	65	64.4	25.4	3.82	0.017	0.584
13	29.44	16.00	10.9	66	65.1	29.9	4.12	0.021	0.608
14	29.47	12.00	14.0	70	69.9	35.4	4.48	0.013	0.923
15	29.47	10.00	17.8	70	70.0	45.4	4.48	0.021	0.818
16	29.47	8.00	21.5	70	70.6	54.8	4.49	0.018	0.957
17	29.44	6.00	25.3	70	70.7	64.5	4.49	0.021	0.963
18	29.44	6.00	29.1	70	71.5	74.4	4.48	0.030	0.868
19	29.44	5.92	32.5	71	73.2	84.4	4.44	0.024	1.018
20	29.44	4.00	38.0	57	56.7	94.4	4.47	0.028	1.037
21	29.44	4.00	42.1	59	58.1	103.4	4.55	0.022	1.225
22	29.44	4.00	45.7	60	61.1	114.1	4.51	0.060	0.775

TYPICAL RESULTS SELECTED FROM TESTS ON 2-IN. BY 0.666-IN. VENTURI TUBE

No.	Temp. of air, deg. fahr.	Pres. of air, lb. abs.	Difference of pres. between mouth and throat, lb.	Ratio of pres. at mouth and throat	Cu. ft. of air per min. at 32 deg., 14.7 lb., computed	Coefficient of tube
12	64.4	24.42	0.01980	0.99919	8.4	1.017
13	65.1	29.52	0.02670	0.99909	10.9	0.999
14	69.9	34.73	0.03680	0.99894	13.9	1.009
15	70.0	44.43	0.04690	0.99894	17.7	1.002
16	70.6	54.43	0.0567	0.99895	21.6	0.997
17	70.7	64.22	0.0664	0.99896	25.5	0.993
18	71.5	73.92	0.0761	0.99897	29.2	0.998
19	73.2	83.82	0.0867	0.99897	33.0	0.986
20	56.7	94.12	0.0978	0.99896	38.0	0.998
21	58.1	104.22	0.1118	0.99893	42.6	1.011
22	61.0	114.13	0.1230	0.99892	46.6	0.982

TYPICAL RESULTS SELECTED FROM TESTS ON AIR ORIFICES

No.	Size of orifice, inches	Temp. of air entering orifice, deg. fahr.	Initial pres. of air, lb. abs.	Final pres. of air, lb. abs.	Ratio of pres. at orifice	Actual discharge per sq. in. of orifice, cu. ft. per min. at 32 deg. and 14.7 lb.	Coefficient of discharge	Discharge per sq. in. of orifice, corrected to 32 deg. fahr.
12	$\frac{3}{16}$ by $\frac{1}{16}$	64.3	24.7	14.7	0.598	311	0.713	321
13	$\frac{3}{16}$ by $\frac{1}{16}$	65.0	29.5	14.6	0.498	394	0.774	426
14	$\frac{3}{16}$ by $\frac{1}{16}$	69.3	36.0	14.6	0.411	507	0.822	526
15	$\frac{3}{16}$ by $\frac{1}{16}$	69.7	45.4	14.6	0.322	644	0.820	668
16	$\frac{3}{16}$ by $\frac{1}{16}$	70.1	54.4	14.6	0.268	778	0.826	807
17	$\frac{3}{16}$ by $\frac{1}{16}$	70.3	63.9	14.6	0.230	916	0.834	951
18	$\frac{3}{16}$ by $\frac{1}{16}$	71.0	73.9	14.6	0.199	1052	0.830	1092
19	$\frac{3}{16}$ by $\frac{1}{16}$	73.0	82.9	14.6	0.176	1178	0.827	1227
20	$\frac{3}{16}$ by $\frac{1}{16}$	57.0	93.9	14.6	0.155	1373	0.830	1408
21	$\frac{3}{16}$ by $\frac{1}{16}$	58.0	104.7	14.6	0.139	1522	0.829	1559
22	$\frac{3}{16}$ by $\frac{1}{16}$	60.4	114.0	14.6	0.127	1658	0.830	1704

pressure. Evidently then the geometric figure that illustrates the relation of the three variables, is a curved surface involving all three dimensions. Examination of the various curves discussed above shows them to be conic sections. The equation of a cone whose axis coincides with the z axis, is:

$$m^2 (x^2 + y^2) = (z - c)^2$$

where m is the slope of the surface of the cone with the z axis and c is the intercept on the z axis. For a special case when the apex of the cone is at the origin, $c = 0$, and when the surface of the cone is at an angle of 45 deg. with the axis, $m = 1$. In our case $c = 0$, $m = 1$, $x = P_2$, $y = Q$, and $z = P_1$; then, by substitution:

$$Q^2 = K'(P_1^2 - P_2^2)$$

or the general form of the equation is,

$$Q = \frac{KA\ (P_1^2 - P_2^2)^n}{\sqrt{T}}$$

To obtain the numerical values of K and n, values of $(P_1^2 - P_2^2)$ were computed from the results of the tests and plotted against the quantity Q in Fig. 9. From this logarithmic curve it was found that $K = 405$ and $n = 0.48$. Thus the final equation is,

$$Q = \frac{405\ A\ (P_1^2 - P_2^2)^{0.48}}{\sqrt{T}}$$

where Q = quantity of air discharged per min. at 32 deg. fahr. and 14.7 lb. per sq. in. abs., cu. ft.
A = area of the orifice, sq. in.
P_1 = initial pressure before orifice, lb. per sq. in. abs.
P_2 = final pressure after orifice, lb. per sq. in. abs.
T = absolute temperature of air entering orifice, deg. fahr.

To check the accuracy of this equation, values were computed for various pressures. These are plotted in Figs. 5 and 8 and are shown by the solid circles. It will be seen that these points coincide closely with the experimental curves.

POWER-PLANT EFFICIENCY

By VICTOR J. AZBE, ST. LOUIS, MO.

Junior Member

THIS paper will deal not so much with the efficiency available in an up-to-date power plant, as with the improvement possible in the thousands of plants that supply power for small factories, office buildings, and various institutions, since these are by far the most prevalent and, also, the most uneconomical.

In 1915 about six hundred million tons of coal were mined in the United States, and this enormous amount is steadily increasing. Suppose the average cost of coal delivered at the power plant is $1.80 per ton, then the total cost will be $1,080,000,000. In the ordinary power plant, conditions as shown in Fig. 1 exist, where the shaded areas (excluding the one marked "Indicated Energy") represent the preventable losses, aggregating about 30 per cent. Of our total expenditure for coal this is $324,000,000 each year, to say nothing of the natural gas and crude oil produced, burned and wasted, also without the cost of handling and firing, and investment in unnecessary boilers, machinery and labor. If everything could be computed, the total loss would exceed half a billion dollars and all due to *inefficiency of man,* which can be subdivided into:

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

a Lack of foresight and business ability
b Improper design
c Improper management and inefficient operation.

Often when a power-plant installation is planned, the owner fails to consult a competent designing engineer; ill advice from incompetent persons, prejudice and fear of investing needless money do the rest. The owner is not an engineer and cannot be expected to know where a greater initial expenditure for more economical power-generating equipment will pay. Therefore, every power-plant owner should have a consulting engineer, proficient in economical power-plant design and operation, and every such consulting engineer should have a staff of specialists capable of examining power plants in regard to their proper up-keep and operation and of instructing the operating force thereupon. Every plant should be examined at regular intervals, and the cost of such examination will be amply rewarded by the savings due to greater efficiency.

Owners are as much in need of education in power-plant economics as their employees. They should be impressed with these possibilities:

a From 10 to 30 per cent fuel-consumption reduction without additional investment, simply by more efficient operation
b Up to three times the amount of power from the same amount of fuel by installing proper equipment
c Investments can be made in a power plant bringing from 10 to 100 per cent in interest
d To obtain the above, specialists on economical power-plant operation and design should be consulted.

VALUE OF INSTRUMENTS

Instruments to show whether a plant is operated efficiently are generally wanting. In boiler rooms from 10 to 20 per cent of the fuel, and more in some of them, is wasted chiefly from lack of indicating devices to detect losses. Every boiler should have a draft gage and if possible a steam-flow meter. No boiler room should be without some form of gas-analysis instrument and flue-gas thermometer or pyrometer. Too much guessing is done in the average power plant, which is, in part, responsible for the miserable results obtained. Few plants pay particular attention to obtaining economic combustion; many operators have no idea what high CO_2, low CO, and other such expressions mean. Hence it is not surprising that there are boilers operated at 40 per cent efficiency.

An automatic CO_2 recorder has a great moral effect upon the fireman, and numerous boiler plants can thank this apparatus for a large saving in fuel consumption. The steam-flow meter on each boiler in connection with proper interpretation of the pressure drops through boiler gas passages, is also of great value and, with intelligent, trained men in charge, even preferred to the CO_2 recorder.

The common differential draft gage is also important, for, when properly connected, it will tell whether the boiler is being operated at, below, or above rating; and whether the fuel bed is too thick, or dirty, or full of air holes. But the draft readings must be intelligently interpreted and they seldom are. Few operating engineers know the real value of the draft gage.

REDUCIBLE LOSSES

The greatest and most neglected loss in the average boiler plant is from excess air. The curves, Fig. 2, show the magnitude of this loss at different CO_2 percentages and are applicable to any fuel, liquid, solid, or gaseous, if its available hydrogen percentage is known.

The impression prevails that coal must be burned with about 50 per cent. of excess air. Some authorities claim that going beyond 10 to 12 per cent CO_2 the loss due to incomplete combustion will offset the saving effected by reducing the excess air. This opinion is based upon certain types of installation only, and should not be accepted and disseminated as a general condition. Some few up-to-date plants are averaging 17 per cent CO_2 with bituminous coal, without serious losses due to incomplete combustion. The author himself obtained an analysis giving CO_2, 17.2 per cent; O, 1 per cent; CO, 0.1 per cent, which appears remarkable with bituminous coal, but is easily possible if the furnace construction is right. Hence it is ridiculous to use 200 per cent excess air as is often done; also 50 per cent is more than is needed, and with proper furnace design not more than 10 per cent excess air is required.

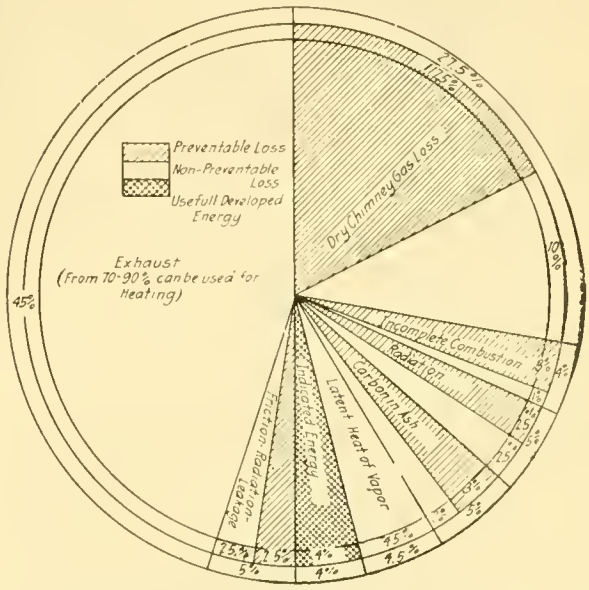

Fig. 1 Distribution of Heat Losses in the Average Power Plant Operating Non-Condensing

With low percentages of excess air, proper design of combustion space becomes much more important, to prevent incomplete combustion and too high furnace temperatures. Exceedingly high furnace temperatures have no real advantage and several disadvantages, therefore heating surface exposed directly to the fuel bed to reduce the furnace temperature will not only cause a decrease of the slagging effect upon the fire brick, and thus increase the CO_2 possible to maintain, but will also increase the efficiency of the boiler due to the heat radiated directly to it, and will increase the boiler capacity without increasing the flue-gas temperature.

Fig. 3 shows the flue-gas temperatures with different well-known installations at various boiler ratings. It shows that results obtained are very varied, and that some installations obtain the same final temperature at 300 per cent of rating as others at 100 per cent. In one case at 200 per cent of rating, the temperature of the escaping gases was 285 deg. higher than in another, and this in spite of the fact that in both cases the amount of air used to generate 10,000 B.t.u. was the same. The seriousness of this will be realized from the fact that this condition causes a loss of about 11 per cent in fuel consumption to the high-temperature plant. This is at 100 per cent overload; at higher ratings this difference will increase as indicated by the curves.

Boilers can be operated at two times the rating, and more, but not economically unless designed for it; with the rates of heat absorption obtained at present in most installations, if operated at very high ratings the loss will be too great, unless the temperature of the escaping gases be reduced in economizers. The increase of velocity will cause draft loss, but this is not so serious, for the necessity of installing mechanical draft brings about advantages.

The author has found reduction of flue-gas temperature possible in most boiler installations by reducing excess air, increasing velocity, eliminating dead-gas spaces, re-baffling or installing auxiliary baffles, exposing some of the heating surface to direct radiation from the fuel bed, and last, but not least, maintaining clean heating surfaces by blowing with steam at regular intervals and scraping the heating surfaces when the boiler is down for cleaning.

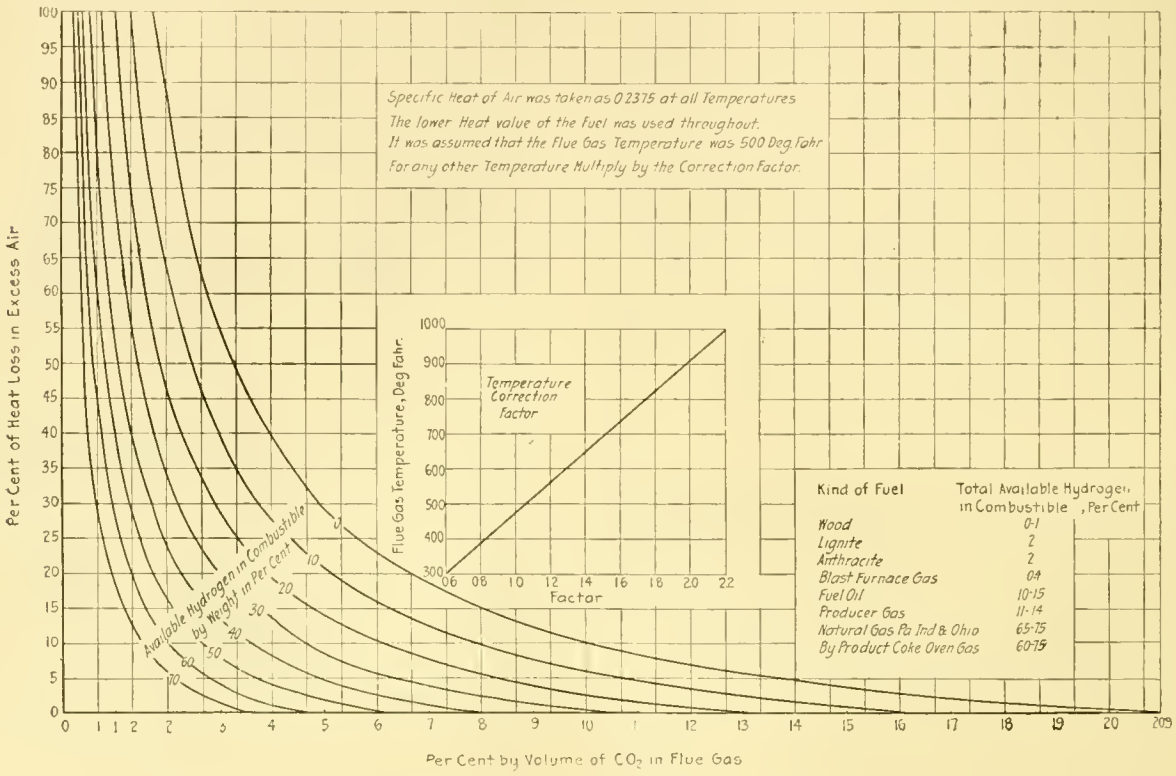

FIG. 2 HEAT LOSS FROM EXCESS AIR WITH FUELS OF DIFFERENT HYDROGEN CONTENT

ADVANTAGES OF ECONOMIZERS

Boiler-plant efficiency can be considerably increased by adding economizers. The objections ordinarily offered are:

a Their initial cost
b Reduction of available draft and, in many plants, necessity of installing mechanical-draft systems
c Cheap fuel (speaking comparatively)
d Low load factors
e Complication of the power-plant outlay.

The chief reason that they are not used more generally is that their value is not realized. They are particularly needed in plants having variable loads. Much depends upon properly proportioning the installation and, therefore, before an economizer is decided upon, a plant must be closely studied and the governing factors, such as flue-gas temperature, feed-water temperature, weight of air per pound of coal, load factor, character of load, etc., very closely predetermined.

Economizers do considerably reduce the draft, but often much of the total loss is the fault of the gas passages from the boiler to the economizer and from them to the stack. With natural draft, there will be additional reduction of available draft resulting from the reduction of the stack temperature. The loss of draft because of economizers is partly offset by the higher efficiency and therefore smaller amount of coal burned, and also by the ability to operate more economically the auxiliaries that previously exhausted into a feed-water heater, which, saving steam, will somewhat reduce the amount of coal burned and, consequently, also the draft required. Maintaining high CO_2 percentage, together with having tight breeching, clean-out doors and dampers on idle boilers, will tend to increase the available draft.

If the stack height is so low, or the boiler load so high, that all the above will not insure sufficient draft at all times, mechanical draft will have to be resorted to. This will in one way reduce the saving, due to added interest on investment, depreciation and operating charges with the power required, but all this can be offset by the greater boiler efficiency possible with thicker fuel beds and, consequently, higher CO_2, and greater rate of heat absorption attending higher velocity of the gas over the heating surface of the boiler and economizer.

Where the natural draft is too weak to warrant a fuel economizer, and conditions are such that mechanical draft cannot be considered, there is still a way to improve the working conditions. At least 40 per cent of the boiler heating surface is inefficient as a heat absorber because of the low temperature difference, and any increase in temperature difference will reduce the amount of heating surface required to cool the gases down to a given point.

The draft loss will not be any more with this installation than when no economizer was attached, but even less, which

can be taken advantage of by increasing the gas velocity over the added economizer heating surface. The installation could follow the European practice of building the economizer directly into the boiler setting, which would further reduce the draft and radiation losses. The economizers could also be of boiler steel since the temperature would never drop to a point where danger would exist from external corrosion, and to further prevent this, water entering should never be below 100 deg. fahr..

PROPER FEED WATER

Much heat is wasted by dirty boilers, and the cost of cleaning in most plants is considerable. Using distilled water as boiler feed should be advocated whenever possible. In other plants, more attention should be paid to treating the feed water. Properly treated feed water will not only improve the efficiency of a boiler as a heat absorber, reduce the cost of boiler cleaning and its repairs and increase its life, but will also greatly increase its safety.

City boiler inspection departments, with the aid of water departments, could be of great aid to the operating engineers in the particular cities, by keeping them informed as to what treatment the water requires to make it suitable for boiler feed. Much good could also be done by the boiler insurance companies, not only to the engineers and power-plant owners, but also to themselves, if they had chemists to inspect samples of feed water and advise proper treatment.

PREHEATED FURNACE AIR

Preheating of furnace air with the heat in the escaping flue gases would save considerable, but is never practiced. A saving of 5 per cent is easily possible and air preheaters to effect this saving could be constructed cheaply, but as they would be quite bulky they could be located outside of the boiler room. Most simply constructed they would consist of a long sheet-iron compartment through which the air and flue gas would pass. The cost of installing would be low, except if an extensive building alteration were required, but mechanical draft would be necessary since there would be not only more friction of the flue gas and less stack draft because of lower temperature, but also more power required to force the air into the furnace. These heat abstractors could be easily cleaned by hand, or like economizers.

ECONOMICAL AUXILIARIES NEEDED

While in many power plants, especially the larger ones, considerable attention is paid to the main power-generating units, the auxiliaries are ordinarily neglected. Throttling steam engines and especially direct-acting double and single pumps are too generally used. Unless they exhaust into feed-water heaters or other heating appliances, they should not be used except in very small units, or only intermittently for short periods. Substituting motor-driven triplex plunger pumps, or motor- or turbine-driven centrifugal pumps would usually result in a substantial saving. Where duplex steam pumps are preferred and the plant operates condensing, in a small plant, the exhaust steam from the pumps could be discharged into the condenser of the main units, or in a large plant, a separate condenser could be installed especially for the auxiliaries, and the discharged circulating water from the main condensers, with the make-up water, could be used to condense the steam from the auxiliaries. Using exhaust steam from reciprocating steam pumps in the low-pressure stages of a steam turbine designed for this purpose is also quite a saving.

The use of high-pressure steam in manufacturing and heating should be discouraged; while sometimes its use is warranted, generally, the use of low-pressure steam will effect a saving if the pressure is reduced through small turbines, engines, or pumps, as, thus, the mechanical energy will be extracted between the high- and low-pressure limits, without materially reducing the heating qualities of the steam. Using large reducing valves to reduce steam pressures, while not a waste of heat, is a distinct waste of power.

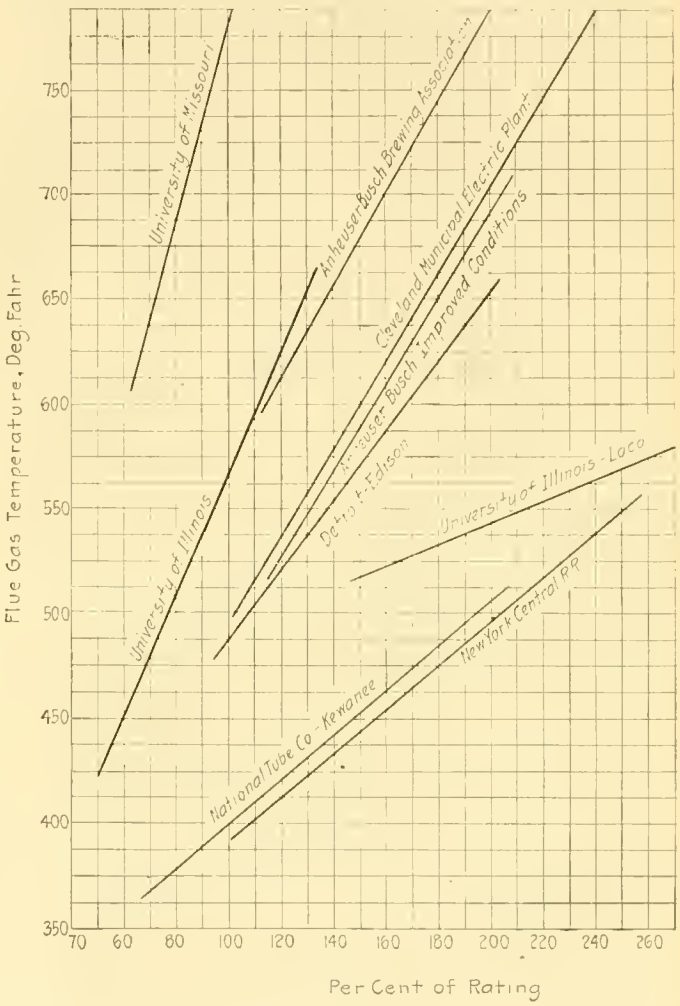

Fig. 3 Flue-Gas Temperatures at Various Boiler Ratings in Several Different Plants

UTILIZING EXHAUST STEAM

The value of exhaust steam for heating and the consequent saving effected has been demonstrated, and many plants take advantage of it, but the practice should be more general. Even plants operating condensing could bleed the low-pressure receiver of a compound engine, or the low-pressure stages of steam turbines and distribute this steam through the buildings. In power plants where economizers are not employed and the temperature of the water is low when fed into the boilers, this partly expanded steam could also be used to advantage in feed-water heaters.

EXTRAVAGANT REFRIGERATING PLANTS

About the most wasteful power plants are the ice-making and refrigerating plants; many make three or less tons of ice per ton of coal, a few about six tons, and only the very exceptional plants reach the ten-ton mark. All except the very small ones and those near coal mines, should be making ten

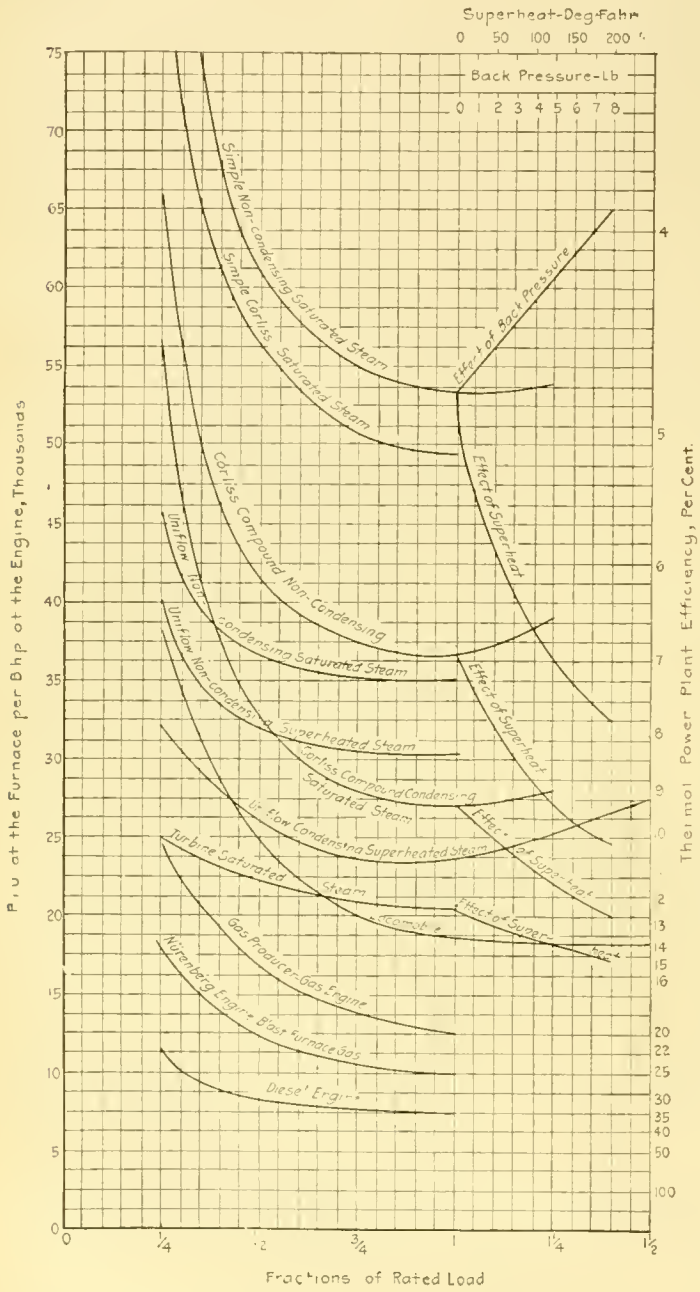

FIG. 4 RELATIVE EFFICIENCY AND HEAT CONSUMPTION OF VARIOUS POWER INSTALLATIONS

tons of ice per ton of coal burned, and in no case less than six tons.

One reason for the existing bad conditions is the low load factor. While during warm weather the equipment is forced far beyond its economical rating, in winter it stands idle. This low yearly load factor, which, in most plants, is between 20 and 40 per cent, is to a certain extent responsible for many plants not being more successful and profitable. Proper-size ice-storage houses reduce the necessary size of power plants, machinery, ice tanks, etc., and consequently also the fixed and operating charges.

Besides the variable load conditions, the following are factors responsible for uneconomic conditions:

a Inefficiency in the boiler houses, where often the coal is burned with from two to four times the air actually required

b The fact that distilled-water ice is made and uneconomical prime movers and auxiliary machinery operated so that sufficient exhaust steam for distilled water will be obtained. This type of plant also condenses the exhaust steam in atmospheric condensers, with the result that the engines operate against a back pressure instead of under a vacuum

c Lack of thorough understanding on the part of many operators of the physical laws governing the compression of gases, refrigeration is often obtained with from 20 to 40 per cent more power than actually required. Many operators insist that ammonia compressors operate best with low back pressures, while exactly the opposite is true.

To be able to operate with high back pressures, ice tanks, brine tanks, and coolers should be designed and piped so that proper temperatures will be maintained without too great a temperature difference between the air (or brine) and the evaporating ammonia. Where two (one high and one low) temperatures must be maintained, the power required per ton of refrigeration will be greatly reduced by installing high- and low-pressure suction lines connecting with a multiple-effect compressor attachment, thus enabling the compressor to operate with very nearly the efficiency obtained with the higher back pressure.

Raw-water ice systems have been so perfected that ice can be made from raw water that is wholly equal to distilled-water ice. Where the water is very bad, it can be purified or a multiple-effect distilled-water system used, avoiding any occasion to employ uneconomical steam machinery to get the required quantity of ice water.

The compression system of ice making with simple non-condensing Corliss engines and its production of six tons of ice for every ton of 12,000 B.t.u. coal burned under its best conditions, high load factor and excellent operation, could be improved upon by various other combinations, as follows:

	Tons of ice per ton of coal
Compression simple Corliss, non-condensing.....	6
Compression compound Corliss, non-condensing....	7
Compression simple Corliss exhausting into generator of absorption machine.....	8.5
Compression compound Corliss, condensing.....	9.5
Compression compound Corliss exhausting into generator of absorption machine.....	11.0

These estimates are for well-operated ice plants and the production could be further increased by adding special devices and by special arrangements, economizers, multiple-effect compressor attachments, flooded and jet ammonia condensers, vertical small-clearance compressors, heat exchangers, flooded systems, etc., also by using uniflow engines supplied with highly superheated steam. In some refrigerating plants Diesel and semi-Diesel engines are used to drive ammonia compressors with great success.

By operating ammonia compressors properly, that is, with a high discharge temperature and leading the gas through a

feed-water preheater, considerable heat could be saved and thus allow, if economizers are not used, employing more efficient auxiliaries or discharging their steam into the generator of the absorption machine. Condenser efficiency is also very important in ice- and refrigerating-plant operation and it is regrettable with what persistence the low-efficiency straight pipe condensers are used, while there are excellent types of flooded, jet condensers and others on the market.

Many large plants are operated non-condensing and while the exhaust steam, in winter, is used for heating, in summer, a large part of it is ordinarily wasted. It would pay some one to buy this steam and use it in an absorption ice machine. Another good combination would be an exhaust-steam absorption ice plant and electric-light plant, with the resulting high efficiency of the two combined.

Opportunities for economy in ice plants are great, not only by better equipment and arrangement, but also by better operation, for many plants are ridiculously inefficient. While operating engineers are coming to realize the importance of frequently indicating the steam engine, they are slow in becoming impressed with the importance of indicating the ammonia compressor.

ECONOMICAL PRIME MOVERS

The uniflow engine is important to the economical operation of the smaller power plants, and the locomobile also deserves honorable mention. Exhaust-steam turbines operating under proper conditions have demonstrated their benefits and should be used more generally. Superheated steam also should be taken advantage of more than it is. In very many plants substantial savings could be made by installing superheaters.

Producer-gas plants, gas engines, and Diesel engines should find a much greater application. With proper care, gas and oil engines today are entirely dependable and much more efficient than steam engines. The advisability of their use depends upon the price of the fuel, but, in any event, the burning of oil and gas under boilers should be discouraged, since they are much more economically used in gas and heavy oil engines.

The gas producer's chief economic advantage is that it can use low-grade fuels unsuitable under steam boilers. The quantities of fuel wasted at the mines could be used in gas producers supplying gas engines driving electric generators and the current distributed for sale. The economical power plant is necessarily more complicated and very often objections offered to producer-gas plants and gas and oil engines are that they require better operating men. This is so and, therefore, we must begin to develop men thoroughly fitted to operate the up-to-date power plant. One-sided development such as inventing more efficient machinery should be balanced by educating the men to properly handle it.

RELATIVE EFFICIENCY AND HEAT CONSUMPTION OF VARIOUS POWER INSTALLATIONS

Fig. 4 shows the relative value of various power installations from a thermal standpoint. Effort was made to have the given values, as far as possible, represent the average conditions.

All sizes of prime mover varied from 300 to 400 b.h.p. except the simple non-condensing engine and the locomobile which were 150 b.h.p., the turbine, 4,000 kw. and the Nürnberg gas engine, 1,200 b.h.p. Boiler efficiency in each case was assumed to be 70 per cent, an allowance of 3 per cent was made for the boiler-feed pump, and 2 per cent for leakage and condensation. For the condensing engines the auxiliary steam consumption was assumed to be 5 per cent of the total steam consumption. The temperature of the feed water entering the boiler was assumed to be 200 deg. fahr. to which point it was heated by either exhaust steam or an economizer.

For the uniflow engine when operating non-condensing with superheated steam, the superheat was 120 deg. fahr. and when operating condensing, 100 deg. fahr. with 25½ in. of vacuum. The turbine tests represent a 4,000-kw. horizontal turbine operating under 28 in. of vacuum, 175 lb. steam pressure and saturated steam. The effect of superheat is shown by the extension of the curve at full load.

The locomobile curve represents tests made on a 150-b.h.p. locomobile with a varying high-pressure superheat of 80 deg. at one-fourth load to 235 deg. at one and one-fourth load, and ordinary intermediate superheat. Since the chart was drawn upon the assumption that the boiler and grate efficiency is 70 per cent, for any other efficiency the value will be.

$$\frac{\text{B.t.u.} \times 0.70}{\text{Boiler Efficiency}} = \text{Actual B.t.u.}$$

OPERATION AND MANAGEMENT

To obtain the greatest efficiency possible in a power plant is not only a matter of design, but a good deal a matter of proper operation and management. Most power plants could make large savings in this way and there are exceptionally few where some improvements could be made without spending a dollar for new equipment. To obtain full benefit from the equipment on hand, the men operating it must be made more efficient and this can be done by:

a Education
b Strict supervision
c Pay according to merits (Bonus systems)
d Competition and advancement
e Welfare

Education, while the most important, is also the most neglected factor in economic operation of a power plant. This is especially true in the boiler room where the waste is greatest. Skilled labor should be employed. Every boiler room should have a man with authority to give orders and with sufficient personality to have his orders respected.. This man should predetermine, by the proper use of various instruments, the most economical ways of burning coal and instruct the firemen as to the best methods, and then insist that these methods be carried out.

License laws and examinations would conduce to better education of operating engineers but in 60 per cent of the United States, by population, there is no license law, and the other 40 per cent consider only ability to operate a plant safely—seldom economic operating ability. License laws should be more stringent, examinations more complete, licenses graded and issued for intended plants. Since fuel-loss prevention is a national problem, efforts should be made to obtain a Government standard license law all over the United States, and members of examining boards should be civil-service employees of the United States Government, thus eliminating politics.

Opportunity should be offered to men, intending to become operating engineers, to acquire the necessary knowledge. While the practical part can be learned in the power plant

directly, the fundamentals of theory which are all important to the up-to-date operating engineer are difficult to obtain properly. Coöperation of educational institutions is needed by the forming of classes at the various universities and other schools to give courses on economic operation of power plants. Instruction should be given by correspondence to those unable to attend in person. Washington University of St. Louis has made the initial step in this direction by starting two night courses especially adapted to the operating engineer.

The effect that proper training of operating men would have on general power-plant conditions and economy cannot be estimated, but it would be of immense value to the owner, mechanical engineer, and also to the men themselves; in fact to the whole community.

SMOKE PREVENTION

There has been considerable agitation against smoke emission and in all important cities, smoke prevention departments have been formed and laws made against smoke emission. The objections to smoke, as stated, are "public nuisance" and "fuel loss." The methods employed by smoke departments are effective in preventing the first, but the value of some of them as to the second is very doubtful. It is well known that the chief loss in a boiler plant is due to excess air (low CO_2) and not due to incomplete combustion, of which the result might be smoke.

To prevent smoke effectively, it is necessary to center attention on the quantity of air used to burn the coal, and keeping it down to a minimum, proper furnace temperature and possibilities for well mixing the combustible gases and the air. At present (with exceptions) most attention is paid to smoke and smoke alone, without paying the attention to excess air loss that it deserves. As a result many plants are wasting more fuel since operating smokelessly than before, because of using more excess air

Smoke prevention departments could greatly aid in preventing national fuel waste and some of them are doing so, but where they are not, it can be laid to:

a Political influence and interference

b Lack of funds to employ expert inspectors

c Employment of methods having no scientific basis, and lack of effort to educate the engineer and firemen, while at the same time more force is employed than is good for the cause

d Lack of confidence on the part of the power plant owner because of all of the above.

Exceedingly few firemen, not even 3 per cent, know the simplest rudiments of combustion Many who are considered good firemen persist in operating their furnaces so that at least 20 per cent of the fuel is wasted; at the same time claiming that it is the better and proper way. To overcome such conditions they must be educated.

It would be a great help if more of the simplest literature could be obtained, describing the economical process of firing, and this written in an interesting way. It is not meant that there is no such literature, for an immense amount of good has been done by Power, Practical Engineer, and other journals of this character, but the man who needs it most does not get it, and it would pay to bring it to him.

The U. S. Bureau of Mines would increase its usefulness by including in its excellent editions on fuel technology from time to time, bulletins of a thoroughly practical nature especially adapted to the average boiler room man. These bulletins should be written by men who know the fireman and who have been through the mill themselves. After such bulletins are ready they should not be kept until those who need them write for them, but they should be given a forced circulation with the aid of boiler insurance companies, smoke inspection departments, business men's leagues, etc.

CARE FOR THE HUMAN ELEMENT

In larger power plants, reading rooms for men waiting for the change in their shift, with some good literature, will cause the men to come, instead of ten minutes before work time, an hour or more. Also good engineering literature should be kept on file for employees to take home. Meetings should be arranged between employees and foremen at regular intervals for discussion and instruction upon the special problems coming up, new work, and better and more efficient operation. Lectures upon different subjects pertaining to efficient power plant operation should be given, and the men kept in close touch with not only the outside, but also the inside details of their work. As a result they will be more interested in their work, eager for learning and, in general, better men by whom the power plant will be operated much more economically.

In smaller plants, typewritten instructions and discussions should be edited at regular intervals and given to the men to be studied.

The proper amount of work and the most economical way of getting the results for each man should be predetermined. He should then be given his instructions, and it should be seen that he carries them out. Absolute strictness and discipline should be maintained and, at the same time, if the men do the proper amount of work, in the proper way, they should receive the right compensation for it. Good men will seldom work for low wages.

A good power-plant manager should have the welfare of his employees at heart, yet usually not even proper washing facilities are provided and the men are allowed to live under unhealthy conditions, with the result that they are not vigorous enough to give efficient service. Proper treatment of the men and just compensation for the service rendered by them is of much greater importance than is ordinarily realized. Labor troubles are usually caused by the employers themselves, through their blindness to the fact that workingmen must be treated as human beings.

Competition is the best stimulus to the attainment of more and better work, and, therefore, should be developed wherever possible. One power plant should be compared with another. The engineers of each should be put in competition with one another whenever possible, and so also the firemen, by posting their fuel loss, obtained from average CO_2 readings, upon a blackboard in the boiler room. When practical, a bonus system should be provided and men given some compensation for the extra efforts made.

Coöperation among power-plant owners and the formation of supervising engineering staffs, to take care of a number of plants would be of great value, as in this way they all would obtain expert supervision, that each alone, ordinarily, could not afford.

Replacement of small uneconomical power plants by large efficient central stations will also promote conservation of the nation's coal supply.

It was the author's aim to outline in this paper the existing weak points and expose the wasteful conditions, whose prevention is not only our duty, but also for our immediate benefit. A nation-wide educational campaign should be started and persistently carried out until results are obtained.

VALUATION PAPERS

THE Valuation Session of the Annual Meeting will be devoted to a discussion of engineers' ideas of principles and methods in the valuation of industrial properties. The Committee on Meetings hopes that the information brought out will form a valuable supplement to the large amount of material already available on the subject of economic theories of values and their application to public utilities.

THE RELATION BETWEEN PERPETUAL-INVENTORY VALUE AND APPRAISAL VALUE

By CHARLES PIEZ, CHICAGO, ILL.

Member of the Society

MOST plants grow from small beginnings, and during their early life expand as the needs dictate. The organization is necessarily small because the most rigid economy must be practiced, and original costs and the costs of additions are frequently so completely submerged in the total assets that no safe records of these costs can be established. Many plants never outgrow this lump-sum treatment of assets. In these cases depreciation of plant and equipment is either wholly disregarded, or else an arbitrary amount is charged against profits, the amount of depreciation varying inversely as the size of the profit it is desired to show.

Industries so managed need the assistance of a competent appraisal company to inform them of the value of their assets, as a basis for embarking on a sounder and safer system of accounting methods. Practically all successful industries so maintain their inventories that additions to the plant are accurately recorded, and depreciation is based on judgment and experience. But even such industries will find it to their advantage to ask the aid of appraisal companies for the purpose of determining authoritative records of the cost of reproducing plant and equipment, so that underinsurance or overinsurance may be avoided, and the basis for the requirements of co-insurance complied with.

Appraisals are also valuable in establishing comparative values of plants that are about to merge, or in serving as a basis of a scheme of financing. But the claims that an appraisal is necessary for figuring overhead costs and the selling price and profit of manufactured articles are, to say the least, sadly overdrawn.

It has been my experience that in well-managed industries appraisal values are usually considerably above sound inventory values established by the management. With the steady advance in prices that has been going on almost continually for the last twenty-five years, it is but reasonable to suppose that replacement values are substantially higher than initial costs, and it is well to establish the amount of such excess if a proper insurance coverage be desired; but such advance is wholly speculative and has absolutely no bearing on the value of the plant from the standpoint of the operating and sales management.

The establishment of true costs is an essential element in the success of a business, and true costs can only be obtained when every item of expense is included. Buildings that were adequate when first erected gradually outgrow their initial advantages, and in spite of substantial increases shown in the appraisal value, they have less value for the purposes to which they are put than they had when first constructed. They may, in fact, prove so unsuitable to the increasing needs of the business as to justify demolition and reconstruction.

Few owners foresee their needs for ten years to come, and fewer still have the means to build or expand along lines giving ample opportunity for future business growth. It is safer, therefore, to provide proper sinking funds through an ample rate of depreciation for use in reconstructing buildings that have outlived their usefulness.

Machine tools have changed very considerably as a result of the development of high-speed steels, and companies that followed appraisal methods of depreciation find themselves with obsolete equipment and no funds to replace it with modern equipment.

Patterns and small-tool equipment often have but temporary value and should disappear wholly from the inventory when they have served their purpose, yet these two items are fertile sources for inflation of values through appraisals.

What the management of an industry is chiefly concerned in is to provide a fund through a proper scale of depreciation which will reimburse it for the difference between the cost price of a piece of equipment and its fair cash selling price when sold either because it is ready for the scrap heap or because some newer form or method has made a change desirable. This difference is properly a part of the cost of the product, but becomes so only by charging depreciation against the expenses of operation.

Has any appraisal company ever investigated the subject of depreciation from the operating standpoint and recommended a schedule of depreciation for adoption? Has any appraisal company ever advocated that depreciation be distributed as an operating expense against the product? Can any appraisal company claim with any justice that it can determine proper rates of depreciation without close contact with and full knowledge of the operating conditions and operating needs of an industry? Certainly without such contact and without such knowledge the claim that successive appraisals are essential factors in the determination of costs, prices and profits, is, to say the least, pure huncombe. The primary business of an appraisal company is to determine an authoritative replacement value, and its entire organization is trained for this purpose. But when the appraisers enter the field of depreciation, operating values, and costs, they are doing their clients positive harm; for appraisals, as previously explained, have a distinct upward tendency, and the increase in value which they show as the result of wholly extraneous conditions have the effect of lulling the manufacturer into a wrong sense of financial security.

The great majority of industries charge off too little for depreciation rather than too much, and the appraisal companies, if anything, are assisting, unconsciously, of course, in increasing this unprofitable and ofttimes disastrous habit.

I had occasion recently to go over the financial statements of a manufacturing plant which had delegated the important function of depreciation to an appraisal company. The amount charged off annually was less than one-half of the proper amount, this being due, the owner said, to the constant and considerable advance in the replacement value of the

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

STANDARD DEPRECIATION RATES ADOPTED BY MANUFACTURERS' COST CONFERENCE, FEB. 25, 1916.

	Per Cent on Cost.	Per Cent on Reducing Balance.
BUILDINGS AND ACCESSORIES:		
Reinforced concrete or steel and tile	2	3
Brick and steel with non-combustible roof and concrete floors	2.5	4
Brick, steel and wood	3	5
Brick and wood	3	5
Steel frame, wooden roof and corrugated iron walls	3.5	7
Steel frame, non-combustible roof and corrugated iron walls	3	6
Concrete block, with wooden roofs and floors	3.5	8
All wood structures, well built (20 years)	4.5	10
All wood structures, cheap (20 years)	5	12
Sprinkler system (20 years)	4	7.5
Heating and ventilating system (20 years)	4	7.5
Water and sewer piping and sanitary fixtures (where separate)	4	7.5
Tanks and reservoirs, steel	4.5	10
Tanks and reservoirs, wood (10 years)	9	20
NOTE: All Repairs and Maintenance to be charged to Account 8059.		
MACHINERY AND LARGE EQUIPMENT:		
Boilers, pumps, feed-water heaters and air compressors	6	15
Power piping	6	15
Switchboards, main wiring and conduit	6	15
Engines and dynamos	5	10
Machinery, motors, machine tools, traveling cranes, etc.	4.5	10
Punch presses, bending rolls, power shears and drop hammers	4.5	10
Shafting, pulleys, hangers and belting	50	..
Machine tool accessories—Boring bars, drivers, key-seating broaches, etc.	50	..
(All renewals to Repairs).		
Cupolas, converters, melting furnaces and accessories	5	10
Annealing and heating furnaces, ovens, forges, etc.	5	10
Motor trucks	20	60
Storage-battery locomotives (battery renewals to Repairs)	10	30
Horses and wagons	12	35
SMALL TOOLS:		
For machines, net additions	50	..
Hand tools, net additions	50	..
PUNCHES, AND DIES:		
(Standard) net additions	50	..
CHILLS, IRON AND STEEL FLASKS AND ACCESSORIES:		
Net additions	50	..
FIXTURES, FURNITURE AND MISCELLANEOUS EQUIPMENT:		
1 Steel shelving, lockers, etc.	5	12
2 Mechanical appliances, net additions	60	..
3 Departmental wiring and electric fixtures, net additions	60	..
4 Miscellaneous items (wood), net additions	70	..
PATTERNS (Standard):		
Metal, net additions	75	..
Wood, net additions	100	..
All patterns required for a particular order or contract to be charged to the job.		
DRAWINGS:		
All new standard drawings to be charged to expense.		
All drawings required for a particular order or contract to be charged to the job.		
MISCELLANEOUS REAL ESTATE IMPROVEMENTS:		
Pavements, sidewalks, fences, retaining walls, roadways, tracks, yard drainage, general conduits, tunnels, vaults, etc.	4.5	10

property. Here was a typical case of reducing the operating burden of a plant by crediting it with a wholly speculative and unrealizable increase in property value. In this case the appraisal company specified the amount to be depreciated each year, and was therefore responsible for this wholly unsound and unscientific procedure. The owner is about to build a new plant, and I take no chances in prophesying that he has some bitter disappointments awaiting him in unforeseen shrinkages of assets when he abandons the old plant.

The problem of determining an adequate scale of depreciation is by no means a simple one, and it goes hand in hand with the problem of distributing depreciation against the cost of the product. It is astonishing to find how widely the practice among different manufacturers in the same line varies.

Largely as a result of the recommendations made by the Federal Trade Commission that the cost-accounting systems of various lines of industry be standardized, the manufacturers of conveyors and elevators have agreed on the standard schedule of rates of depreciation given herewith. The rates are but compromises growing out of the judgment and experience of the individual members of the manufacturers' conference, but their correctness can later be verified by matching the perpetual-inventory values which these rates will establish, against the actual experience of loss in cash value when equipment or buildings are discarded.

They establish, therefore, a broad basis upon which fair operating values and the shrinkage in these values, due to wear and tear and change in style, can be computed, and serve as the preliminary step to the equitable distribution of these shrinkages or depreciation in value over the cost of the product.

I recognize the value of the work done by the appraisal companies in establishing authoritative replacement values for purposes of insurance, for the purpose of comparing the physical values of various plants about to be purchased or merged, or as the foundation upon which a perpetual inventory kept by the industry itself can be based; but I am convinced that only a perpetual inventory providing for a sound schedule of depreciation, and intelligently handled by the management of the industry, is of value in determining the true cost of the product.

VALUATION OF INDUSTRIAL PROPERTIES *VS.* VALUATION OF INDUSTRIAL METHODS

BY WALTER N. POLAKOV, NEW YORK, N. Y.

Member of the Society

THE question of determining the value of the physical properties of our industrial establishments and public utilities has been recently brought to public attention. The purpose was primarily to justify the increased cost of commodity rates and transportation as gravely influenced by heavy investments in the machinery of production. Discussing the subject at the conference on valuation held in Philadelphia in November, 1915, the writer said: "The loss to the companies from the undervaluation of their property is insignificant in comparison to the actual losses due to the lack of proper operating methods. The subject of correct methods of appraising a property is completely overshadowed by the importance of determining the proper methods of using this property . . . What is needed most is the correct valuation of operating and managerial methods in vogue, and overestimating the importance of property valuation is like trying to trace old sins instead of preventing the committing of new ones."

It is a fact that the fixed portion of the capital invested in real estate and equipment has materially increased since the tractor replaced the ox plow; modern factory equipment has taken the place of artisans' tools and transportation is done

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by rail and automobiles instead of horses. The correspondingly increased financial burden has created a new problem; how to absorb the expense of wear and tear, obligations to money lenders, etc., increased by adopting expensive machinery of production as a result of engineering progress.

The solution offered by financiers and accountants of the old school was to include in the manufacturing cost all the fixed charges of a plant and all the financial obligations of a company, irrespective of whether these investments or expenses contributed anything to the value of the commodity or in any way benefited the production. If the instruments of production were completely used up in the process this theory would be correct. However, in a typical case, the value of the instruments of production passes only partly into the cost of commodities as they are produced. Apparently the self-evident fact that the equipment not used in production cannot pass any part of its value into the product was usually obscured by a consideration that it loses value during idleness and meanwhile accumulates such charges as rent, interest, insurance, etc.

The absurdity of including these expenses of idleness in the cost of an article, already bearing its share of fixed charges, was so clearly exposed at the Buffalo meeting of this society by H. L. Gantt, that any further argument seems superfluous. *Present practice manifestly tends to charge against the cost of a product the cost of over-equipment and mismanagement, thus imposing on society the penalty for tolerating these conditions in the industries.*

The paradox that adopting improved machinery devised by designers reduces the rate of profit of the enterprise, can be explained either by the fact that the improvement is merely illusory or that an improper use is made of the improvements. No careful manager would approve a replacement or new installation of equipment unless study proved beyond any doubt that the advantages offered by such a change are ample to more than pay for the investment. When the cost of production increases after an investment is made it indicates plainly either that it was poor judgment to make the change or that the method of management does not offer the opportunity to secure the advantages inherent in the new improvement.

Nevertheless, the tendency of the average rate of profit to fall is but an expression of progressive development of the productive powers of society. Automatization, growing speed and capacity of machinery cause the same number of laborers in the same time to convert a larger quantity of raw and auxiliary materials into product. In other words, the fall of the rate of profit is not due to an absolute, but only to a relative, increase of the capital invested in means of production over its part invested in labor. This law, though seldom recognized, is actually followed in our industrial development. It requires an increasing mass of total capital for the purpose of using the same quantity of labor to secure the same mass of profit, though at a falling rate of profit. If the mass of profit is to be increased through the introduction of improved machinery (i.e., with corresponding increase of investment) without curtailing the wages or lengthening the working day, the intensity of labor must be increased.

In other words, to keep pace with industrial progress in order to meet the requirements and competition, improved instruments of production must be adopted. Increase of investment is followed necessarily by reduction of the rate of profit, and in order to secure the same or larger earnings the manufacturer must expand the production, ergo—increase the investments. This is the process we actually observe in our industrial development. No amount of pains given to the subject of proper appraisal of physical property can alter the tendency for the rate of profit to fall. Salvation is sought therefore through raising the commercial profits by increasing the selling prices. This method, although temporarily expedient, overtaxes eventually the purchasing capacity of consumers and creates a so-called business depression.

At the outbreak of this war, our country was rushing headlong into a period of industrial depression caused by surplus production that could not be consumed in the United States on account of the small purchasing capacity of the people, and could not be exported because poor shop methods prevented us from producing as cheaply as other countries. The undeveloped stage of our credit system contributed a further obstacle to the development of export. There was no incentive for us to plunge into the war since there were no foreign markets to fight for, neither could anything be gained by a territorial expansion. A crisis seemed imminent, but the loading up of our industries with European orders postponed it.

The misuse of or failure to use the expensive machinery of production is not a sufficient reason to either advance prices or to lower wages, as both undermine our future. Neither is it necessary. A manufacturer adopting superior methods of planning and managing his business, working with improved methods of production that have not yet become general, can sell below the market price, but above his individual cost of production. In this way his rate of profit rises until competition levels it down. During this period the second requisite comes into play—the expansion of the invested capital, facilitated by the previous period of accumulation. According to the degree of his expansion he will be enabled to employ all of his workmen or more; in other words, he will be enabled to produce the same or a greater mass of profits. As long as industrial development along these lines is still possible, and this possibility is accentuated not only by European experience but by our numerous experiments and successful demonstrations of the adaptation of scientific principles to the management of various industries, the revision of our methods is a paramount problem. Therefore the problem of determining the real value of our industrial and managerial methods, if properly solved, offers the opportunity of rectifying the errors of the past.

The appraisal of industrial property when accurately made discloses the fact otherwise overlooked that, as a rule, there are more means of production than are made use of, and the idle capital investments represent also idle labor. *The revenue-producing factor in our mode of production is not the investment but the method of its use. It is the business* of financiers to invest money in industries and they want to know what this investment is and what return they are getting. Ultimately the question they will ask is, *What is the value of the methods and what do they lead to?*

This statement does not imply a suggestion to appraise property according to the capitalization of the earnings. The use-value of the plant has nothing to do with its cost-value and is in the highest degree unfit for the purpose, as it varies with personnel, policy and methods. Evolution in our industrial relations will eventually reverse the present situation and all charges for unprofitable investments and non-productive forces will not be borne by the consumers, who as yet have no power nor means to take an active part in the management of the industries. Unfit methods and incapable leaders are equally harmful to both investors and consumers, and their interests unite in demanding that methods of the highest value be developed.

MACHINE SHOP PAPERS

THE Machine Shop Session of the Annual Meeting will be devoted to the discussion of the two important papers printed below. The Sub-Committee on Machine Shop Practice which will have charge of this session has been exceedingly fortunate in securing the ideas of Mr. Carl G. Barth on Machine Tool Standardization. Mr. Hathaway's paper represents the results of his experiences on this sub-committee.

STANDARDIZATION OF MACHINE TOOLS

SOME SUGGESTIONS REGARDING STANDARDS OF SPEED AND FEED SERIES AND STANDARDIZED POWER OF MACHINE TOOLS, ETC.

By CARL G. BARTH, PHILADELPHIA, PA.

Member of the Society

THE object of this paper is to try to enlist the coöperation of the Society in encouraging machine-tool builders to adopt certain standards, for even only the approximate attainments of which the writer has had to spend a large sum of money in each of a number of machine shops in which he has found such standardization highly desirable, if not to say absolutely necessary, as one of the steps in the installation of

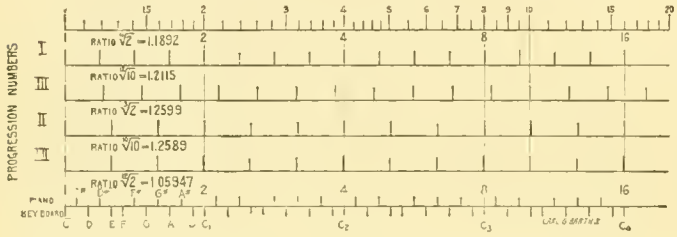

FIG. 1 LOGARITHMIC PLOT OF SUGGESTED ALTERNATIVE STANDARDS FOR SPEEDS AND FEEDS

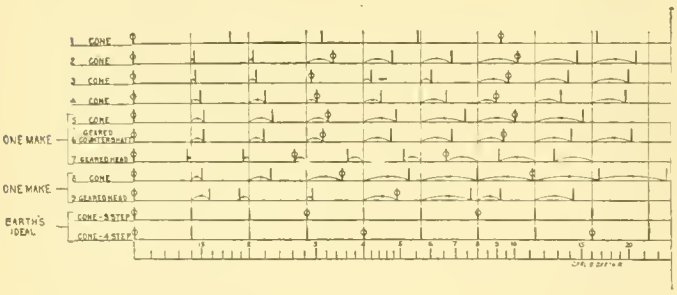

FIG. 2 LOGARITHMIC PLOT OF SINGLE COUNTERSHAFT SPEED SERIES OF NINE 16-IN. LATHES

a more or less complete Taylor System of Scientific Management as practised by him.

STANDARDIZATION OF MACHINE EQUIPMENT OF SHOP AS A WHOLE

During his many years of experience the writer has gradually been forced to see an enormous advantage in standardizing the machine equipment as a whole, aside from the standardization of the mathematical and certain constructive features of each machine. Wherever possible his effort is to have the very same make of machines only in a certain productive group, and in the expansion of such a group to add machines of exactly the same design, even to the extent of having a manufacturer furnish what is no longer his most recent product—only, however, if this or some other manufacturer's most recent product is not a sufficient improvement over the old to warrant the introduction of a new machine as a new standard for the work to be done, with the intention that this type will eventually crowd out and replace the older type.

STANDARD SPEED SERIES

As in the present state of the science and the art of cutting metals, it is, on the average, impossible to determine the most economical or suitable speed and feed at which to run a machine for any set of conditions closer than a certain percentage, it is by this time universally accepted by those who have a right to an opinion in the matter, that the available speeds of a machine should be in a geometrical progression.

This being agreed to, the writer's idea is that a universal speed series should be adopted by all machine-tool builders for all machines such as lathes, boring mills, milling machines, drill presses, etc. that are provided with a spindle for either the work or the cutting tool, and which, except in the case of certain single-purpose machines not included in this discussion, may be rotated at different speeds; for our present knowledge does not warrant us in asserting or assuming that a progression of speeds for one kind of these machines should have a lesser or a greater constant ratio than for any other kind; and, evidently, if there is no reason for making them different, there is every reason for making them just alike. The question then becomes, what should be the constant ratio of such a universal geometrical progression of speeds?

As far back as 1888 the writer designed for William Sellers & Company, Inc., of Philadelphia, a large lathe which had 30 speeds in a practically perfect geometrical progression, with a ratio of a little over 1.15, obtained by a correct relation between a 5-step cone, two back-gear reductions and two forward speeds of the countershaft. Again, in 1892, he designed another with 36 speeds which had a practically constant ratio of but little over 1.14, obtained by a 6-step cone, two back-gear reductions and two forward speeds of the countershaft.

These designs, only the latter of which was actually built, prove that this company was long ago able to appreciate the theoretical value of close speed regulation, though at that time the prevailing style of shop management, or, rather, lack of shop management, throughout the country was such that the knowledge was undoubtedly of no practical value to the generators even in the shops of this company. In fact, when the writer finally got some real ideas about such matters during his first two years of association and coöperation with Mr. Taylor at the works of the Bethlehem Steel Company, immediately after Mr. Taylor and Mr. White had made the discovery of the high heat treatment of tungsten steels, he realized that he had overreached himself in those two lathes. Therefore, in designing some special lathes for the Bethlehem Steel Company for the better utilization of high-speed tools, he

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adopted 1.2 as a more rational ideal, and he has never since found any reason for deviating materially from this ratio; though it was several years later before he recognized the desirability of an absolutely constant ratio, not only for all lathes, but, as referred to above, for all machine tools with a revolving spindle.

However, if we construct a geometric progression with this simple ratio 1.2 and beginning with 1, all subsequent terms of this will naturally be found to be anything but simple numbers, thus: 1 1.2 1.44 1.728 2.074 2.488 2.986 3.583 4.300 5.160 6.192 7.430 8.916 10.70 12.84 15.41 18.49 22.19 26.62 31.95 38.34 46.00 55.21 66.25 79.50 95.40 114.5 137.4 164.9 197.8, etc.

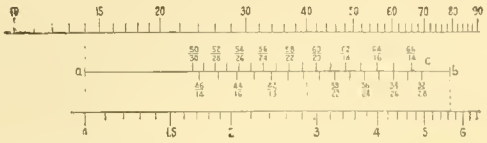


FIG. 3 LOGARITHMIC METHOD FOR GETTING CLOSEST APPROXIMATION TO A GIVEN RATIO WHEN TWO SETS OF GEARS ARE INVOLVED

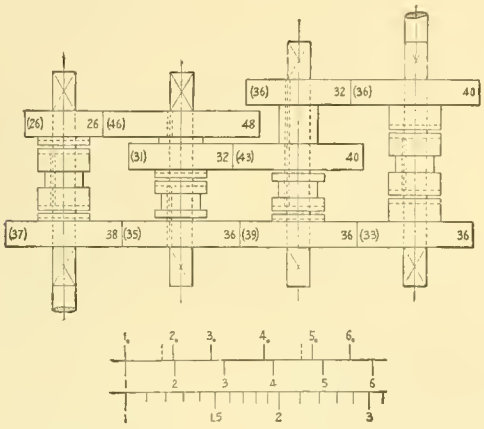


FIG. 4 DIAGRAM OF SPEED VARIATOR OF A WELL-KNOWN MAKE OF PLANER

(Figures in parentheses show number of teeth in gears as made; other figures show number of teeth to improve the speed series. 1_0 to 6_0 = logarithmic plot of original relative speeds; 1 to 6 = logarithmic plot of improved relative speeds.)

In reality, therefore, we will have a simpler progression by slightly modifying this ratio 1.2 such that the fifth term becomes 2 instead of $1.2^4 = 2.074$, for then the whole progression becomes

1	$2^{\frac{1}{4}}$	$2^{\frac{1}{2}}$	$2^{\frac{3}{4}}$	2	$2.2^{\frac{1}{4}}$	$2.2^{\frac{1}{2}}$	$2.2^{\frac{3}{4}}$,	4 etc.,
1	1.1892	1.4142	1.6818	2	2.3784	2.8284	3.3636	4 .....[I]

or with every fourth term a power of 2, the simplest of all numbers except unity itself.

This is, to the writer, an exceedingly attractive progression and represents his ideal for some six years past. For lack of a better term, he has named a series of speeds conforming to the above geometrical progression a *chromatic* speed series, though the term chromatic in connection with a musical scale has reference to the geometrical progression involved, rather than to the ratio 2 of the number of vibrations of two notes an octave apart.

It may be, however, that the majority of machine-tool builders will consider the ratio $\sqrt[4]{2} = 1.1892$ unnecessarily small, and would deem a somewhat larger ratio preferable, in order to obtain a larger final ratio between the slowest and the fastest speeds of a machine which, for one consideration or other, may have to be arranged with a rather limited total number of speeds, as, for instance, a lathe with a single back-gear reduction, or a small drill press or milling machine with no back-gear reduction at all.

The writer's answer is, that he has had in mind also as a possibly more generally acceptable progression, one with the constant ratio $\sqrt[3]{2} = 1.2599$; that is,

1	$2^{\frac{1}{3}}$	$2^{\frac{2}{3}}$	2	$2.2^{\frac{1}{3}}$	$2.2^{\frac{2}{3}}$	4	$4.2^{\frac{1}{3}}$	$4.2^{\frac{2}{3}}$, etc., or
1	1.2599	1.5874	2	2.5198	3.1748	4	5.0397	6.3496.....[II

which is as much entitled to the name chromatic as is progression [I].

Again, as a compromise between progressions [I] and [II], and to favor a possible preference for a progression with 10 rather than 2 as a periodically recurring ratio, the following progression may also be looked upon as a candidate:

1	$10^{\frac{1}{12}}$	$10^{\frac{2}{12}}$	$10^{\frac{3}{12}}$	$10^{\frac{4}{12}}$	$10^{\frac{5}{12}}$	$10^{\frac{6}{12}}$	$10^{\frac{7}{12}}$	$10^{\frac{8}{12}}$, etc., or
1	1.2115	1.468	1.778	2.154	2.610	3.162	3.831	4.642.....[III

The constant ratio of this progression $\sqrt[12]{10} = 1.2115$ is very close to the geometrical mean of the ratios of progressions [I] and [II], which is $\sqrt{2^{\frac{1}{4}} \cdot 2^{\frac{1}{3}}} = 2^{\frac{7}{24}} = 1.224$.

And, finally, a certain interesting simplicity would also be introduced by the adoption of the constant ratio $\sqrt[10]{10} = 1.2589$, thus:

1	$10^{\frac{1}{10}}$	$10^{\frac{2}{10}}$	$10^{\frac{3}{10}}$	$10^{\frac{4}{10}}$	$10^{\frac{5}{10}}$	$10^{\frac{6}{10}}$	$10^{\frac{7}{10}}$	$10^{\frac{8}{10}}$, etc.,
1	1.2589	1.5848	1.9953	2.5119	3.1623	3.981	5.012	6.310....[IV]

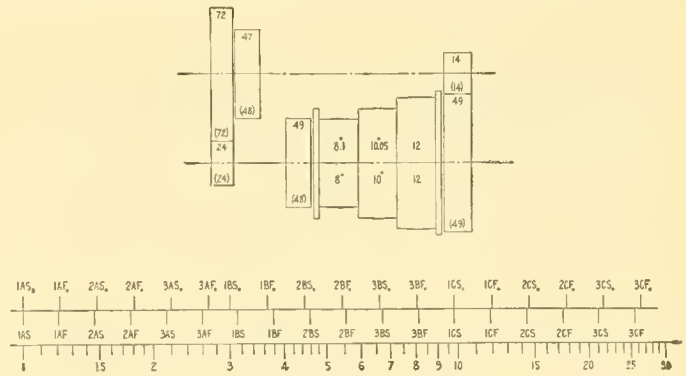


FIG. 5 DIAGRAM OF LIVE HEAD OF A WELL-KNOWN MAKE OF LATHE

(Figures in parentheses show respectively number of teeth in gears and diameters of cone pulleys as made; the other figures indicate a simple change that would further improve a very good speed series. 1 AS_0 to 3 CF_0 = logarithmic plot of original speeds; 1 AS to 3 CF = logarithmic plot of improved series.)

It will be noticed, however, that there is in reality a theoretical difference only between progression [II] and this progression, the tenth number (7.943) of this being less than 0.8 of one per cent smaller than the tenth number (8) of the former.

But the best comparison of these four progressions is made by plotting them on a logarithmic scale, as in Fig. 1, on which is also plotted the progression that represents the relations between the number of vibrations of the strings of a piano, the constant ratio of which progression is $\sqrt[12]{2} = 1.05947$.

Having thus indicated that there may be a choice of standards, the writer gives in the paper strong reasons for favoring progression [I], admitting at the same time that under

certain conditions every other term may be omitted, thus leaving the progression

1	$\sqrt{2}$	2	$2\sqrt{2}$	4	$4\sqrt{2}$	8	$8\sqrt{2}$	16, etc.,
1	1.4142	2	2.8284	4	5.6568	8	11.3137	16.....[V]

Progression [I] represents a fair average for the speed series provided by certain well-known machine-tool builders in some of the machines produced by them in recent years, after they had realized that the time had come for the provision of closer speed regulation, even if this meant a considerable reduction of the ratio of the fastest to the slowest speeds obtainable.

An example of this fact is represented in Fig. 2, which shows the speed ratio of nine 16-in. lathes offered by six different manufacturers in answer to an inquiry in February, 1914. One manufacturer offered three different designs and a second two different designs. It will be noted that the difference between the speed series provided in the different designs of the same maker, differ as much among themselves as do the designs of different makers, except in the case of lathe No. 1, which represents the least up-to-date design.

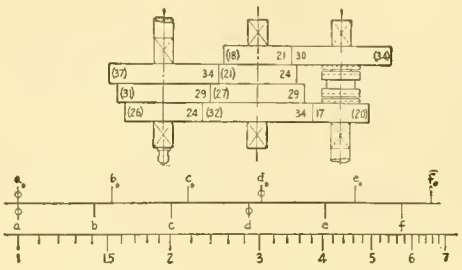
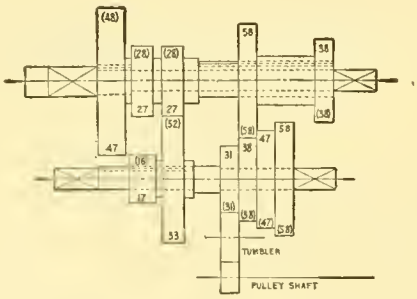


Fig. 6 Diagram of Gears in Feed Box of a Well-Known Make of Drill Press

(Figures in brackets show number of teeth as made; other figures show improved number of teeth.
a_0 to f_0 = logarithmic plot of original relative feeds;
a to f = logarithmic plot of improved relative feeds; these conform quite closely to Progression V, p. 969.)



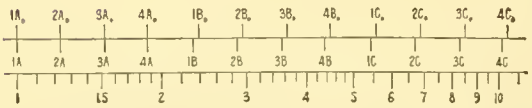


Fig. 7 Diagram of Driving Gear of a Well-Known Make of Milling Machine

(Figures in brackets show number of teeth in gears as made; other figures indicate number of teeth in gears to further improve an already excellent speed series.)

To make the diagram clearer, the speed ratios are laid out for a single forward countershaft speed only, thus showing only every other ratio of the full progression intended.

Most designers of the present day, whether mathematically inclined or not, are familiar with the use of the simple slide rule in selecting practical numbers of the teeth for a gear and pinion of a single set of gears to give a certain ratio as closely as possible, but a simple logarithmic scale method for getting the closest possible approximation to a given ratio when two sets of gears are involved, which the writer has used for some years past, is not generally known, if indeed at all known to anybody who has not worked with the writer in connection with these matters.

This method will be fully disclosed by a single illustration embodied in the diagram Fig. 3, and we will take for our example the ratio $4\sqrt{2} = 5.6568$, with the restriction that neither pinion is to have less than 14 teeth, and that the sum of the numbers of the teeth in the one set of gears is to be 80, and in the other 60.

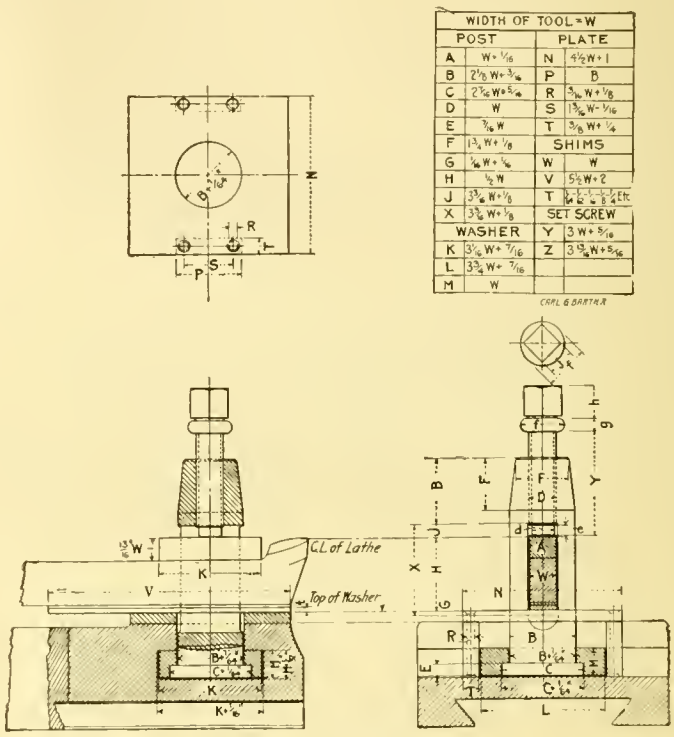


Fig. 8 Proportions Used by Author for Swivel Form of Tool Post for Moderate-Sized Lathes

By means of a logarithmic scale which is shown just below the significant part of the diagram, lay off the ratio 5.6568 from *a* to *b*. Now place the graduation point for 14 on the logarithmic scale, representing a pinion of 14 teeth, at *a*, and make a mark at the graduation point representing the gear that would be a mate to this pinion, namely one having 80 — 14 = 66 teeth. This operation is indicated by the logarithmic scale above the significant part of the diagram. The distance *ac* then represents the ratio 66/14. Similarly, 15 is placed at *a* and a mark made at 65, 16 is placed at *a* and a mark made at 64, and so on, as far as will eventually appear necessary. Next, below the line place the graduation point 14 at *b*, and mark off toward *a* the point for the mate for this pinion in the second set of gears, namely, 60 — 14 = 46, repeat for 15 and 45, 16 and 44, etc.

On completion of this repeated operation we at once discover that the closest coincidence between the marks on both sides of the line *ab* is for the two sets of gears 65/15 and

34/26, whose combined ratio is 5.6667, which is less than 0.2 of one per cent greater than 5.6568.

It will also be seen that the two combinations $\frac{59}{21} \times \frac{40}{20}$ and $\frac{58}{22} \times \frac{41}{19}$ come quite close to the required ratio.

Of course, special requirements may often complicate a problem of this kind in various ways, but the method described can always be used as a help in its solution. However, no further consideration will be given the matter here.

To further emphasize how even some fair attempts at regular progressions of speeds and feeds have fallen short of what might have been attained, Figs. 4, 5 and 6 are submitted as a few of numerous cases that have been investigated by the writer.

Fig. 7 also shows how even a quite excellent speed series may be further improved.

STANDARD FEED SERIES

What has been said above in discussing the adoption of a standard speed series, holds equally good about a standard feed series, except for the most up-to-date designs of lathes, in which the feeds for plain turning are obtained as a constant fraction of the screw-cutting feeds. For these latter it is suggested that both the cross feeds and the longitudinal feeds be made the same fraction of the screw-cutting feeds for all lathes regardless of size.

D	A	B	C	E
BOLT DIAM	$1\frac{1}{2}$ D	$\frac{5}{8}$D+$\frac{7}{64}$	$1\frac{3}{4}$D+$\frac{5}{32}$	$\frac{1}{2}$D+$\frac{1}{64}$
$\frac{3}{8}$	$\frac{9}{16}$	$\frac{11}{32}$	$\frac{13}{16}$	$\frac{1}{32}$
$\frac{7}{16}$	$\frac{21}{32}$	$\frac{25}{64}$	$\frac{59}{64}$	$\frac{1}{32}$
$\frac{1}{2}$	$\frac{3}{4}$	$\frac{27}{64}$	$1\frac{1}{32}$	$\frac{1}{32}$
$\frac{5}{8}$	$\frac{15}{16}$	$\frac{1}{2}$	$1\frac{1}{4}$	$\frac{1}{32}$
$\frac{3}{4}$	$1\frac{1}{8}$	$\frac{37}{64}$	$1\frac{15}{32}$	$\frac{1}{32}$
$\frac{7}{8}$	$1\frac{5}{16}$	$\frac{21}{32}$	$1\frac{11}{16}$	$\frac{3}{64}$
1	$1\frac{1}{2}$	$\frac{47}{64}$	$1\frac{29}{32}$	$\frac{3}{64}$
$1\frac{1}{8}$	$1\frac{11}{16}$	$\frac{13}{16}$	$2\frac{1}{8}$	$\frac{3}{64}$
$1\frac{1}{4}$	$1\frac{7}{8}$	$\frac{57}{64}$	$2\frac{11}{32}$	$\frac{3}{64}$
$1\frac{3}{8}$	$2\frac{1}{16}$	$\frac{31}{32}$	$2\frac{9}{16}$	$\frac{3}{64}$
$1\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{64}$	$2\frac{25}{32}$	$\frac{1}{16}$

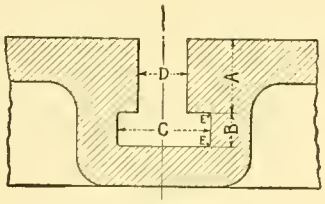


Fig. 9 Author's Proportions for T-Slots

TOOL POSTS FOR LATHES

In Fig. 8 are shown proportions for the swivel form of the tool post for moderate-sized lathes which the writer has used as a standard for several years past. The most essential part of this, as regards size, is the width of the slot, which is for a tool body of approximately 1/30 of the swing of the lathe over the bed, and a distance from the center of the lathe to the tool-supporting plate that corresponds to the ground height of the roughing tools shown in On the Art of Cutting Metals. The propriety of these propositions is decidedly open to discussion, particularly the latter.

T-SLOTS

An exceedingly important part of the machine equipment of a shop are the T-slots in various machines, and the writer has also spent a great deal of money in bringing these to a standard, a matter that has at times meant entirely new face plates or tables for some machines.

A great many years ago experiments were made by William Sellers & Company to ascertain the strength of T-slots relatively to a T-headed bolt, and on the strength of these, that company adopted a standardized set of slots, which, as later modified by the writer, have also been used by him for several years past. They are shown in Fig. 9.

LATHE CENTERS AND DRILL-PRESS AND MILLING-MACHINE SOCKETS

It is well known that the Morse standard sockets are no standards at all, but a perpetuated, laudable, but unsuccessful attempt of years ago to establish standards. However, compelled for the time being to accept them as they are, everybody has now at least two standard tapers for sockets and shanks to contend with, namely, the Morse, and the Brown and Sharpe. The best the writer has been able to do, therefore, has been to make all lathe centers conform to a Morse Standard, so as to enable drills or drill sockets to be directly inserted in either spindle of certain or all lathes in a shop; and to make all milling-machine sockets conform to the Brown and Sharpe Standard, with Morse drill sockets having Brown

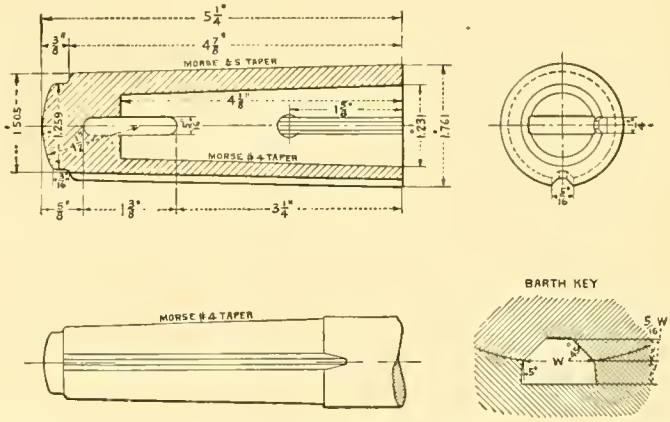


Fig. 10 Author's Key Method of Driving Drill, Arbor and Boring-Bar Shanks

and Sharpe shanks for use with these, whenever holes have to be drilled in a milling machine.

The writer unqualifiedly recommends the universal adoption of the Brown and Sharpe Standards all around, and the use of Morse sockets with Brown and Sharpe shanks during the change. He also recommends the universal abandonment of the tang as a means of driving. We have now for years had the ridiculous inconsistency of drill makers, that they still furnish taper-shank drills with the old-style tang as a means of driving, and along with this extensively advertise and sell various forms of "use-them-up" sockets for drills with the original tang broken off.

More than twelve years ago the writer adopted a modification of William Sellers & Co.'s key method of driving as a substitute for the tang of drills, arbor and boring-bar shanks. This is illustrated in Fig. 10, and differs from the Sellers method in the special form of key, which has become somewhat known as the Barth key. The virtue of this as a means of driving consists in its being subjected to crushing pressures only, and that it has no tendency to work out of its seat; and for a taper-drill socket it has the additional great advantage over the Sellers straight key, that the drill shank can be inserted rapidly without any special care.

A PROPOSED PLAN FOR THE ACTIVITIES OF THE MACHINE SHOP PRACTICE SUB-COMMITTEE OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

BY H. K. HATHAWAY, PHILADELPHIA, PA.

Member of the Society

THE writer has been impressed with what seems to be a weakness in the organization and conduct of all scientific and technical societies. Such societies, he believes, should be the agencies through which constructive work of a definite character leading to the development of a profession should be carried on. The proceedings of such societies should provide authoritative and usable data covering the entire range of activities in their respective fields.

Such data should be grouped and codified in accordance with a logical scheme of classification and indexing which would bring together in the most accessible and usable form everything pertaining to each of the divisions and subdivisions of the science or art.

A definite plan of action should be worked out for procuring from the members best qualified papers dealing with each subject covered by the classification, so that when properly arranged these papers would constitute a classified reference library covering the whole field of the science or art.

It might be pointed out that in the past the securing of papers has been a very haphazard affair, it being largely left to chance that members in a position to add to the knowledge of their profession share with their fellow members the results of their experience. Very often those best qualified to write on a given subject, by reason of their own familiarity with it underestimate its importance and the lack of knowledge of the subject on the part of others. Modesty, a feeling of inadequate literary ability, or a disinclination to share with others may prevent the presentation of papers which would be valuable contributions to a society. Frequently papers cover in a superficial way a multitude of subjects or phases of a subject, any one of which, if properly developed, might furnish material for a volume. Often a member may be moved to present a paper on a subject interesting him intensely at the moment but which may be of infinitely less value than would be one on another subject which he is preëminently qualified to handle.

In the creation of committees dealing with the several broad divisions of mechanical engineering, our Society has taken the first step toward carrying out such a plan as the writer offers for consideration. Now to make the work of these committees more effective there should be, first a predetermined plan, and second, the permanent employment of a secretary who, under the guidance of the committee, would devote his time to carrying out this plan.

While the writer has specifically in mind the activities of the sub-committee on Machine Shop Practice, such a plan might profitably be considered in connection with the work of all other sub-committees of the Society.

In addition to providing a plant and a classification of Machine Shop Practice, the sub-committee should classify the members with respect to the phases of machine shop practice on which they might be best qualified to present papers, and then make a consistent effort to secure the papers, giving adequate time to properly handle the subject.

Plans for securing papers should be made much further in advance than is possible under the present scheme where a new chairman is elected each year and expected to provide papers for the meetings during his year of office. So far as his year of office is concerned, it would seem to be better if instead of devoting his time to securing papers for presentation during that year he were to devote his time to securing papers for the next year.

Gathering in and codifying all knowledge concerning the best existing practice should represent only one phase of the work of the sub-committee on Machine Shop Practice.

A second and even larger undertaking would be the prosecution along predetermined lines, of research that would result in definite advancement of the art. At present this is almost entirely left to the enterprise of individuals or companies, and there is no coördination of effort.

Experiments along identical lines may be carried on by several different individuals or companies without any one of them having knowledge of what the other is doing, thus resulting in considerable waste of effort, time and money, and frequently in conflicting results. The writer happens to know, at the present time, of two sets of experiments being carried on independently in the art of drilling to accomplish some such work as was done by the late Frederick W. Taylor and his associates, as covered in a paper to the Society on "The Art of Cutting Metals," and Taylor's "Experiments in the Use of Leather Belting." Much remains to be done in the study of cutting metals. For example, there is little available knowledge on the subject of cutting brass and bronze, on tapping, on the use of milling cutters, etc.

The only thing that is done by societies such as ours in the way of research is that undertaken by committees of men whose time is so fully occupied by their own affairs that they can at best give an insufficient amount of time to the problem they have in hand, and are obliged to carry on at their own expense such experiments or research as may be necessary to reach a conclusion.

Would it not be better for all concerned if the Society were in a position to employ experts for investigation and research who might give their entire time to the work assigned them? Would not the results be achieved much more quickly and at less expense to the profession as a whole, and more particularly to those industries to whom the results would be of immediate value?

The first part of this plan, that of gathering in, codifying, and making available all existing knowledge pertaining to the profession, is something which might be undertaken at once. The writer has worked out a classification of machine shop practice which is appended to this paper (the classification is not included in this résumé), and in doing so has endeavored to so arrange it as to permit of easy expansion and correction. In the matter of determining who among the membership is best qualified to write upon the various subjects, help must be had from all of the members.

The second part of the plan, that of conducting, along predetermined lines, investigate and experiments for the purpose of advancing the art and providing scientifically determined information in place of opinion, calls for an outlay of money which would have to be financed probably by subscriptions from the individuals and companies who might be benefited by this work.

For presentation at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application All papers are subject to revision.

GAS POWER PAPERS

THE Sub-Committee on Gas Power will have charge of a session at the Annual Meeting, at which important papers on gas manufacture, gas analysis, comparison of steam and gas engines, internal-combustion engines, and gas tractors will be presented. Two of the papers for this session were given last month, and two more are published below.

A GAS PRODUCER FOR BITUMINOUS FUEL

By O. C. BERRY, LAFAYETTE, IND.

Non-Member

WHEN bituminous coal is gasified in a standard up-draft producer of the anthracite type, the volatile hydrocarbons are liberated immediately. These vapors mix with the hot producer gas leaving the fuel column, and, upon cooling condense in a fog of finely divided particles of tar that, depositing, will clog up pipe lines, stick valves, and prove a general nuisance. Therefore, the special problem in designing a bituminous gas producer is to eliminate this tar from the gas.

The most obvious solution is a mechanical tar extractor that will remove the tar without affecting the quality of the gas in any other way. The plant manufactured by R. D. Wood & Co., and used by the United States Geological Survey in its experimental plant at St. Louis, is probably one of the best examples of this type of a bituminous gas producer. A second solution is to eliminate the tar vapors in the fuel column of the producer itself. This may be accomplished by applying one or both of the following well-known principles:

a If tar vapors are caused to pass through a bed of incandescent fuel, they will be "cracked," or split up into permanent gases, such as CH_4 and free H_2, and lamp black, or finely divided particles of pure carbon. Thus the tars may be destroyed completely, and a considerable quantity of valuable fuel gas will result

b Tar is a mixture of many complex hydrocarbons, and will therefore burn to CO_2 and H_2O. These gases may be passed through the incandescent fuel and split up into CO and free H_2, the same gases that are obtained in the gasifying anthracite coal.

The multiple-combustion-chamber producer, the down-draft producer with a combustion zone at the top and one at the bottom, and the recirculating producer, which is discussed in this paper, are all examples of this second class.

The volatile matter may all be driven off from a bituminous coal at a temperature considerably below the highest attained in a gas producer. In the recirculating producer advantage is taken of this fact by drawing the finished gas from well below the top of the fuel column, where the coal is sufficiently hot for the last trace of tar to have been removed. The tar-laden gases from the top of the producer are re-entered into the fuel column near the bottom. In the Whitfield producer they are introduced directly into the "incandescent" zone, while in the Daniels producer and several others they are passed into the combustion zone of the fuel column.

Fig. 1, from the patent drawings of Charles Whitfield, illustrates the general idea. The coal is trapped into the producer at the top, and the only air inlet is below the grates. The producer is kept almost filled with fuel, so that the outlet for the finished gas is well down toward the center of the fuel column. All of the combustion takes place just above the grates, forming a layer of ash immediately above them, a combustion zone just above the ash, an incandescent zone just above the combustion zone, and distillation zones of decreasing temperature continuing toward the top of the fuel column. The recirculating pipe *A*, in which flow is induced by the steam nozzle *B*, takes the products of distillation from the top of the producer down to and into the incandescent zone. The annular chamber *C* extends entirely around the producer, and makes it possible to distribute the tarry vapors to all sides of the incandescent zone.

In developing a producer of this type, information was needed that could not be found in print, and that therefore required special investigation, such as:

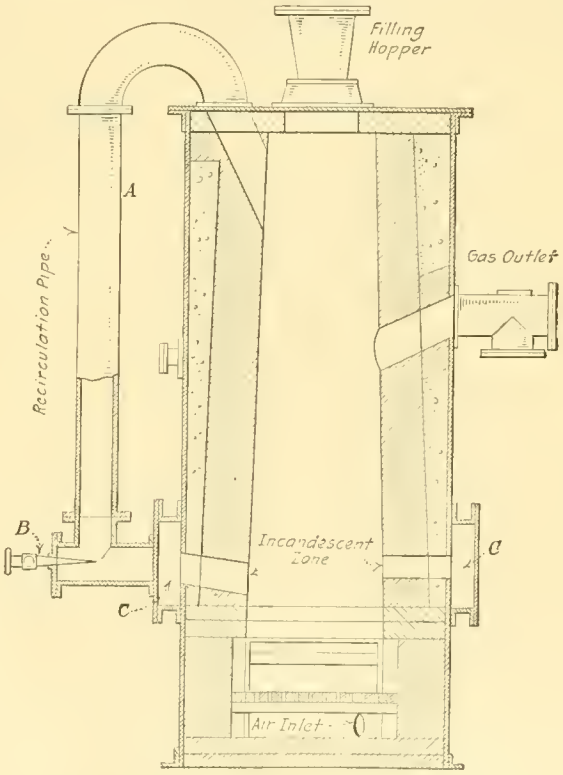


Fig. 1 Whitfield Recirculating Producer

a The most efficient and best type of blower to use

b The temperature at which the pipe, the blower and the gases themselves must be kept to recirculate the gases with the least deposit of their tar content, and the least trouble from other sources

c The temperature at which the top of the fuel column must be held to prevent troublesome tar deposit there

d The lowest temperature at which one may be certain that the last trace of tar has been removed from the coal used.

The author has done investigative work along each of these lines. This work was started at the University of Wisconsin, but most of it has been done in the laboratories of Purdue University.

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THE RECIRCULATING BLOWER

In good anthracite-producer practice about one-half pound of steam should be decomposed per pound of combustible burned. This steam is mixed with the air for combustion as it enters the fuel column, and is obtained either from a vaporizer on the producer itself, or from some outside source. The possibility of using this steam to circulate the gases was taken advantage of by the earliest investigators. The steam exhauster is so obviously the best type of blower to use that the problem simplifies itself into a choice of the type of the steam blower.

A very inefficient blower can deliver the required amount of gas with less than a half-pound of steam, but some classes of bituminous fuel contain so much moisture that a highly efficient blower is desirable. This, with other requirements that the blower must meet, are as follows:

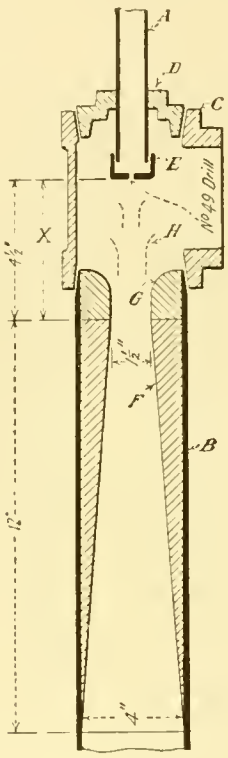


Fig. 2 Recirculating Blower

a The required quantity of gas must be delivered with the least steam

b The blower must be capable of operating continuously without clogging up or varying from its normal delivery of gas

c In delivering the gas the blower must not cause the precipitation of too much of the tar

d The blower should be accessible and easily cleaned

e Since change in the character of the fuel column will change the pressure against which the blower works, the blower's capacity must not be appreciably affected by the discharge pressure.

Comparative tests were made on three blowers, all using the same amount of steam per hour, and all working against the same back pressure. The construction of the blower from standard pipe and fittings may be understood from Fig. 2. The Cap *E* on the pipe *A* was drilled with a No. 49 drill. Within the pipe *B* is a wooden cylinder *F* bored out to a taper, and above this is a throat piece *G*, rounded at the top as indicated; the two blocks together form the expanding pipe of the blower.

When set up as indicated, the stream of steam from the hole in *E* will pass along the center line of the pipe *B*, and the whole apparatus will serve as a steam exhauster, the air being drawn in at the side opening of the tee *C*, and forced out through *B*. By screwing the pipe *A* in the plug *D*, the distance from the lower end of *E* to the upper end of *F* could be varied from ½ to 7 in. The throat pieces *G* were made of different shapes and lengths, and the cylinders *F* in lengths varying from 4 to 12 in. Likewise the pipe caps *E* were supplied with holes of different sizes. The large number of duplicate parts was provided so as to arrive experimentally at the combination giving the highest efficiency and best performance.

The second blower was the same as the first, except that the steam orifice *E* had a number of holes placed so as to distribute the steam evenly over the entire area of the top of *F*. The size of the holes was chosen so as to use the same amount of steam as the nozzle in the first type with which it was compared.

The third type was the same as the first except that a varying number of air-expanding pipes was used between the steam orifice and the final air-expanding pipe, as indicated by the dotted lines at *H* in Fig. 2. These pipes were used in a variety of numbers, sizes, shapes and spacings, in an attempt to get at the best combination for the conditions under which they were to operate.

The results showed that type I was most efficient, most dependable for continuous performance with the least chance of trouble, and easiest to clean. The following general conclusions may be drawn from the result of these tests:

a In working against small back pressures probably the most efficient and best type of steam exhauster is the one shown in Fig. 2

b The height of the steam orifice above the expansion pipe is important

c The length and the angle of taper used in the expansion pipe are both important

d The capacity of the blower is almost directly proportional to the steam pressure at the orifice

e In a separate set of tests it was shown that superheated steam gave better efficiency and threw down less tar than saturated or wet steam.

PROPER TEMPERATURE FOR THE RECIRCULATED GASES

The second line of investigation was to determine the temperature at which the recirculated gases, the blower and the recirculating pipe should be held to throw down the smallest amount of tar and give the least trouble. One of the most searching tests for tar is to cause the gas to impinge against a hard surface at a high velocity. This was done, the gas and the surface impinged against being held at different temperatures during the different trials.

The apparatus used is shown in Figs. 3, 4 and 5. The gas was generated in a furnace made of a 24-in. length of 6-in. pipe, fitted with a coupling and plug at both top and bottom, and with a set of grates near the bottom. This is shown at *A*, Fig. 3. The air blast was furnished by the blower *B*, and the pressure of this blast was steadied through the tank *C*. The fumes from the furnace were carried away through the pipe *D*, the pressure inside of the furnace and the quantity of

blast passing through it being regulated by the valve at the top of tank *C* and the valve on the pipe line *D*. The pressure in the furnace was indicated by the mercury manometer *E*.

The apparatus for testing for tar is shown at *F* and a cross-section is given in Fig. 4. Here *A* is the side of the furnace, which is connected by a short nipple to the ¾-in. cross *B*. The thermometer *C* is securely packed in the plug *D*, and extends directly into the stream of gas. The steel plug *E* is threaded to fit *B*, and is also threaded into a steel bar *F*. The outer end of *E* and the corresponding face of *F* are machined to a single finished surface, and the copper block *G* is clamped against this surface. The copper block furnishes the surface against which the gas is to impinge. It is a good conductor of heat, so that it is possible to keep all parts of the block at nearly the same temperature.

The shape of the block is indicated in Fig. 5. The ends are drilled as shown at *a* so that a blow-pipe flame may be directed into each hole to aid in heating the block. The face of *G* bearing against *F* is milled out as shown at *c* to furnish

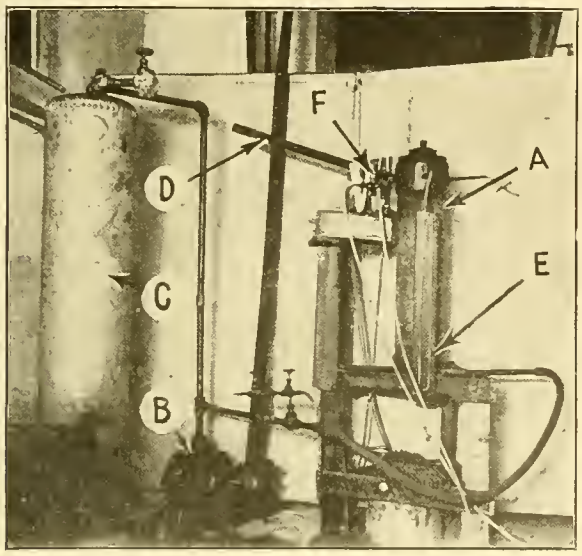


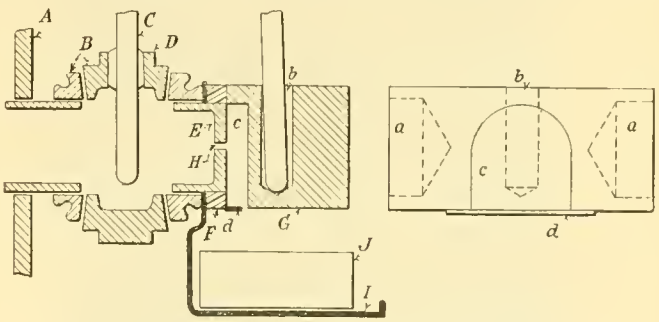
Fig. 3 Apparatus for Determining Proper Temperature for Recirculated Gases

an eddy chamber for the gases, which would impinge against it at a point directly opposite the orifice *H* in the plug *E*. The temperature of the surface of the block at this point is indicated by a thermometer in a mercury bath in the hole *b*. To prevent eddy currents of cold air from passing up into the milled chamber *c*, it was found necessary to restrict the outlet by the strip of sheet steel *d*.

In Fig. 4, *I* is a sheet-steel platform designed to hold a paper tray *J* to catch any tar that is deposited in *c* and runs out at its lower edge. By keeping the pressure in the furnace constant at 3 in. of mercury, and keeping the hole *H* clean, a constant quantity of gas will pass through the device per minute. By holding the temperature of the gas and the block constant for 4 min., catching the deposit for that length of time in the tray *J* and in the chamber *c*, this deposit could be accurately weighed and compared to the deposit from a similar unit quantity of gas at any other temperature.

The results showed that at the lower temperatures comparatively large amounts of tar are deposited, as would be expected. This tar is soft and sticky at room temperature, and contains considerable water. As the temperature of the deposit is raised, the amount of the deposit is continuously decreased, and the tar when cooled to room temperature becomes harder and more brittle. All of the tar is thin and liquid at the temperature at which it is deposited, so that so long as the deposit is a tar, the block *G* tends to have only a thin coat on it, the larger part of the deposit appearing in the paper tray. After a while a temperature is reached at which the deposit, though still a tar, is almost too little to be weighed. This temperature of small deposit starts at about 280 or 300 deg. cent. and extends up to about 500 deg. At no point is there a place where the deposit entirely disappears. At about 500 deg. the deposit begins to turn over from a tar to a sort of coke, and instead of being fluid, it all sticks to the block. Between 500 and 600 deg. this deposit increases slowly in amount, and then increases more rapidly as the temperature nears 700 deg.

The condition where the gas and block are at the same temperature is the only one which has been worked out carefully. The best temperature at which to recirculate the tar-laden gas seems to be between about 300 deg. and 450 deg. cent. At any point within this range the deposit of tar is small, and such as there is tends to flow off from the surface of the blower. At temperatures higher than 450 deg. cent. there



Figs. 4 and 5 Details of Tar Tester

is a chance that the deposit will accumulate on the walls of the blower, and stop it up.

Experience has shown that a heavily tar-laden gas in passing through a cold bed of coal will deposit its tar in the coal until the whole layer of coal becomes impervious to the gas. This state of affairs would be disastrous to the operation of a gas producer. For this reason it becomes interesting to know the lowest temperature at which one may be assured that such a thing will not happen. The tests just reported answer this question as well. If the coal is above 280 deg. cent. this deposit cannot occur.

The results obtained in these special lines of investigation have a direct bearing on the problem of developing a gas producer of the recirculating type for the use of a bituminous fuel. The more important conclusions may be summarized as follows:

a The type of steam exhauster shown in Fig. 2 is efficient and reliable, and is probably the best to use in connection with a gas producer

b The recirculated gas and the pipes through which it passes should be kept between 550 deg. and 900 deg. fahr. in temperature

c The coal at the top of the fuel column should be kept above 550 deg. fahr

d The lowest temperature at which one may be certain that the last trace of tar has been driven off from the coal will vary with the coal used, but will lie between 1000 deg. and 1250 deg. fahr.

Any producer for the use of bituminous fuel should meet all of the requirements which an anthracite plant must meet, and some others. It is difficult to list all, but the following are among the more important:

a The plant must be simple in construction, and must wear well

b All parts of the fuel column must be readily reached by the poker

c A ready means must be provided for cleaning out the clinker and ash

d The air must enter evenly over the entire area of the bottom of the fuel column

e The steam must be evenly distributed through the air for combustion

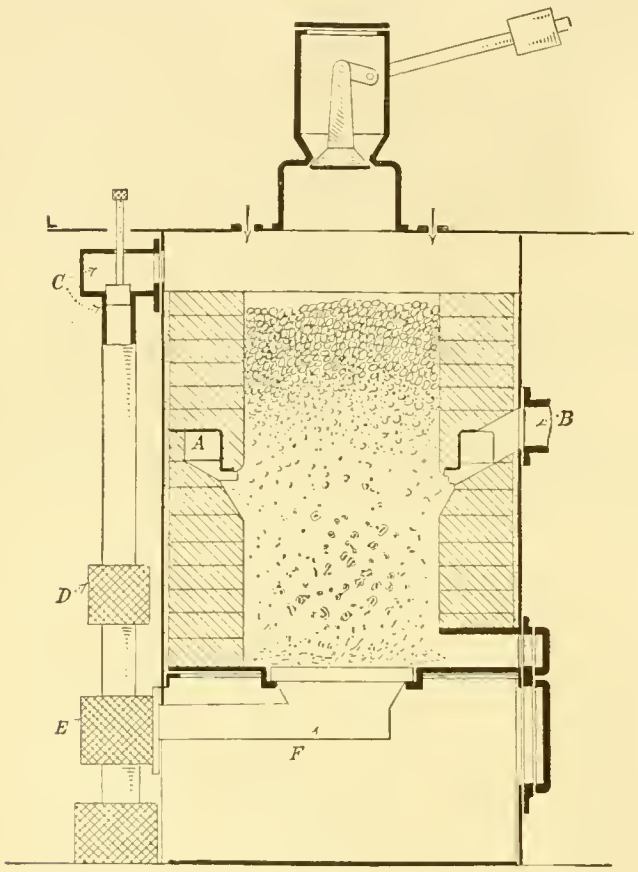


Fig. 6 Experimental Producer in Purdue Laboratory

f The air must be equally free to circulate in all parts of the fuel column

g The gas must be so taken from the producer as to cause an even circulation through the upper part of the fuel column.

PRODUCER DEVELOPED BY AUTHOR

With these points in mind, the author has developed the recirculating gas producer[1] shown in Fig. 6. The coal is trapped in at the top, the only air inlet being below the grates. The combustion all takes place right above the grates. The finished gas is drawn off from the fuel column into the annular chamber *A*, which is formed in the firebrick lining of the producer. From here it passes out through the pipe *B*. The products of distillation and the other recirculated gases are drawn into the pipe *C* by the steam blower *D*. These gases are then delivered into the header *E*, and from there into the distributor *F*. This distributor is so constructed as to deliver an equal amount of the recirculated gases to every part of the grate area, and in such a way that the gas burns as it mixes with the air, largely in the lower part of the combustion zone of the fuel. The recirculated gases burn to CO_2 and H_2O, and in passing through the incandescent zone above, the CO_2, taking up one more carbon atom, is changed into CO, according to the equation

$$CO_2 + C + \text{heat} = 2CO$$

and the H_2O is split up into free H_2 and CO, according to the equation

$$H_2O + C + \text{heat} = H_2 + CO$$

Thus the finished gas obtained from the tars and the other hydrocarbons is the same as that from anthracite coal, and instead of being wasted the tars are converted into useful gas. The gas from this producer should therefore be free from the fluctuating hydrocarbon content that has been the source of so much inconvenience in connection with the gas from most bituminous plants.

Fig. 7 is from a photograph of a 50-h.p. installation of this producer in the laboratories of Purdue University, at Lafayette, Ind., for experimental purposes. Peep-holes *A* are provided to enable the operator to examine the temperature of the fuel column. In the hottest part, where the temperature changes are the most important, this is especially easy. A tube with a rod inside of it may be thrust into the center of the producer, and the rod removed. By looking through the tube the temperature of the fuel at the end of the tube may be estimated. By drawing the tube out slowly and watching the temperature at its end, comparatively slight differences in temperature between the outside and the center of the fuel column may be detected. This is often of great importance in interpreting producer performance. These peep-holes are drilled through the shell and tapped ¾-in. pipe size. Nipples 6 in. long are screwed into these holes, and are capped on their outer ends by standard unions with glass packed in them. The small outlets shown at the sides of many of the ¾-in. pipes are used to draw off samples of the gas to be tested for tar.

The trap *B* is filled with water and catches any tar that may be thrown down in the steam blowers or the recirculating pipes. The header *C* communicates with the gas-distributing device under the grates. The steam blowers *D* and the recirculating pipes are in duplicate, one being used and one held in reserve. The gas from this plant is cooled in a coke-filled scrubber. From this scrubber the gas goes directly to a 43-h.p. Fairbanks-Morse engine.

Returning again to a consideration of the factors influencing the proper performance of this type of producer, if three things are accomplished the gas will be free from tar:

a All of the tar must be driven out of the fuel while it is still above the openings which communicate with the annular chamber.

b All of the tarry vapors driven out of the fuel in the distillation zone must be drawn out and recirculated.

c The recirculated gas must not be allowed to form a cold path for itself between the grates and the outlet on the one hand, nor form an explosive mixture with the entering air on the other. The former would allow the tars to get into the finished gas, and the latter would cause explosions which might prove serious.

It is possible to accomplish these three things continuously

[1] Patented.

and certainly, and to get a gas from a heavily tar-laden fuel which is entirely free from tar.

Inability to meet the first requirement has been the cause of failure of several recirculating producers. Coal is a poor conductor of heat, and little heat can pass by conduction from one lump of coal to another. The heat distribution in the fuel column of a standard up-draft plant is due to the hot gases from the incandescent zone that pass up through the entire fuel column on the way out. In the recirculating producer, the finished gas is drawn out of the fuel column at about mid-height. If the only gases that pass through the fuel above this point are the products of distillation, the heat-carrying medium will be absent above the annular chamber, and the coal will remain cold until after it passes this point. This means that the first requirement has not been met and the producer will not be able to furnish a tar-free gas.

To overcome this a blower of sufficient capacity must be used to recirculate a considerable part of the hot gases from the incandescent zone along with the products of distillation. It is thereby possible to maintain as high temperatures in the fuel column at the top of a recirculating producer as in the up-draft producer, and the coal may be heated until the last trace of tar has been driven off before it reaches the gas discharge level.

This positive stream of gas passing from the bottom of the producer to the top past the annular chamber also enables the producer to meet the second requirement, as it will prevent any of the products of distillation that are driven off from the coal above the discharge level from backing up and passing out at the discharge.

On the third requirement is where many recirculating producers have failed. The gases from any given point in the grate area will tend to establish their own individual path between the grates and the outlet. If they are inert, or do not mix with air and burn in the combustion zone, or, mixed with air, do not burn the coal in the combustion zone, they will not have any heat of combustion with which to establish an incandescent zone. They will therefore form a cold path for themselves right through the zone that should be incandescent, and escape through the discharge outlet unburned and uncracked. To avoid this, the recirculated gases must be evenly distributed over the entire grate area.

To prevent the formation of an explosive mixture, the gases and air must burn as they mix. In this producer this is accomplished by having the gas introduced into the air in the restricted area between the grates, thus preventing them from backing up and mixing with the air below the grates.

The down-draft producer and the double-combustion-zone producer, while both successful in delivering a tar-free gas, have certain shortcomings. The down-draft producer is open to the following criticisms:

a The ash contains a high per cent of the carbon in the coal

b A large part of the tars are cracked in a reducing atmosphere, and consequently produce large quantities of lampblack

c The fuel column is subject to the formation of hard clinkers

d A large proportion of the total heat value of the coal burned is lost in the sensible heat of the gases leaving the producer

e Some types of the down-draft producer cannot be cleaned while running, but must be shut down every week or ten days to have the fire pulled. This is a disagreeable task, besides making it necessary to have two plants.

The double-combustion-zone producer gets around the first and fifth difficulties without adding any serious new ones, but is an equally bad offender in the other three.

The high proportion of total carbon in the coal lost in the ash is characteristic of all down-draft producers. The older types that could not be cleaned while running obviously lose considerable of the carbon when the fire is pulled. In the newer types that are capable of continuous operation, the high carbon in the ash may be explained in that the combustion takes place at the top of the fuel column, but all of the carbon cannot be burned out of the fuel here, as about half of it must be left to reduce the CO_2 in the incandescent zone. This reduction in the incandescent zone is due not only to the high temperatures there, but also to the presence of a large excess

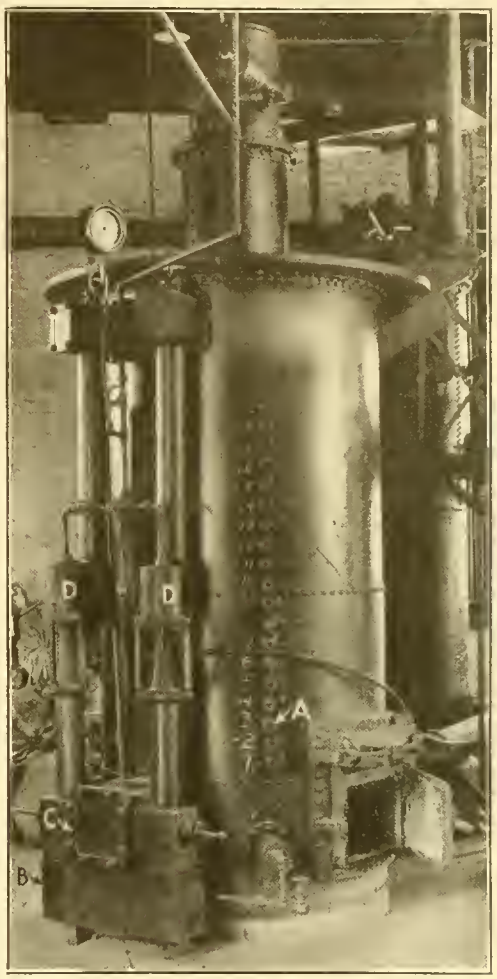


Fig. 7 Photographic View of Installation of Producer Shown in Fig. 6

of carbon. Therefore all the carbon cannot be burned out of the fuel in the incandescent zone and have the gas reasonably low in CO_2.

When the tarry vapors are heated to a high temperature in an oxidizing atmosphere they burn, and no lampblack is formed. If, however, the heating takes place in a reducing atmosphere, combustion is impossible, and the tars will be cracked and large quantities of lampblack formed. In both the down-draft producer and the double-combustion-zone producer, the higher-temperature tars from the central part of each lump of coal are inevitably driven off in the incandescent zone. Hence, the ever-present lampblack in the gases from these producers.

All of the causes leading to hard clinkers do not seem to

be understood. It seems, however, that clinkering will be augmented by concentrating the ash in the hottest part of the fuel bed, by stirring or poking this part of the fire, and by the existence of lampblack in the fuel. In both of these types of producers the coal is about half burned at the top of the fire, and is as nearly completely burned as it ever gets to be while it still remains in the incandescent zone. In other words, the coal at the bottom of the incandescent zone is nearly all ash. This incandescent ash is mixed with lampblack, and is frequently and more or less vigorously poked.

The reports of the work done by the United States Geological Survey, in its experiments with gas producers furnish much valuable information. In some cases they give the heat value of the coal, the number of cubic feet of gas obtained from one pound of the coal and the chemical analysis of the gas. Knowing the chemical analysis of the gas, a close estimate can be made of the quantity of undecomposed water that accompanied the gas as it left the producer. The specific heats of all of these gases are quite accurately known. From these figures the per cent of the total heat value of the coal that appears as sensible heat in the hot gases leaving the producer will be nearly equal to the number of hundreds of degrees fahrenheit of temperature of the gases. In other words, gases having the fuel column at 2200 deg. are carrying away about 22 per cent of the total heat value of the coal. But to get a good reduction of the CO_2, it is necessary to have a temperature of at least 2200 deg. fahr. in the incandescent zone of the producer. In the down-draft and the double-combustion-zone producers, the loss due to the sensible heat of the gases as they leave will be above 20 per cent of the total heat value of the fuel used.

In the recirculating producer here proposed, all five of these difficulties are met without introducing any new ones of comparable gravity:

a The combustion takes place as in a standard up-draft anthracite plant. The air all comes from underneath and passes through the ash before reaching the fuel. The last trace of carbon in the hot ash at the bottom of the combustion zone is exposed to the pure air which supports the combustion, so all of it should be burned up. In either the anthracite plant or the recirculating plant the quantity of carbon in the ash is due largely to the care with which the fire has been tended, and should be small.

b All of the tarry vapors are burned in a highly oxidizing atmosphere, so no lampblack is formed

c The fuel being burned after it has passed through the incandescent zone, as it is in the standard anthracite plant, much of the tendency to clinker is avoided. No worse clinkers are produced in this plant than in the anthracite producer; and with proper care and a good coal they can be avoided entirely

d The temperature necessary to eliminate the tar in the coal is never more than 1250 deg. fahr. The gases will have to leave the producer at a temperature somewhat higher than this, say at 1500 to 1600 deg. Still considerably less is lost in the sensible heat in the gas

e The ash can be removed from the producer while it is in operation, and the plant is capable of continuous operation, the length of the run being limited only by the life of the fire-brick lining.

Thus far the author has not been able to carry out long and exhaustive tests on this plant, and regrets his inability to quote figures showing its performance. The best report that can be made is that the plant has run all day (10 hours) each day for a week without making any tar. The heat value and chemical analysis of the gas were not obtained.

THE COMMERCIAL SAMPLING AND ANALYSIS OF PRODUCER GAS

BY PHILIP W. SWAIN, NEW HAVEN, CONN.

Junior-Member

An analysis of producer gas is ordinarily considered complete if carbon dioxide, oxygen, illuminants, carbon monoxide, hydrogen, methane and nitrogen (by difference) are determined. The quantities of other gases present are almost always negligible, and of illuminants and oxygen usually so small as to make their determination unimportant.

The quality of the gas may usually be judged from the carbon dioxide alone. Low carbon dioxide almost invariably means gas of high heating value and good producer efficiency. The determination of the carbon dioxide can be quickly, easily and accurately carried out with a simple and inexpensive portable apparatus. The ordinary Orsat apparatus or some modification of it may be used, or, if the gas is properly cleaned, some form of automatic recording carbon dioxide machine. The latter, however, at present are expensive and require expert attention to keep them in order. The chief objection to carbon dioxide as a gas quality indicator is that long-period samples collected over water suffer considerable change in carbon dioxide content by absorption or evolution of that gas by the water.

Some plants use the per cent of carbon monoxide in the gas as the basis of a bonus system for producer operators. The carbon monoxide is not appreciably affected by water, so that long-period continuous samples can be taken. Although this element furnishes the greater part of the heat in the gas, high carbon monoxide might be produced at the expense of hydrogen by changing the ratio of steam to air in the blast. If this is taken into account or controlled, the carbon monoxide should give a good indication of the quality of the gas.

To make rapid and accurate determinations of carbon monoxide the apparatus should have two bubbling pipettes, containing the regular cuprous chloride solution which is used for this purpose. One of these solutions should be kept quite fresh and be used to absorb the last trace of carbon monoxide after the other has absorbed most of it.

Before long it will probably be the practice to determine gas quality by some form of recording calorimeter. Such instruments have been used for years, and often have proved very useful. In general, however, they require frequent adjustment if absolute rather than merely relative values are desired. This difficulty will doubtless be overcome in time.

A rather crude but ideally simple way of estimating the quality of gas almost universally used is a test flame left constantly burning. By its use the producer operator can detect large variations in the gas quality.

SAMPLING

The sample of gas may be drawn directly from the gas main or from a pipe through which fresh gas continuously flows, such as that which supplies the test flame. For a continuous sample the pressure in the pipe should be practically constant where the sample is taken. Any variation increases or decreases the flow of gas into the sampling bottle

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

even when the flow of water from the bottle is properly regulated. The sampling connection will be at practically atmospheric pressure if it is on the test-flame pipe beyond the valve that regulates the flame.

If there is no gas main with a pressure above atmospheric, some form of steam aspirator[1] can be used to produce a steady flow of gas from the main. The rate of flow should be such that the gas in the aspirator pipe will always be substantially the same as that in the main.

The proper form and position of the sampling pipe in the gas main has received a great deal of attention. The writer believes that, if the gas is sampled after passing through the scrubber, it is so thoroughly mixed that an open-end sampling tube at the center of the main will draw a representative sample. In fuel-gas installations where the gas is not washed the mixture of the gas in the main is much less complete, but special sampling tubes with small holes would be so likely to become clogged if used with unwashed gases that the open-end sampling tube would be better, placing it as far as possible from the producer to insure the maximum amount of mixing.

Of the several ways for drawing the sample, probably the most common is the so-called "two-bottle method." Two large bottles have openings near the bottom connected by a long rubber tube. The bottle for collecting the gas has a rubber stopper through which passes a glass tube connected to the sampling pipe by a rubber tube. The bottle are partly filled with water, which admits gas to or expels it from the sampling bottle when the second bottle is lowered or raised. Before taking a sample a charge of gas is drawn and shaken up with the water to saturate it and thereby reduce its effect on the sample. The water is then forced to the top of the sampling bottle and the rubber tube connecting the bottles closed with a pinch cock. Then the second bottle is placed some distance below the other and the pinch cock opened to let the water flow from the sampling bottle.

When continuous samples extending over long periods are taken, using the ordinary two-bottle method, a number of errors occur aside from that due to the absorption and evolution of carbon dioxide by the water. If the rate of sampling is not proportional to the flow of gas in the main and the gas composition varies widely, a considerable error may result.

Two reasons why the flow of water—and hence the rate of sampling—varies are that the restricted opening in the compressed rubber tube tends to clog and that the net head producing the flow of water, which is the difference in level in the water surfaces of the two bottles, is constantly decreasing as the water flows from the upper to the lower bottle.

It is evident that the ordinary two-bottle method never gives an exactly correct sample, and that clogging of the thin tapering opening in the rubber tube may produce a large error without being detected.

Fig. 1 shows an arrangement that the writer has devised for easily measuring and controlling the rate of sampling. The upper bottle is connected as in the ordinary two-bottle method, but the water passes into the top of the lower bottle through a simple form of orifice flow meter. This meter is constructed largely of ⅛-in. brass pipe fittings. A thin copper disk with a small orifice is clamped between the two halves of the union so that the head of water which is producing the flow through this orifice can be measured on the manometer shown at the left of the union. A small opening in the top of the elbow shown on the right prevents the nipple below from acting as a tail pipe to increase the head on the orifice. The orifice, being made in a very thin plate, gives little trouble from clogging if clean water is used; however, a small cloth filter can be inserted in the nipple at the left of the tee. The iron fittings in the neck of the lower bottle serve merely as a support, and may be replaced by a stopper with two holes, one to admit the ⅛-in. nipple and the other to act as a vent. A series of orifices for various rates of flow may be prepared by piercing disks of copper foil with needles and smoothing off the rough edges on an oil stone.

For sampling at a uniform rate the water in the manometer tube can be kept to any mark by an occasional adjustment of the pinch cock on the rubber tube. To take a continuous proportional sample it is necessary to have a flow meter in the gas main and scale of rate of flow on the manometer. Since it is only necessary that the rate of flow of the water be

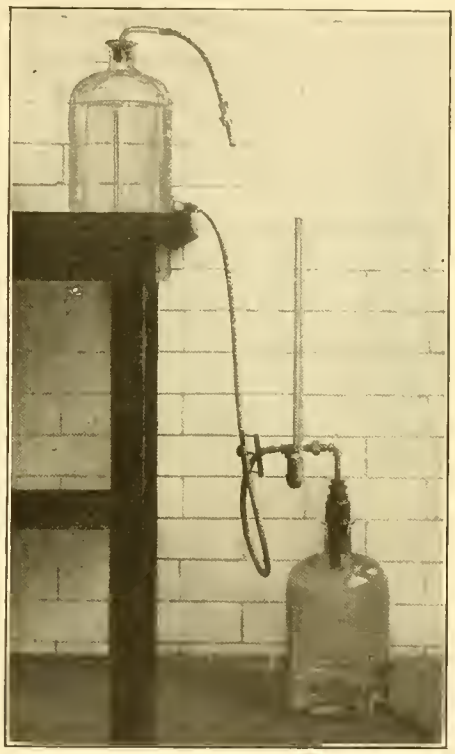


Fig. 1 Apparatus for Proportional Sampling

proportional to the rate of flow of the gas in the main, it is immaterial what units of flow are used. Four scales of flow are used by the writer chosen so that it is usually possible to pick one whose graduations (without regard to the decimal point) more than cover the probable range of readings of the flow meter on the gas main.

A test to determine the accuracy of this flow showed a maximum variation of 2 per cent from the mean.

GAS ANALYSIS

The engineer testing or operating gas producers usually desires a portable gas analyzer that is rapid, reliable and easy to operate and will give each constituent correctly within 0.2 or 0.3 per cent of the total volume of gas.

In the Orsat apparatus used to analyze furnace flue gases the pipettes for absorbing the components usually contain the following reagents: for carbon dioxide either caustic pot-

[1] For a description of such an aspirator, see Bulletin No. 97 of the Bureau of Mines on "Sampling and Analyzing Flue Gases."

ash or caustic soda, for oxygen either an alkaline pyrogallol solution or sticks of phosphorus (in water), and for carbon monoxide either an acid or an ammoniacal solution of cuprous chloride.

The absorption of carbon dioxide by either the caustic potash or caustic soda solution is rapid and the solutions have a large absorbing capacity so that frequent changes are not necessary. The alkaline pyrogallol solution for oxygen is slower in its action and has a smaller absorbing capacity. The solution must be carefully protected from air by a rubber bulb, and tends to give off carbon monoxide if old or improperly prepared.

Phosphorus sticks ordinarily make an ideal reagent for absorbing oxygen. The presence of 0.1 cc. of oxygen will produce fumes that are easily visible, and the reaction once started

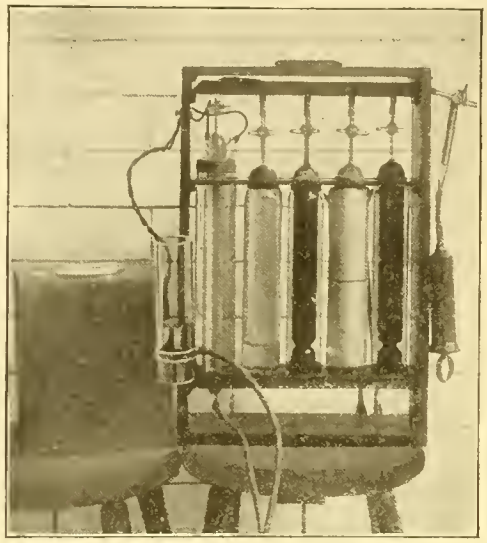


Fig. 2 Williams Apparatus for Producer Gas Analysis

is always complete in a minute or two if a large surface of yellow phosphorus is exposed. Presence of a small quantity of ethylene completely prevents the reaction between phosphorus and oxygen, so phosphorus should not be used for producer gas that contains ethylene unless the ethylene can be absorbed before the oxygen. If the slightest fumes are visible it is known that the phosphorus is acting properly, and almost any producer gas will contain enough oxygen to produce visible fumes. The sticks gradually turn dark and become inactive if exposed to the sunlight, so that the pipette should be wrapped with dark paper. With this precaution one set of phosphorus sticks can be used for years without any attention.

The carbon monoxide is the least satisfactory to absorb of the three gases. The cuprous chloride solution acts slowly, has a small absorbing capacity and is unreliable unless quite fresh, for there is no way of telling when the absorption is complete. It is impossible to absorb all of the carbon monoxide with a solution that has already taken up considerable of the gas. With the producer gas a fairly complete absorption of the carbon monoxide can be made by using two pipettes, the second to take out only the remnant left by the first.

Some of the newer types of Orsat apparatus are arranged so that the gases can be bubbled through the reagents. This greatly reduces the time required for absorbing all the gases, particularly the carbon monoxide. With phosphorus nothing is gained by using a bubbling pipette, as the reagent is a solid.

The ordinary Orsat apparatus is not sufficient to completely analyze producer gas. Provision must be made for determining hydrogen, methane and illuminants (chiefly ethylene).

The Williams apparatus, shown in Fig. 2, is one of several portable instruments now on the market similar to the Orsat. Bubbling pipettes are used for all of the liquid reagents. From left to right, the pipettes shown contain caustic soda solution for carbon dioxide; bromine water for illuminants; phosphorus sticks for oxygen, and an acid cuprous chloride solution (containing copper strips) for carbon monoxide. Since there are only four pipettes, a second cuprous chloride pipette could only be obtained by omitting the bromine water for illuminants. If this is done a pyrogallol solution should be used instead of the phosphorus, because the gas might contain a little ethylene.

In the ordinary method of operation the carbon dioxide, illuminants, oxygen and carbon monoxide are absorbed in this order and the hydrogen and methane are then determined by explosion with air in the explosion burette. It is necessary to use a slight excess of air and to measure the contraction on explosion and the carbon dioxide produced by the explosion. The latter is determined by absorption in the first

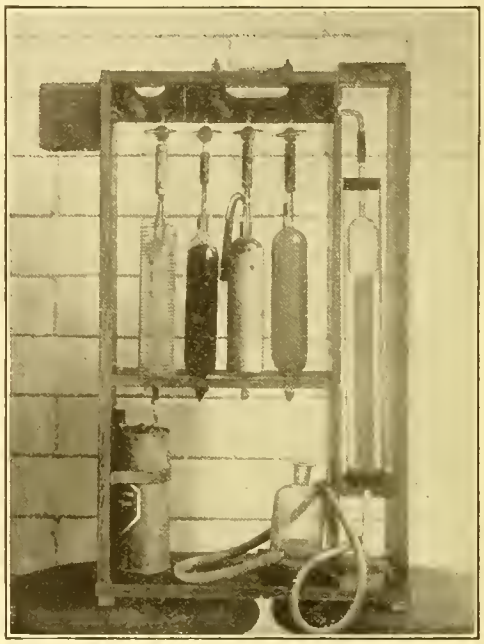


Fig. 4 Orsat Apparatus with Explosion Pipette

pipette. If the full amount of gas left after the absorption of carbon monoxide is used for the explosion, the following equations are employed:

methane = carbon dioxide produced

hydrogen = 2/3 contraction − 4/3 carbon dioxide produced

The method just described is the usual one for the analysis of producer gas with a portable apparatus, but it has certain disadvantages, as follows:

a On account of the large amount of carbon monoxide in producer gas the cuprous chloride solution must be changed very often, with consequent trouble and expense.

b As the amount of methane present is small it may easily happen that the hydrogen content of the gas may be so slow that the gas will not explode with air. In this case it becomes impossible to determine the hydrogen and methane by the ordinary method.

Instead of absorbing the carbon monoxide it may be determined with the hydrogen and methane by one explosion. This does away with the troublesome cuprous chloride solution and insures an explosion if the gas is combustible. This, however, requires the determination of the oxygen consumed as well as the contraction and the carbon dioxide produced. The absorption of the oxygen left over from the explosion is quicker than the absorption of carbon monoxide. On the other hand, the computations required are somewhat more extensive, but this work can be greatly simplified, as will be shown later.

gas it is sufficient to use 124 cc. of air (26.0 cc. oxygen). With this quantity of air the explosive mixture would make more than 200 cc. and could not be contained in the burette so the volume of gas must be reduced before explosion. To simplify the calculation it is well to throw away exactly one-half of the volume of gas remaining after absorbing the carbon dioxide, illuminants and oxygen and then to take in 62 cc. of air containing 13.0 cc. of oxygen. If one-half of the gas is used for the explosion the following equations give the percentage of hydrogen, carbon monoxide and methane in the original gas:

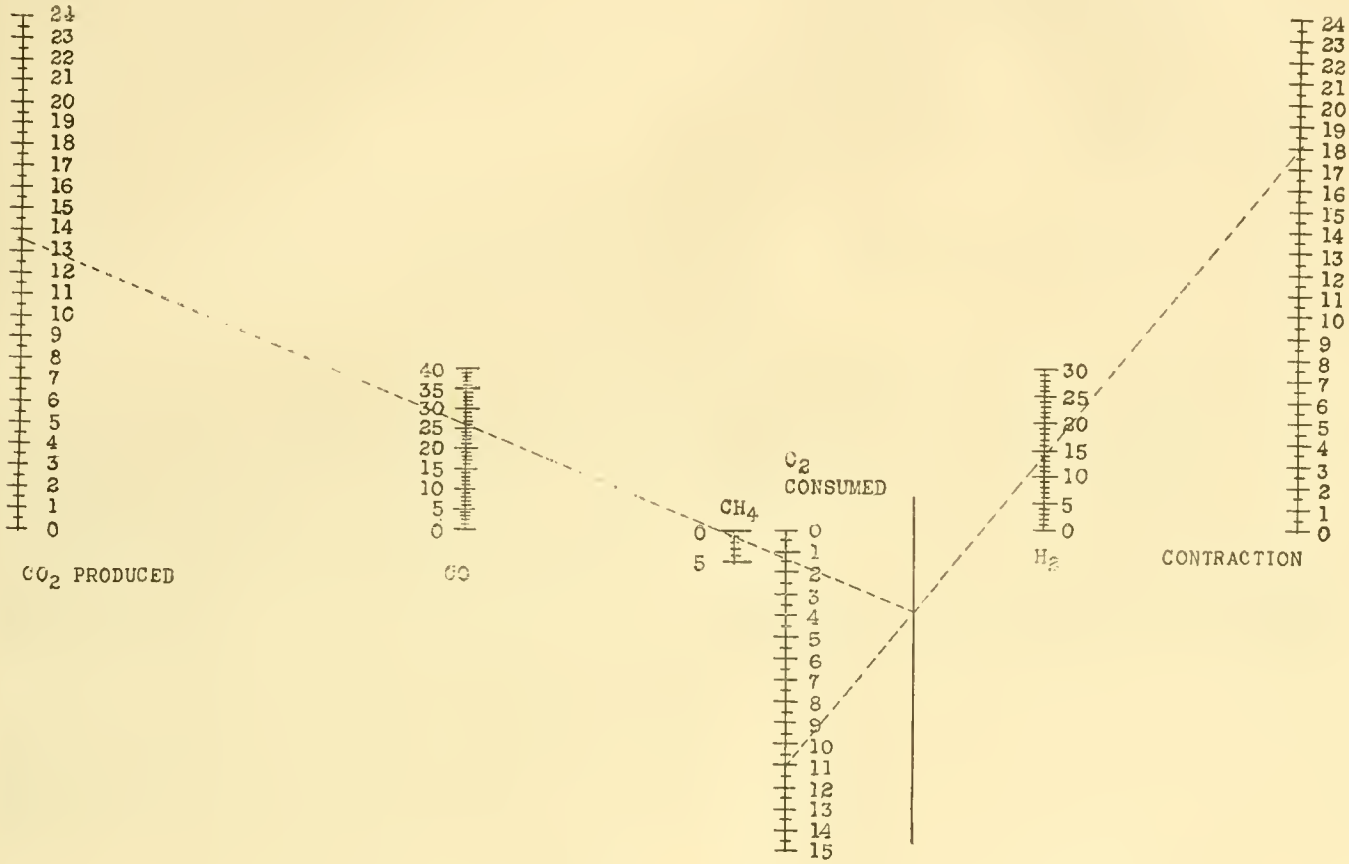


Fig. 3 Diagram for Determining Hydrogen, Carbon Monoxide, and Methane

The burette of the Williams machine is graduated like that of an ordinary Orsat with the zero where the volume is 100 cc. and the 100 mark at the top. This is the best arrangement where only absorption determinations are made, but is somewhat confusing when making a complete analysis. The instrument shown in Fig. 2 has been provided with another scale on the left, which gives the volume directly. Moreover, the graduations have been extended nearly to the bottom of the burette so that a volume up to 115 cc. may be measured. This provides for the increased amount of air which must be used when the carbon monoxide is left in the gas which is to be exploded.

In the determination of carbon monoxide, hydrogen and methane by one explosion it is necessary to measure the oxygen consumed in the explosion as well as the contraction and carbon dioxide produced.

The first two are determined as in the ordinary method where only the hydrogen and the methane are exploded. To determine the quantity of oxygen consumed the air taken in must be measured and the excess of oxygen determined by the phosphorus pipette. For 100 cc. of ordinary producer

Hydrogen = 2 (contraction — oxygen consumed)

Carbon monoxide = 2 (1/3 contraction + 4/3 carbon dioxide produced — oxygen consumed)

Methane = 2 (oxygen consumed — 1/3 contraction — 1/3 carbon dioxide produced)

To solve these equations quickly for routine analyses the diagram Fig. 3 may be used. The dotted lines show the method of using the diagram, but in ordinary solutions no lines need be drawn if use is made of a celluloid straight edge and a fine needle. The manipulation might be as follows:

a Place needle at contraction.
b Swing straight edge around needle to the oxygen consumed.
c Read hydrogen.
d Place needle at intersection of straight edge and blank.
e Swing straight edge around needle to carbon dioxide produced.
f Read carbon monoxide.
g Read methane.

This method of reading the diagram is rapid and accurate. More accurate readings can be made if a larger diagram is used.

The data and results of the analysis may be conveniently recorded on a form similar to the following (readings on true volume scale):

a.	Take 100 c.c. of gas,	absorb carbon dioxide	reading .....
b.	.....	absorb illuminants	reading .....
c.	.....	absorb oxygen	reading .....
d.	Throw away one half of remaining volume		reading .....
e.	Take in 62 cc of air (13 cc. of oxygen)		reading .....
f.	Explode		reading .....
g.	Absorb carbon dioxide produced		reading .....
h.	Absorb oxygen left over		reading .....
i.	Contraction due to explosion		(e — f) .....
j.	Carbon dioxide produced by explosion		(f — g) .....
k.	Oxygen consumed in explosion		[13-(g — h)] .....
		Carbon dioxide	(100—a) .....
		Illuminants	(a — b) .....
		Oxygen	(b — c) .....
		Hydrogen	(diagram) .....
		Carbon monoxide	(diagram) .....
		Methane	(diagram) .....

Producer gas is often free from illuminants, so that time may be saved by passing directly to the phosphorus pipette after the carbon dioxide has been determined. If any fumes appear the absorption of oxygen can be continued. In this case the same reading is recorded at *b* as appears at *a*. If fumes do not appear the gas is passed into the pipette containing bromine water and then into the carbon dioxide pipette to absorb the bromine fumes. The action is rapid, so that one pass through each pipette is sufficient.

If the analysis is made with the explosion of hydrogen and methane only, the following form may be used for the data and results:

a.	Take 100 cc. of gas,	absorb carbon dioxide	reading .....
b.	.....	absorb illuminants	reading .....
c.	.....	absorb oxygen	reading .....
d.	.....	absorb carbon monoxide	reading .....
e.	Throw away one half of remaining volume		reading .....
f.	Take in an excess of air		reading .....
g.	Explode		reading .....
h.	Absorb carbon dioxide produced		reading .....
i.	Contraction due to explosion		(f — g) .....
j.	Carbon dioxide produced by explosion		(g — h) .....
		Carbon dioxide	(100—a) .....
		Illuminants	(a — b) .....
		Oxygen	(b — c) .....
		Carbon Monoxide	(c — d) .....
		Hydrogen	(4/3 i—S/3 j) .....
		Methane	(2j) .....

Fig. 4 shows an ordinary Orsat apparatus modified for analyzing producer gas. From right to left, the first three pipettes contain caustic potash solution, phosphorus and bromine water. The fourth pipette is arranged for explosion through a heated platinum wire. Using a heated wire instead of a spark gap eliminates the induction coil, so that the apparatus is self-contained. The copper leads pass down through a glass tube. This tube has an explosion-tight joint, but can be easily removed or replaced if necessary. The results obtained are as accurate as with the Williams apparatus, but more time is required for an analysis on account of the type of burette and pipettes employed.

A professorship in aeronautics has been established in the division of mechanical engineering at the University of Illinois. Elisha N. Fales, of Buffalo, N. Y., has been appointed Assistant Professor of Aeronautics.

During the first year Mr. Fales will present only general introductory courses on the subject, but a more elaborate program will be offered next year. For the present the instruction will be open to senior students in the College of Engineering.

There are some forty students in his class. The University is now trying to get a flying station of the War Department located on University grounds, and also get an equipment which will enable it to do something in a really scientific way. (From a letter of Dr. Edmund J. James, President, University of Illinois.)

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A most glaring example of the lack of knowledge regarding screw-thread fits comes from a maker of munitions who is supplying a nation that is well known for the excellence of its mechanical lines. The product turned out by this manufacturer had a number of screw-thread fits, one in particular being very carefully gaged. It so happened that a large number of these parts got by the factory inspector with the outside diameter a mere trifle under size. The pitch diameter was practically perfect. They fitted a threaded ring gage satisfactorily, but the outside snap gage, which should not have been used at all, showed the work to be slightly under size.

In vain the maker tried to show the inspector that the fit was perfect, and that for the outside diameter to be exact was practically of little account. "Orders is orders," and the pieces were condemned. But they were not thrown away; not by a long ways. If outside diameter was what they wanted, they should have it.

So a special rolling tool was made, with the lead a trifle off, and the threads were rolled so as to increase the diameter. At the same time it distorted the lead slightly, so that the metal rolled up would not make the piece a loose fit in the ring gage. In this way all the rejected parts were saved—all passing inspection—and yet they were not so good a job as before they were "doctored for the inspector." (*American Machinist*, vol. 45, no. 17, October 26, 1916.)

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A new non-metallic gear material is a product of heavy duck bonded together with Bakelite by heating while under heavy pressure. It is said to be as strong as cast iron, unaffected by atmospheric changes, vermin-proof, and may be stored indefinitely without shrinkage or other deterioration. It can be operated in oil without any signs of swelling, and is self-supporting, in most cases requiring neither bushes nor flanges. When properly applied and lubricated, it is stated that gears of this material will outlast those made from rawhide or other non-metallic gear materials, and in certain classes of service will outlast cast iron.—*The Electric Journal*, August, 1916.

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According to a recent issue of *Nature*, a Swedish company has been formed to manufacture ammonium nitrate and other nitrogenous compounds by chemical processes from easily accessible raw materials. It is thought possible that the new system will prove a serious rival to the electrical fixation of nitrogen.

RAILROAD PAPERS

TWO papers on Electric Locomotives and Clasp Brakes, to be presented at the Railroad Session on Friday morning, were published in the November Journal. An abstract of a third paper, on Pulverized Fuel for Locomotives, is given below. Next to labor, the largest item of cost for transportation is the fuel used for locomotives, and the paper sets forth how the use of pulverized fuel will assist in improving railway operation.

PULVERIZED FUEL FOR LOCOMOTIVES

By JOHN E. MUHLFELD, NEW YORK, N. Y.

Member of the Society

As next to labor the largest single item of cost for transportation is the fuel used in locomotive operation, and as in the final analysis the cost per revenue passenger or per ton mile is largely conditioned upon the capacity, effectiveness and economy of the unit of motive power per hour, it is easy to realize to what extent the credit of a steam railway is controlled by its locomotive performance and expense.

In order to set forth how the use of pulverized fuel will assist in improving steam railway operation, the following facts and conclusions resulting from a number of years of investigation and research and of development work in connection with this most important subject may be of immediate interest.

a The expenditure for locomotive fuel for the steam railways in the United States now approximates $300,000,000 per annum, of which from $75,000,000 to $100,000,000 represents the proportion that is expended to kindle, prepare, clean and maintain fires on grates when locomotives are standing, drifting or otherwise not actually using steam to move themselves, either light or with trains.

b Changes in the domestic and foreign supply and demand, as well as in the regulations, methods and labor governing mining operations, cause a progressive increase in the price per ton of fuel.

c Necessity for conserving the limited supply of oil in the rapidly exhausting fields for other than railway fuel purposes will soon eliminate this fuel from locomotive service; while the higher prices and shortage in supply of the larger sizes and better grades of solid fuels that are in demand for the commercial trade will bring about the use of the less salable general by-product of the mines in pulverized form, by the railways and industries which are adjacent to the mines.

d The extraordinary expenditure required for first cost and fixed charge, as well as for combined maintenance and operation, together with the necessity for reliability and flexibility in motive power, precludes the general use of electricity either from an engineering or an operating standpoint for the movement of heavy traffic over long distances.

e Steam locomotives will be equipped to approximate electric service by the use of pulverized fuel, which in turn will eliminate smoke, soot, cinders, sparks and fire hazards; reduce noise, time for dispatching at terminals, and stand-by losses;

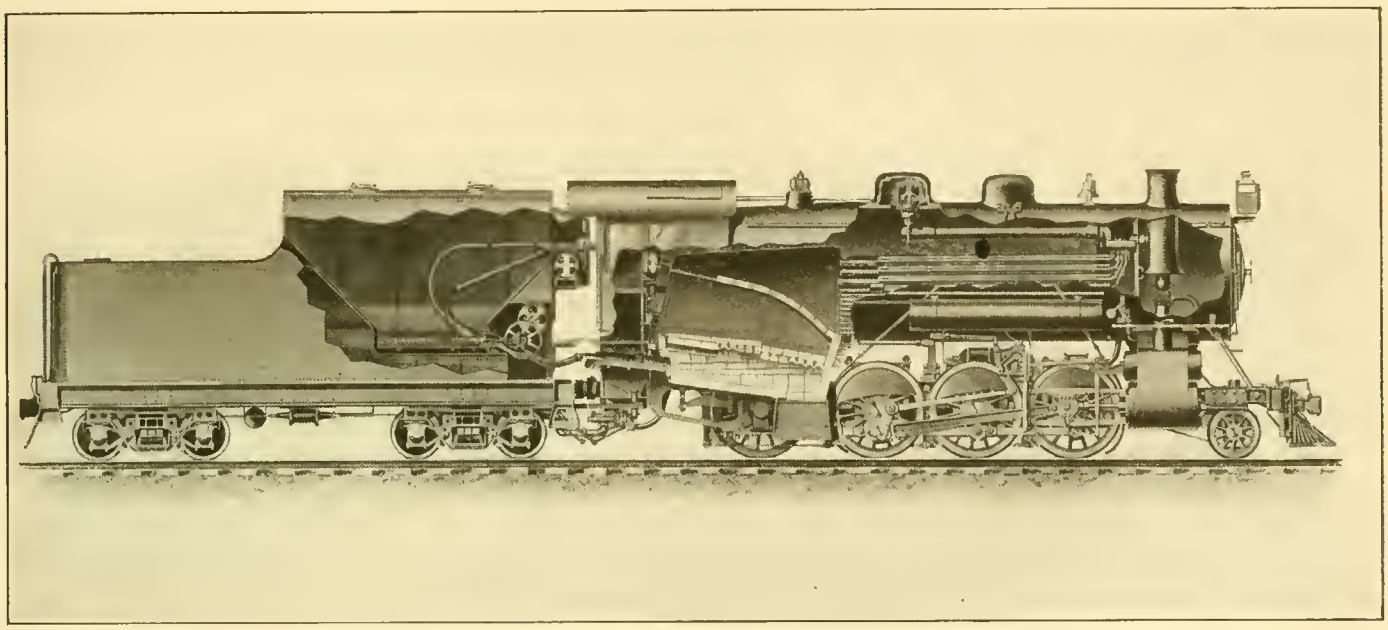

Fig. 1 Sectional View of Locomotive Showing Pulverized-Fuel-Burning Equipment

The fuel in the enclosed fuel tank gravitates to conveyor screws which carry it to the fuel and pressure-air feeders, where it commingles with the air. It is then carried through the connecting hose to nozzles and blown into the fuel and air mixers. Additional air is supplied and the mixture is drawn into the furnace by the smokebox draft. The fuel conveyor, feeder and commingler are driven by a variable-speed turbine. The liquid ash runs down the underside of the main arch and the sides of the furnace and is precipitated into a self-clearing slag pan where it solidifies into a button of slag which can be readily dumped.

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and increase the daily mileage by producing longer runs and more nearly continuous service between general repair periods.

f In order to provide the maximum draw-bar horsepower per hour, the steam locomotive must be so improved as to secure continuity of working steam pressure, greater sustained boiler capacity, increased boiler efficiency, reduced cylinder back pressure, and more highly superheated steam, all of which can be produced by the use of pulverized fuel.

g The large quantity of steam required by the modern locomotive necessitates excessive rates of evaporation, such as can only be effectively and economically produced by the burning of pulverized fuel in suspension in order to utilize the heat units that now go out of the stack and into the ash-pan when solid fuel is fired on grates.

h By mechanically feeding and burning pulverized fuel, arduous labor on the part of the fireman, such as is now required to shovel ahead and supply coarse coal to grates and to rake and clean fires and ash pans, is replaced by the more skilled manual control of combustion and assistance to the engineer in the operation of the locomotive and observation of track and signals.

i The future steam locomotive, on account of its track and bridge weight and tunnel and overhead clearance limitations, will be required to produce the maximum possible hauling capacity per unit of total weight. As the cylinder horsepower available is entirely dependent upon the boiler horsepower and temperature of superheated steam produced, the use of pulverized fuel to increase the heat value per cubic foot of firebox volume and provide a higher average and more uniform firebox temperature in combination with a reduced front-end or waste-heat temperature, appears to be the most logical means for the solution of the problem.

j The opportunity for reducing the non-productive time of existing locomotives and for relieving terminal congestion that is now caused by the necessity for cleaning fires, ash pans, flues, and smokeboxes; inspecting and repairing draft, grate and ash-pan appliances and for firing-up and supplying firing tools and equipment to locomotives burning coal on grates, makes the use of pulverized fuel one of the most effective and economical means for increasing the net earning capacity of present single- and double-track steam roads.

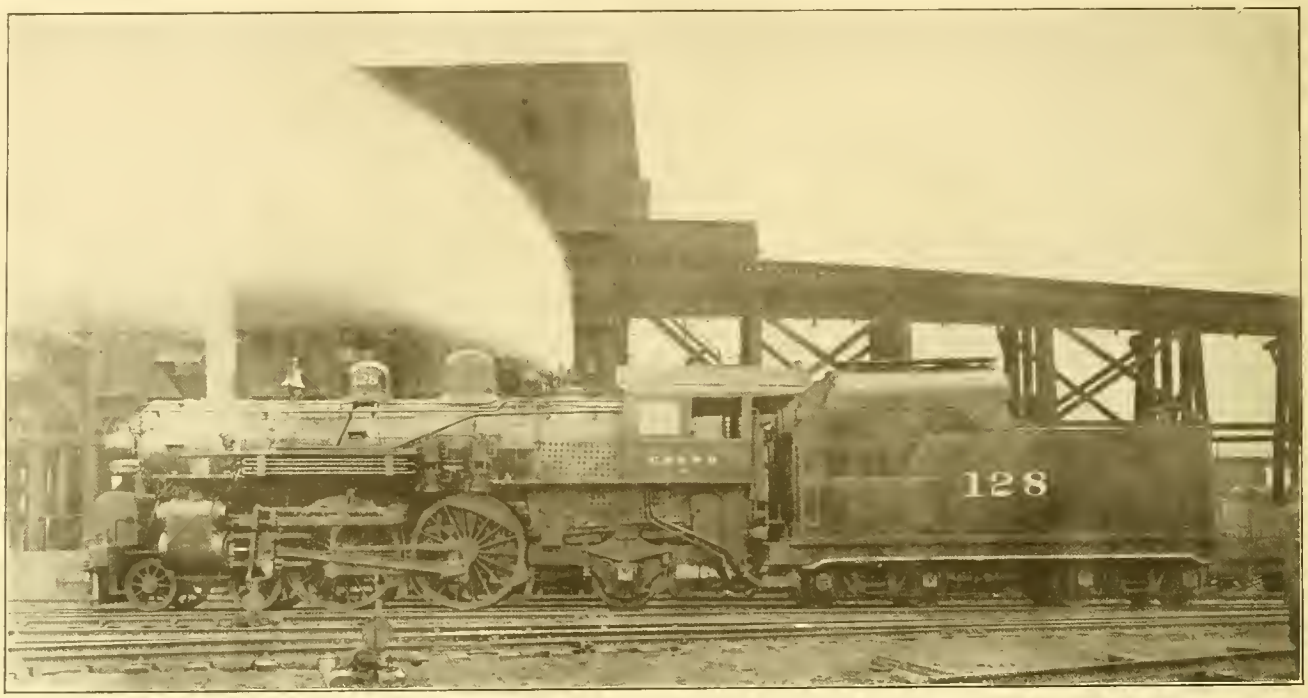

Fig. 2 Chicago and North Western Railway Atlantic Type Passenger Locomotive No. 128, the First to Burn Pulverized Fuel in Regular Fast-Passenger Service

Specifications for Pulverized Fuel

From investigations to date, any solid fuel that, in a dry, pulverized form, has two-thirds of its content combustible, is suitable for steam-generating purposes.

Domestic and steam sizes and qualities of anthracite, bituminous, and semi-bituminous coals and lignite and peat, as well as the inferior grades, such as anthracite culm, dust and slush, and bituminous and lignite slack, screenings and dust, are all suitable for burning in pulverized form.

To produce the best results these fuels should be mechanically dried and milled so that they will be of about the same dryness and fineness as portland cement; or so that the moisture will not exceed 1 per cent, and that 95 per cent of the total will pass through a 100-mesh screen and 85 per cent of the total will pass through a 200-mesh screen. This applies to anthracite as well as to bituminous coals.

Equipment and Cost for Preparing Pulverized Fuel

As over 8,000,000 tons of pulverized fuel are now being used annually in the United States for industrial kilns and furnaces, it is not thought that the equipment or process for preparing pulverized fuel requires any comment.

The total cost to prepare pulverized fuel properly in a suitably equipped drying and pulverizing plant will range from 15 to 45 cents per ton, depending upon the capacity of the plant. For a railway coaling station of average capacity, this total cost will be less than 25 cents per ton, an item which

will be more than offset by the difference in the cost on the tender of the grades of coal purchased for pulverizing and those that are required for burning satisfactorily on grates.

STORAGE AND HANDLING OF PULVERIZED FUEL

The raw fuel should be dried, pulverized and stored in metal or other fireproof material containers in such quantities as are needed to supply the demand. After pulverizing it should not be exposed to open lights or the atmosphere, and the production of light "dust-clouds" should be avoided.

Pulverized fuel should be handled with the same care as fuel oil.

EQUIPMENT FOR SUPPLYING PULVERIZED FUEL TO TENDERS

This consists of one or more overhead storage bins equipped with suitable means for supplying 15 tons of pulverized fuel to a tender in 3 or 4 minutes without exposing the fuel to the atmosphere during its conveyance, or producing any dust-clouds.

Complete control of the fuel flowing to, and of the air exhausting from, the tender must be maintained, and this can only be done by installing special equipment suitable for the requirements.

OPERATION OF PULVERIZED-FUEL-BURNING EQUIPMENT

For firing up a locomotive, the usual steam blower is turned on in the stack, a piece of lighted waste is then entered through the firebox-door opening and placed on the furnace floor, just ahead of the primary arch, after which the pressure fan and one of the fuel and pressure-air feeders are started.

From 45 to 60 min. is ordinarily sufficient to get up 200 lb. of steam pressure from boiler water at 40 deg. fahr.

After firing up, the regulation of the fuel and air supply is adjusted to suit the standing, drifting or working conditions, the stack blower being used only when the locomotive is not using steam.

Fig. 3 The Delaware and Hudson Company Consolidation Locomotive No. 1200 Standing on Exhibition Tracks at Atlantic City, with Pop Valves Blowing and Burning at the Rate of 6,000 lb. of Bituminous Coal Per Hour

The operation of the fuel-burning equipment is as follows:

The prepared fuel, having been supplied to the enclosed fuel tank, gravitates to the conveyor screws, which carry it to the fuel and pressure-air feeders, where it is thoroughly commingled with the pressure-air and carried by it through the connecting hose to the fuel and pressure-air nozzles and blown into the fuel and air mixers.

Additional induced air is supplied in the fuel and air mixers, and this mixture, now in combustible form, is induced into the furnace by the smokebox draft.

The flame produced at the time the combustible mixture enters the furnace obtains its average maximum temperature (from 2500 to 2900 deg. fahr.) at the forward combustion zone under the main arch, and at this point auxiliary air is induced by the smokebox draft to finally complete the combustion process.

The liquid ash runs down the underside of the main arch and the front and sides of the forward combustion zone of the furnace and is precipitated into the self-clearing slag pan, where it accumulates and is air-cooled and solidified into a button of slag which can be readily dumped.

Fig. 4 The Delaware and Hudson Company Consolidation Locomotive No. 1200, the Largest of Its Type in the World, Equipped for Burning Pulverized Fuel

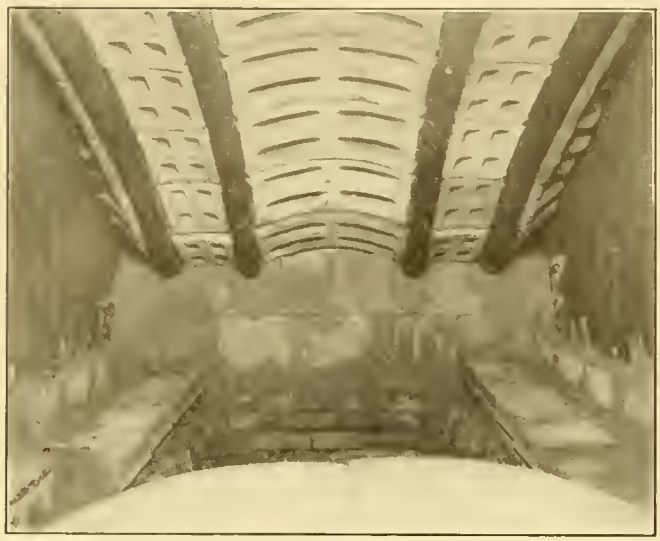

Fig. 5 Final Combustion Chamber at Front of Firepan and Firebox

As each of the fuel and pressure-air feeders has a range in capacity of from 500 to 3000 lb. of pulverized fuel per hour, and as from one to five of these may be easily applied to the ordinary locomotive tender, there is no difficulty in meeting any desired boiler and superheater capacity.

The uniformity with which locomotives can be fired is indicated by the fact that the regularly assigned firemen can maintain the steam within a variation of 2 lb. of the maximum allowable pressure without popping off.

Chemistry of the Combustion of Pulverized Fuel

The principal fuels adaptable for use in pulverized form in locomotives are anthracite, semi-anthracite, semi-bituminous and bituminous coals and lignite and peat. (Pulverized-fuel-burning locomotives are also readily convertible for the use of fuel oil.)

Generally speaking, it is necessary to break up any fuel to such uniform size that the oxygen in the air can unite perfectly for combustion. A deficiency in this respect results in some portions of the fuel passing off as unburnt hydrocarbons, and other portions being left as incompletely burned coke. It is equally important that the proper quantity of air should be admitted to the furnace, as any insufficiency or excess lowers the efficiency.

For e. ample, the preventable fuel loss with 8 per cent of CO_2 in the stack gases will be about 10 per cent, with 12 per cent of CO_2 it is reduced to about 3 per cent, and with 16 per cent of CO_2 there is practically no waste.

As a 1-in. cube of coal exposes but 6 sq. in. of area for absorbing oxygen and liberating heat, but when pulverized to the proper fineness will expose from 20 to 25 sq. ft. of area for oxidation, the first essential for complete combustion is the breaking up of the fuel into dry, minute and uniform particles. Then by diffusing these so that each may be surrounded with the right quantity of air for complete combustion, it will be possible to burn practically all of the available combustible, regardless of the percentage of non-combustible.

The value of a fuel is determined by the quantity of heat that it will generate when burned, and this in turn is dependent upon how much combustible carbon, hydrogen, hydrocarbons and sulphur and how much non-combustible moisture, ash, oxygen and nitrogen it contains.

Of the non-combustibles, ash, which usually contains a mechanical mixture of silica, alumina, iron, lime, potassium, sodium and magnesium, is the most detrimental. Like moisture, it is anti-calorific, and furthermore it acts as an obstruction to the flow of air and gases, reduces boiler capacity and efficiency, and incurs heavy expense and delays in the cleaning of fires and ash pans and in the final disposition of the ash.

The "clinkering" and "honeycombing" of ash is one of the worst troubles to be contended with in the combustion of coal, and its formation may be either chemical or by fusion.

Clinker is of two kinds, "hard" and "soft."

"Hard clinker" is formed by the direct melting of some of the ash content. It hardens as it forms and usually gives but little trouble.

"Soft clinker" is formed by the slagging of the ash and is either pasty or fluid and steadily grows in size.

"Honeycomb" or "flue-sheet" clinker is formed by the condensation or coking of tarry matter or vapor as it strikes against the firebox sheets, and results in the accumulation of a relatively soft, light, ashy substance that grows or spreads over certain of the refractory or metal parts of the furnace.

With the use of pulverized fuel the usual difficulties resulting from the formation of hard and soft clinker on grates are eliminated, but with fuels containing certain intrinsic combinations of ferrous silicates which fuse at comparatively low temperatures (2000 to 2300 deg. fahr.), the honeycomb formation will result when the proper air supply and combustion conditions do not obtain to produce ferric silicates, which fuse at relatively high temperatures (2500 deg. fahr and above). For example, during the process of combustion ferric sulphide

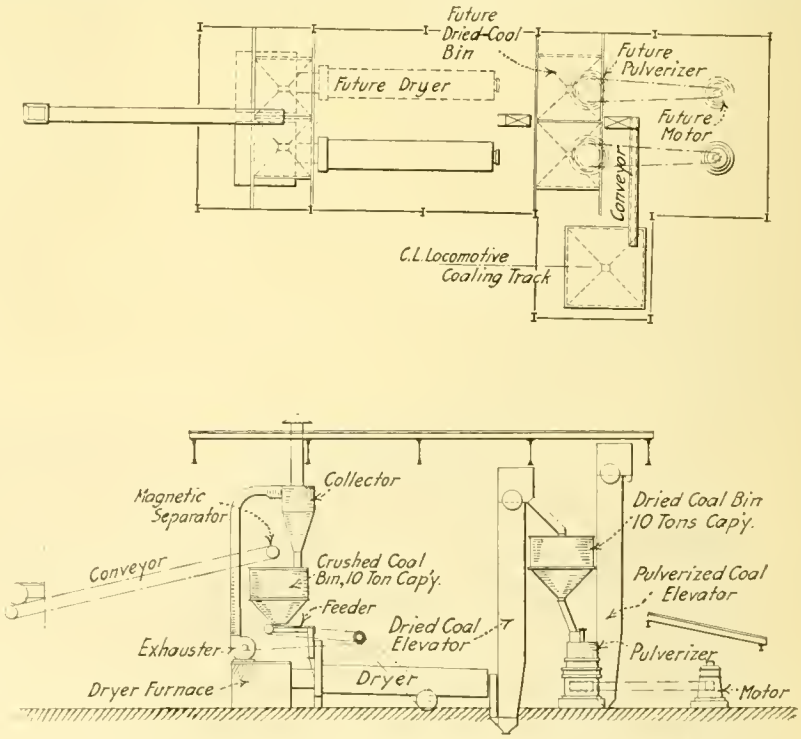

Fig. 6 Typical 8-ton Per Hour Capacity Double Unit Milling Plant, and Single Bin Locomotive Coaling Station

(FeS_2), commonly known in fuel as iron pyrites, is reduced to ferrous sulphide (FeS) as the result of the chemical reduction illustrated by the following formula:

$$FeS_2 = FeS + S.$$

As ferrous sulphide (FeS) melts at a comparatively low temperature (2138 deg. fahr.), it may surround itself with fuel and ash and form a pasty mass which may act as a binder to collect other ferrous sulphide (FeS), fuel and ash, all of which may tend to collect on, and adhere to, the hottest parts of the firebox sheets, such as staybolt heads, flue beads, and like parts which are higher in temperature than the melting point of ferrous sulphide (FeS) and the surrounding metal surfaces, while the temperature of the latter may be lower than the melting point of the ferrous sulphide (FeS).

The following formula shows the result of *incomplete combustion* owing to *insufficient air.*

$$2\,FeS + 2\,O = 2\,FeO + 2S$$

By providing *sufficient air* through an excess supply, the following formula shows the result of *complete combustion:*

$$2\,FeS + 9\,O = Fe_2O_3 + 2\,SO_3$$

For this latter process an oxidizing atmosphere must at all times obtain in the firebox to prevent the reduction of ferric sulphide (FeS_2) to ferrous sulphide (FeS), as expressed in the first formula.

The ferrous sulphide (FeS), as has been shown, is the direct cause of honeycomb, for the reason that it produces ferrous oxide (FeO), which unites with the silica to form a honeycomb that is very fusible at temperatures over 2400 deg. fahr.; whereas by the production of ferric oxide (Fe_2O_3), in combination with the silica present, a highly infusible clinker is formed.

As a general rule an increase in the percentage of silica, alumina and magnesium in the fuel matter will tend to decrease, while an increase in the percentage of iron, lime, potassium and sodium in the fuel matter will tend to increase the fusibility of ash, but in every case a relatively high percentage of ferrous oxide (FeO) resulting from an insufficient supply of air for combustion will be accompanied by honeycomb formation that will tend to adhere to various parts of the firebox.

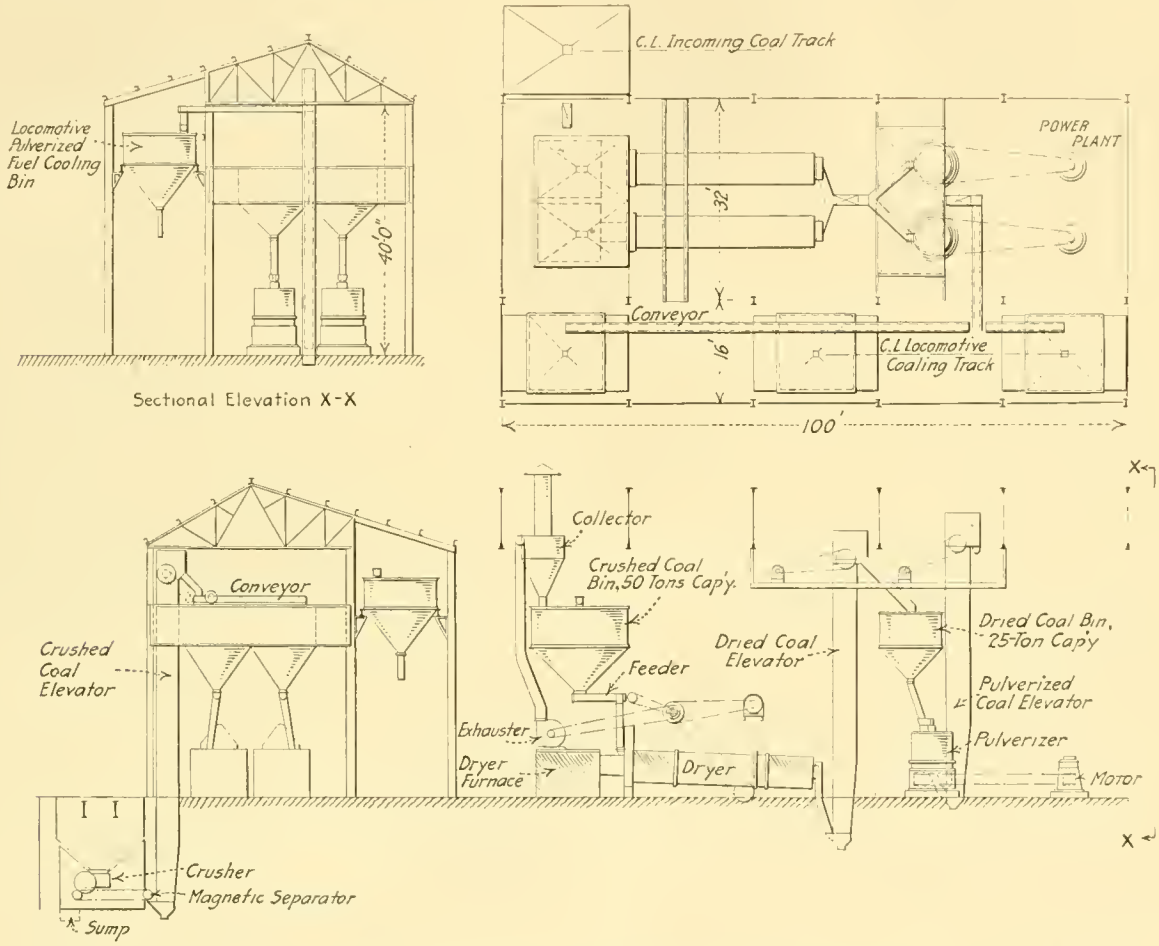

Fig. 7 16-ton Per Hour Capacity Double Unit Milling Plant and Triple Bin Locomotive Coaling Station for the Central Railway of Brazil

LOCOMOTIVE PERFORMANCE

For the fiscal year ended June 30, 1914, the Interstate Commerce Commission reports a total of 64,760 locomotives of all classes in the United States having made a total of 1,755,972,325 miles. This gives an average for each locomotive owned of about 27,115 miles per annum, 74 miles per day, or but little over 3 miles per hour.

From the foregoing figures it is easy to imagine that over one-half of the time of locomotives is now spent at terminals in the hands of the transportation and mechanical departments, and that most of this delay is due to the necessity for cleaning fires, ash pans, flues and smoke boxes; inspecting and repairing draft, grate and ash-pan appliances; and for

firing up and supplying firing tools and equipment. Frequently the delays to locomotives waiting to reach ashpit tracks and to rekindle fires exceeds the time required to do this work, and during the interim much fuel is needlessly consumed and the boiler subjected to excessive contraction and expansion.

With pulverized fuel a locomotive having the boiler filled with cold water may be brought under maximum steam pressure within an hour, and the fuel feed then stopped until it is called for service. When standing or drifting at terminals or on the road, the fuel feed can also be discontinued, as the steam pressure can always be quickly raised. After the trip or day's work the locomotive can be immediately stored or housed, the usual ashpit delays being entirely eliminated.

The possibilities for increasing the productive time of existing locomotives and for relieving terminal congestions that are now brought about by the necessity for cleaning and rebuilding fires on grates makes the use of pulverized fuel one of the most attractive and quickest methods for increasing the earning capacity of present single- and double-tracked steam railways.

RESULTS OBTAINED FROM USE OF PULVERIZED FUEL

From the actual operation of steam locomotives in regular train service the use of pulverized fuel has demonstrated in particular the practicability of eliminating smoke, cinders, sparks and fire hazards; increasing draw-bar horsepower per hour per unit of weight; improving the thermal effectiveness of the steam locomotive as a whole; reducing non-productive time at terminals; utilizing otherwise unsuitable or waste fuels; eliminating arduous labor; providing greater continuity of service and producing more effective and economical operation and maintenance.

The performances given in Table 1 may be of interest. They relate to a ten-wheel type of freight locomotive, rated at 31,000 lb. of cylinder tractive power, with 69-in. diameter driver wheels, when used in fast through-freight service on runs of from 91 to 138 miles in length for the purpose of testing various fuels under identical adjustment conditions.

TABLE 1 PERFORMANCES OF TEN-WHEEL TYPE OF FREIGHT LOCOMOTIVE

Item	Pulverized		
	No. 1 Bituminous	No. 2 Bituminous	No. 3 Bituminous
Fuel:			
Fineness, per cent through 200 mesh	0.85	0.85	0.85
Moisture, per cent	0.40	0.81	0.59
Volatile, per cent	24.72	36.27	24.36
Fixed carbon, per cent	68.43	58.29	65.05
Ash, per cent	6.85	5.44	10.59
Sulphur, per cent	1.96	0.68	0.84
B.t.u. per lb	14,739	14,334	13,912
Miles run, total	1,324	426	398
Cars per train, average	61	65	60
Adjusted tonnage per train, average	1,719	1,808	1,759
Speed when train was in motion, miles per hour, average	26	25	24
Boiler pressure when using steam (200 lb.), average	198.3	193.5	194.9
Front-end draft when using steam, ins. of water, average	7.15	7.79	6.69
Firebox draft when using steam, ins. of water, average	3.50	3.22	3.18
Temperature of steam, deg. fahr.	562	573	555
Coal fired per hour of running time, lb. (average)	3,275	3,063	3,457
Adjusted ton-miles per lb. of coal (average)	12.84	13.97	11.59

The locomotive was worked at its maximum capacity on all trips, about 10 per cent more tonnage being hauled than usual for like locomotives burning coal on grates, and at practically fast-freight schedule speed. The exhaust-nozzle opening was about 25 per cent larger than the maximum for hand firing.

The general results were excellent, particularly as regards tonnage, speed, combustion, and steam pressure, the latter being maintained at full speed with injector supplying the maximum amount of water to the boiler.

With the highest-sulphur coal (No. 1) and the highest-ash coal (No. 3) there was less than 1 cu. ft. of slag in the slag box at the end of each run, and practically no collection of ash or soot on the flue or firebox sheets. In fact, with the No. 3 fuel there was less than two handfuls of slag, ash and soot collected on each trip.

The steam railways in the anthracite coal-mining district generally use for their locomotive fuel mixtures which will run from 25 to 50 per cent bituminous and the balance of anthracite pea and buck sizes which will pass through a 7/8-in. and over a 5/16-in. round opening. As anthracite coal is very low in volatile, ignites slowly, and is a poor conductor of heat, the bituminous mixture is used to overcome the trouble this causes when the smaller sizes must be burned on grates, and even then it necessitates the use of unusually small exhaust nozzles to create sufficient draft.

In the experiments with pulverized anthracite fuel for locomotives the idea has been to utilize the grade of coal of lowest commercial value, such as birdseye, which is of a size that will pass through a 5/16-in. and over a 1/16-in. round opening, as well as the refuse called culm or slush, which passes through the 1/16-in. round opening and is usually wasted in the washery water or used for back-filling the mines.

To reclaim this slush a couple of wooden bins were installed, through which the washery water could be finally passed for the collection of the solid matter.

The analyses of the various fuels used may be approximated as given in Table 2.

TABLE 2 ANALYSES OF FUELS USED IN EXPERIMENTS

Item	Pulverized		
	Bituminous	Anthracite	
	Run-of-Mine	Birdseye	Slush
Moisture, per cent	0.50	0.50	1.00
Volatile, per cent	29.50	7.50	6.00
Fixed carbon, per cent	60.00	77.00	71.00
Ash, per cent	10.00	15.00	22.00
Sulphur, per cent	1.50	1.00	2.5
B.t.u. per lb	13,750	12,750	11,250
Fineness, per cent through 200 mesh	86.00	86.00	86.00

At the commencement of the development work the locomotive was equipped with an arrangement of refractory baffles and fuel and air inlets for burning 100 per cent bituminous coal, and after this has been properly accomplished successive adjustments were made to burn mixtures:

First: 75 per cent Run-of-Mine Bituminous and 25 per cent Anthracite Birdseye
Second: 67 per cent Run-of-Mine Bituminous and 33 per cent Anthracite Birdseye
Third: 60 per cent Run-of-Mine Bituminous and 40 per cent Anthracite Birdseye
Fourth: 60 per cent Run-of-Mine Bituminous and 40 per cent Anthracite Slush
Fifth: 50 per cent Run-of-Mine Bituminous and 50 per cent Anthracite Slush
Sixth: 40 per cent Run-of-Mine Bituminous and 60 per cent Anthracite Slush

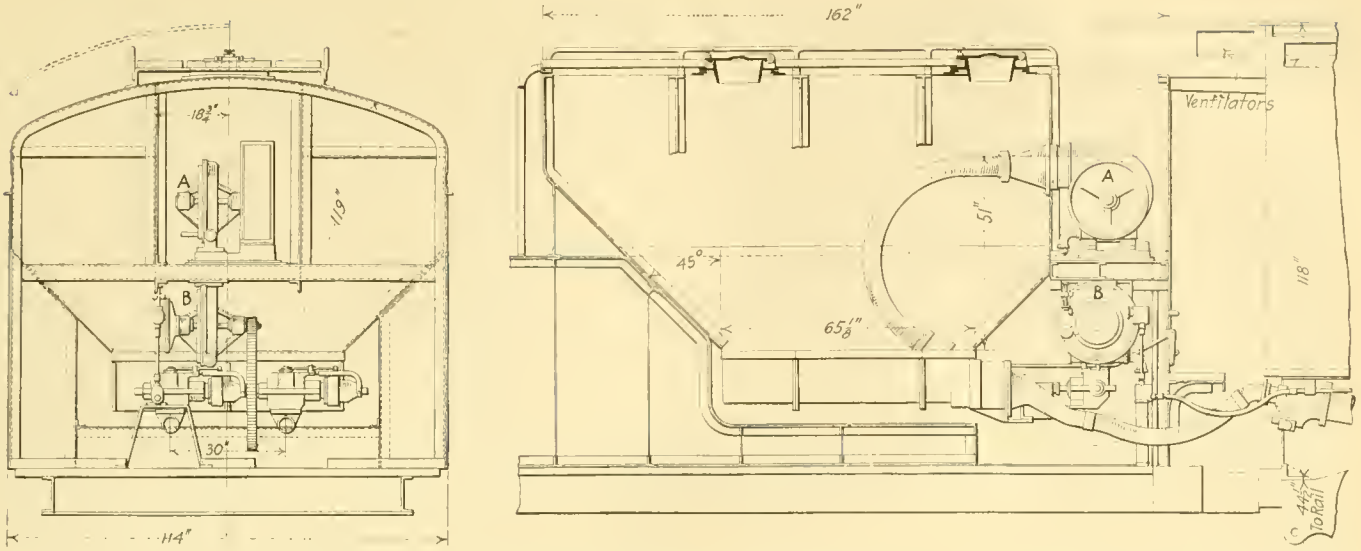

Fig. 8 Double Feeder Equipment as Applied to Tender for 10-wheel Type of Passenger Locomotive for the Central Railway of Brazil

Further work along this same line will determine just how great a percentage of anthracite slush can be used to the best advantage, but the evaporative results so far obtained, *i.e.*, about 7 lb. of water from feed-water temperature per lb. of coal, indicates that considerably more than a 60 per cent anthracite slush mixture may be utilized. This accomplishment not only means a decrease of 25 per cent in the cost per ton for locomotive fuel, but also the release of a large tonnage of commercial anthracite, which is becoming more scarce and in greater demand each year.

The principal trouble to be overcome has been on the intermittent runs, as it is more difficult to maintain proper combustion with a slow fire and to re-ignite the fuel after the feed has been stopped for a time, with the low than with the higher volatile coals.

The same increase can be made in the size of the exhaust

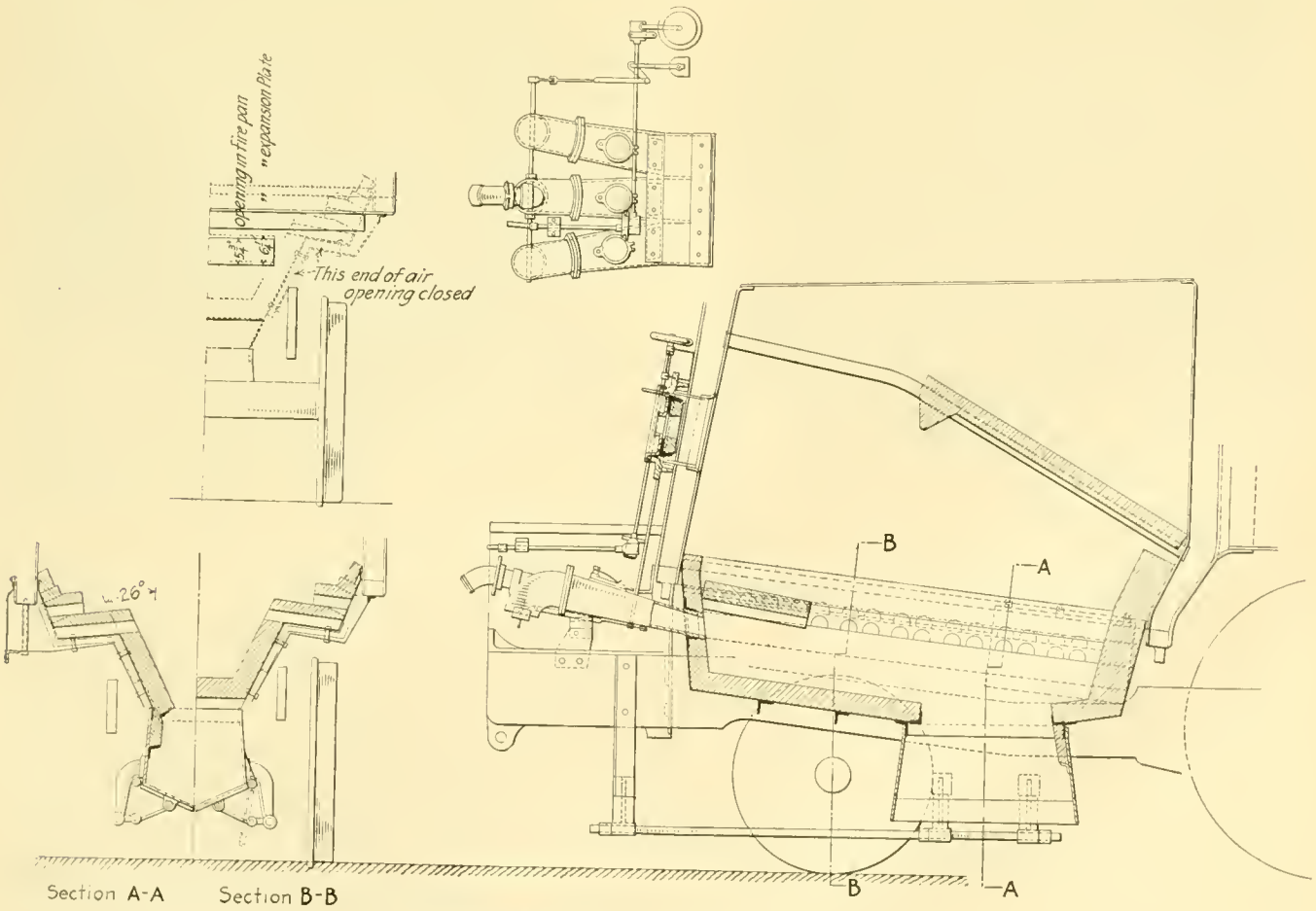

Fig. 9 Triple Burner and Fire-pan Equipment as Applied to Pacific Type of Locomotive for the New York Central Railroad

nozzle openings (about 25 per cent) for anthracite as for bituminous coal when burning in pulverized form, as compared with hand firing of coal on grates.

The development of sufficient drawbar pull in a consolidation type of freight locomotive with 63-in. diameter driver wheels, rated at 61,400 lb. of cylinder tractive power, to haul a freight train of 23 loaded cars (representing about 1562 actual tons) over a ruling grade of 1½ miles of 1.65 per cent grade with a 6-deg. curvature, further indicates the advantages of sustained boiler horsepower in combination with reduced cylinder back pressure, which is only made possible by this method of stoking and burning coal.

NOTES UPON PERFORMANCE

From tests made with pulverized lignite having an analysis of about 1.8 per cent moisture, 47 per cent volatile, 41 per cent fixed carbon, 9.5 per cent ash, and 0.75 per cent sulphur, and a heating value of 10,900 B.t.u. per lb., in regular passenger locomotive service, the same satisfactory results were obtained as with bituminous coals, the combustion and operating being entirely smokeless, sparkless and cinderless, and the steam pressure being fully maintained.

With pulverized fuel the control of the fuel feed and thereby of the over- or under-production of steam is nearly perfect. A locomotive can be fired up and the fuel consumption then stopped until a few minutes before starting time. At the end of the run, or when drifting, the fire can be extinguished at will and quickly re-ignited without any special equipment or materials. A locomotive with boiler full of water and 185 pounds of steam pressure, after standing 11 hours, without fire, still had 80 pounds of steam pressure.

Comparative tests made between similar locomotives in the same service resulted in the use of 2,775 lb. of lump coal, hand-fired, to get up steam and for terminal handling and dead time, as compared with 1569 lb. of pulverized screenings to produce the same result, or an increase of over 75 per cent. The greatest saving is in the firing up alone, this requiring 1700 lb. of lump coal as compared with 750 lb. of pulverized screenings, or an increase of over 225 per cent.

In the engine-house terminal handling there is the least possible delay and expense. No more time or facilities are required than for fuel-oil-burning locomotives. A locomotive fired up at 6 a. m. can leave with its train at 7 a. m., and upon arrival at the destination engine house can be immediately fueled, watered and housed, the slag pan being dumped over the engine stall pit.

Delays incident to building and preparing fires and cleaning ashpans out-bound, and for waiting to get on ashpits and to inspect and clean fires, grates, smokeboxes and ashpans in-bound are entirely eliminated, as is also the necessity for subjecting fireboxes and flues to the chilling effect of cold air due to standing around and hostlering.

Through the possibility of enlarging exhaust-nozzle openings from 25 to 50 per cent as compared with the areas required for burning coal on grates or fuel oil, the full benefit of expenditures for improved cylinders, valves and valve gears, particularly in connection with cylinders of large volume, can now be obtained. Heretofore the necessity for maintaining relatively small exhaust-nozzle openings to produce the required firebox draft has enabled but little benefit to be gained from improved steam distribution, as cylinder back pressures of from 15 to 30 lb. when operating at maximum capacity of engine and boiler are not at all uncommon in some of the most recently built stoker-fired single-expansion locomotives. As every pound of cylinder back pressure saved is equal to at least 2 lb. added to the boiler pressure when a locomotive is working at its maximum capacity, and further provides freer movement and less wear, tear and fuel consumption, the benefits to be derived are obvious.

As the limiting factor of a steam locomotive is, or should be, the ability of the boiler to produce steam, the rate and effectiveness of combustion become the controlling factors. When coal is burned on grates a rate of about 50 lb. of run-of-mine, and of about 60 lb. of lump bituminous coal, per sq. ft. or fire surface per hour is the maximum allowable for the greatest boiler efficiency. However, as this limits the rate of consumption to a total of from 3,000 to 6,900 lb. per hour for the average modern locomotive of great power, and as the actual coal supplied to the firebox by mechanical stoking frequently reaches a rate of 150 lb. per sq. ft. of grate area, or a total of from 9,000 to 15,000 lb. per hour, the boiler efficiencies frequently run as low as from 55 to 45 per cent and even less. Therefore the necessity for eliminating grates if much over 12 lb. of water per sq. ft. of evaporating surface per hour is to be obtained with reasonable efficiency.

From results established during the past six months, the quantity of live steam required for the operation of pulverized-fuel-burning equipment when the locomotive is being worked at its maximum boiler-horsepower capacity, is about 1½ per cent of the saturated steam generated, which is considerably less than what is required for the steam-jet operation of mechanical stokers when firing coal on grates, and very much less as compared with what is used in the generally existing steam-jet practice of burning fuel oil; this latter amount, according to reports made by the U. S. Naval Board, is approximately about 6 per cent of the total steam generated, exclusive of the reduction of efficiency in combustion due to the evaporation of steam into hydrogen and oxygen and back into H_2O in the firebox.

Comparing the use of pulverized fuel and fuel oil for steam-locomotive purposes, it may be stated that with pulverized coal at 13,750 B.t.u., costing $2.35 per ton, and fuel oil at 19,500 B.t.u., costing $2.75 per ton, an amount of at least $2.50 must be expended for the fuel oil necessary to perform the same useful work as will obtain from $1.00 expended for pulverized fuel.

As anthracite slush is not burned on grates, no comparison is available for the pulverized performance. However, comparing the performance of anthracite birdseye hand-fired on grates equipped with forced blast below and induced draft above the fire, with the same fuel pulverized and burned in suspension, there is an average increase of over 40 per cent in the evaporation in favor of the latter.

In general, it may be stated that the use of pulverized anthracite slush will double the steam-generating capacity of boilers now burning birdseye anthracite hand-fired on grates, and at the same time eliminate fire cleaning, greatly decrease the amount of ash to be handled, and reduce the boiler-plant labor cost about 40 per cent. Furthermore, with the pulverized fuel the boiler pressure can be more readily maintained or increased or reduced to meet the requirements, and when one or more of the boilers are not needed temporarily, the fuel feed can be stopped and started at will, thereby eliminating the necessity for maintaining banked fires and burning fuel when not required in order to have the boilers ready for instant use.

STEAM BOILER PAPERS

TWO of the steam boiler papers to be presented and discussed at the Friday morning session in charge of the Boiler Code Committee are given below. The first of these describes a new type of contra-flow boiler. The second is a practical paper on safety valves.

THE TALBOT BOILER

By PAUL A. TALBOT, NEW YORK, N. Y.
Non-Member

THIS is essentially a boiler of the contra-flow type, water entering near the stack and leaving in the form of steam near the furnace. The circulation is through water tubes and is forced at a high velocity by means of a pump, doing away with a water drum. By preventing gravity circulation, the steam is drawn directly from the lower tubes, eliminating the steam drum. The boiler is internally fired, and hence self-contained. Feed water and fuel burners are automatically controlled to adjust the boiler to widely varying demands for steam. The boiler should not be confused with "flash" boilers in which the heat-charged tubes furnish steam in direct proportion to the feed supply without regard to the control of the fire. By means of the high velocity, forced circulation and contra-flow principles, the evaporative capacity of the boiler is largely increased.

Any or all of the tubes may be readily removed and replaced without disturbing any manifolds, pipes or connections. Official tests recently carried out in the Navy Yard, New York, included a tube renewal test of a 100-horsepower boiler. A tube was removed from the boiler under 250 lb. steam pressure and replaced by another tube in 61 seconds, the total period between the time of shutting off the fire and feed water and the time of regaining full pressure and maximum capacity of operation being 3 minutes and 16 seconds.

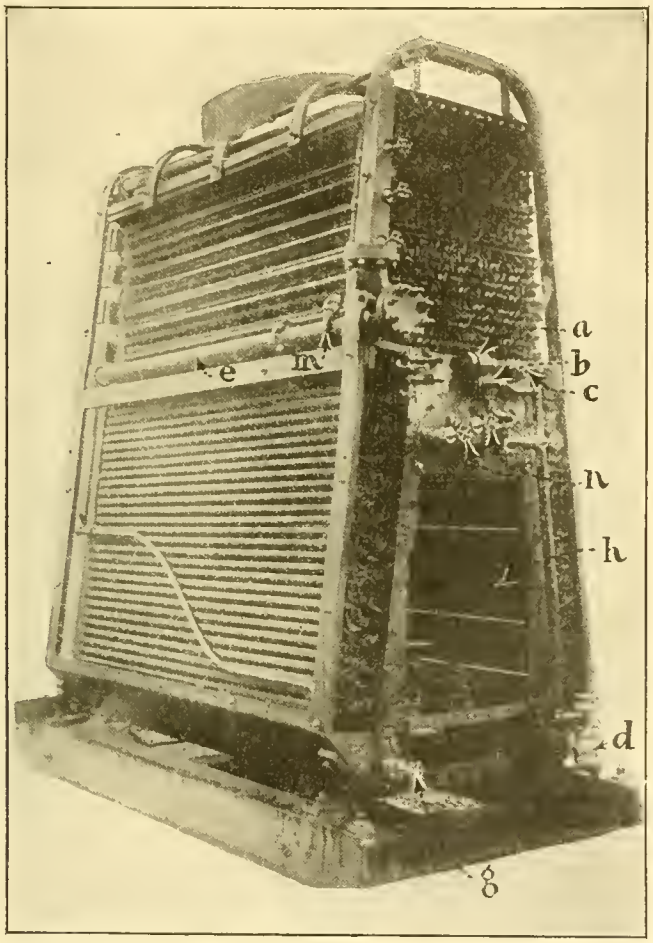

Fig. 1 Front of Boiler, Casing Removed

a Automatic regulator valve, *b* Oil valve, *c* Hand valve, *d* Main check valve, *e* Main steam pipe, *f* Separator, *g* Separator drain, *h* Combustion space, *m* Atomizer pipe, *n* Burner valves

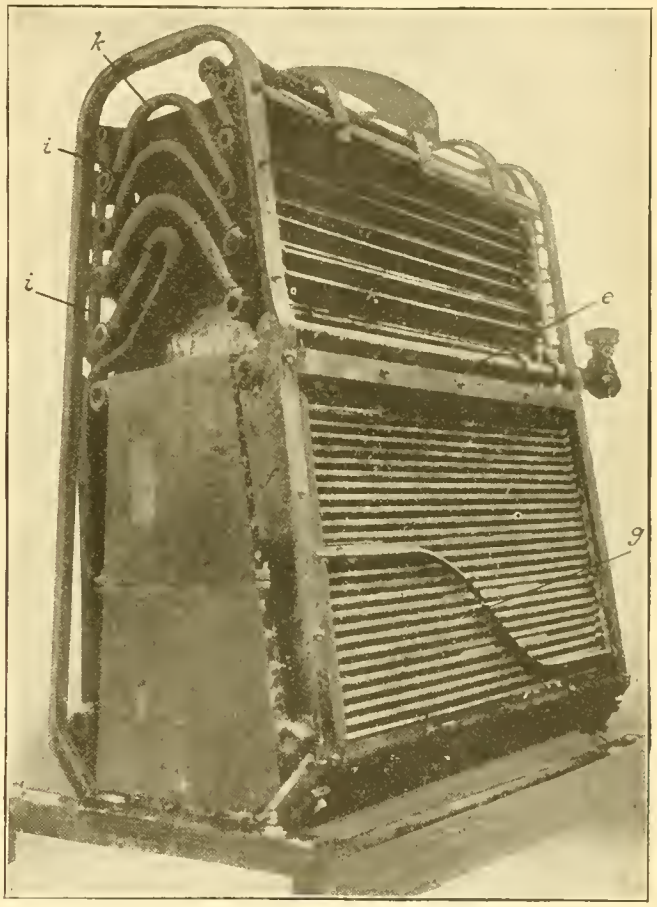

Fig. 2 Rear of Boiler, Casing Removed

f Separator, *e* Main steam pipe, *g* Separator drain, *i* Feed pipe, *k* Trap

CONSTRUCTION

An idea of the general construction of the boiler may be obtained from Figs. 1 and 2. Fig. 1 shows the front and Fig. 2 the rear of the boiler with the casing removed. Fig. 3 shows the complete boiler with its casing. The illustrations are of a boiler having an evaporation of 15,000 lb. of water per hour with ¼ in. of water draft, 20,000 lb. per hour with 1 in. draft, and double the normal capacity at slightly above 2 in. draft.

The frame consists of front and rear sections, roughly re-

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision.

sembling horseshoes in shape, fastened together at top and sides by lateral ties and at the bottom by the ash pan and additional ties. The stack ring and upper panel work are supported by frame work bent to conform to the curve of the front and rear frames. For fastening the boiler in position, feet are provided which are bolted to the main frame through the ash pan. The door frame, of angle cross-section, is fastened at the top and bottom to the main frame, and serves as a support for regulating valves shown in Figs. 1 and 3 and described more fully later.

The tubes throughout the boiler are all alike. As will be seen in Fig. 4, the crucible steel header consists of two sets of overlapping compartments, into one of which is screwed the open-end field tubes, and into the other the generating

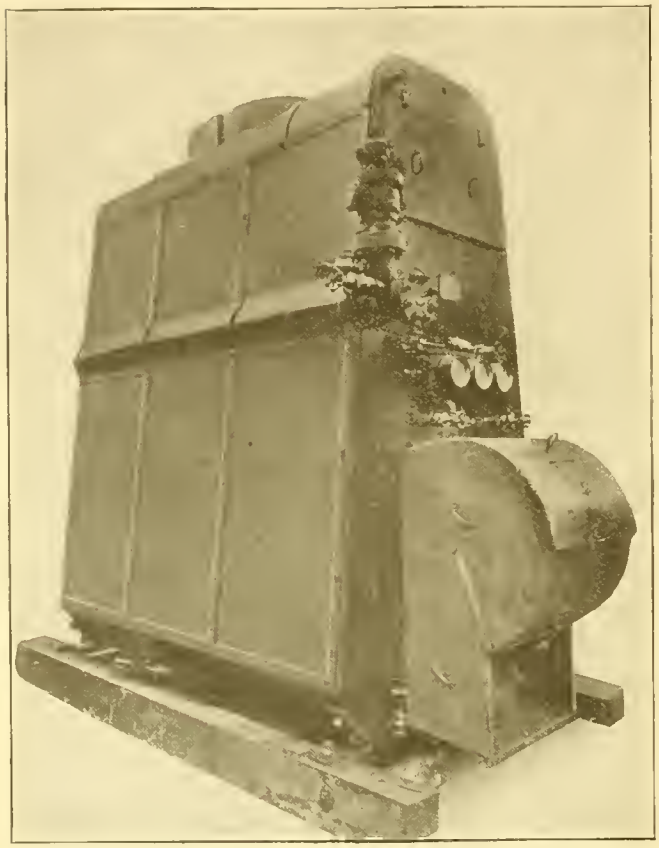

Fig. 3 Front of Boiler with Casing

a Automatic regulator valve, *c* Hand valve, *n* Burner valves

tubes, there being an annular space between the two tubes. The end of each generating tube is welded together so as to close it. These closed ends are free to expand and are supported in front by perforated sheets of metal. The method of fastening the tubes into the headers is shown in Fig. 5. Both tubes are threaded with double the standard taper, which makes it easy to remove them. The fit is sufficiently tight to hold a pressure of 1000 lb. per sq. in., using standard weight pipe.

Five sets of tubes with horizontal headers are placed above the combustion space, and on each side of the combustion space is placed another set of tubes with headers arranged vertically. The rear of the furnace is closed by a wall containing water-circulating passages connecting the tubes on the sides, as shown in Fig. 2.

Between each set of headers is a *trap connection,* shown in Fig. 2. These traps perform the important function of preventing water from draining by gravity from one header to the next below until sufficient water is forced into the upper header. The formation of steam prevents the water from syphoning when circulation is at rest, and the correct amount of water is thus maintained in each header, in readiness for full capacity demands.

Accessibility. There are three doors in the front of the boiler, which, when opened, give access to the free ends of all the tubes. Any tube can be removed by applying a wrench to its end and unscrewing it from its header.

OPERATION

The circulation of water is maintained by a pump, delivering the feed water to the main check valve at the bottom of the doorframe, from whence the water rises in a core and passes around the door frame to the regulator valve. The water then passes to the rear of the boiler to the uppermost set of tubes. In order to understand the circulation through the tubes, reference must be made to Fig. 4, which shows a typical header and tubes forming a single section, the path of water through it being indicated by arrows.

Having passed through the first set of field tubes and returned to the inner compartment of the header by way of the annular space in the generating tube, the water returns to the front of the boiler through a similar annular space in the next set of tubes and back to the outer compartment of the header by way of the inner field tubes. This process is repeated until the water has traversed to the opposite end of the header, where it passes out, through a trap connection, to the header immediately below. Passing from header to header the water has a general downward direction to the set of tubes, which is on the left side of the furnace, as seen in Fig. 2. The circulation through all sections of tubes is the same.

Referring to Fig. 2, the steam or water from the set of tubes on the left of the furnace enters a rear wall, which is partitioned to carry it at high velocity from one side to the other until it is finally discharged, at the bottom of the right-hand corner, into the set of tubes on the right side of the combustion chamber.

During this passage the water has gradually changed to steam, and it now leaves the last set of tubes through the herringbone steam separator at the back of the boiler and enters the steam pipe, crossing to the front of the boiler, where safety valve and steam nozzle are located. The separator drain passes to the front of the boiler, where the valve controlling it is located.

The length of water passage from the point of entering the boiler to the point of leaving it varies with the size of the boiler. The passage in a 1000-horsepower boiler is 795 ft. long, 668 ft. of which is through tubes. The areas through which the water flows also vary with the boiler and are restricted to increase the velocity of flow.

The friction of water and steam by reason of the restricted areas is about 100 lb. at normal load. This friction increases as the load increases.

The velocity through the boilers in which larger tubes are used is much greater than when smaller tubes are used. Thus the velocity of the steam in the last stages of the boiler varies from 6000 to 12,000 ft. per min., depending upon the size of boiler tubes used. This velocity increases, of course, as steam is formed, so that the velocity in a large boiler is about 500 ft. per min. in the first and 12,000 ft. per min. in the last passages when in the form of steam.

A high rate of evaporation is obtained because of the high

velocity of water through the tubes. The tubes which line the furnace evaporate as much as 30 lb. of water per sq. ft. of heating surface, while the average, including economizer and superheating surface, is 8 lb. per square foot at rated capacity.

The formation of scale is prevented by the high velocity and consequent scouring action of the water, which keeps the solids in constant motion. The actual velocity great enough to prevent scale formation is not known, but it has been determined that with a velocity as low as 60 ft. per min. and very poor water, mud forms in the economizer section of the boiler. The water tested was alkali, of 27 degrees hardness, such as is found in desert regions. With a normal velocity of 500 ft. per min., such as is used, a minimum velocity of 150 ft. per min. can be maintained at partial loads. It has been found that at very low velocities the deposits have been confined to the water portion of the boiler where the temperatures are between 100 and 150 deg. fahr. As the entire heating surface is active and subjected to these high velocities, feed-water purifiers are not necessary for this boiler.

The soot blower. The soot which forms on the economizer

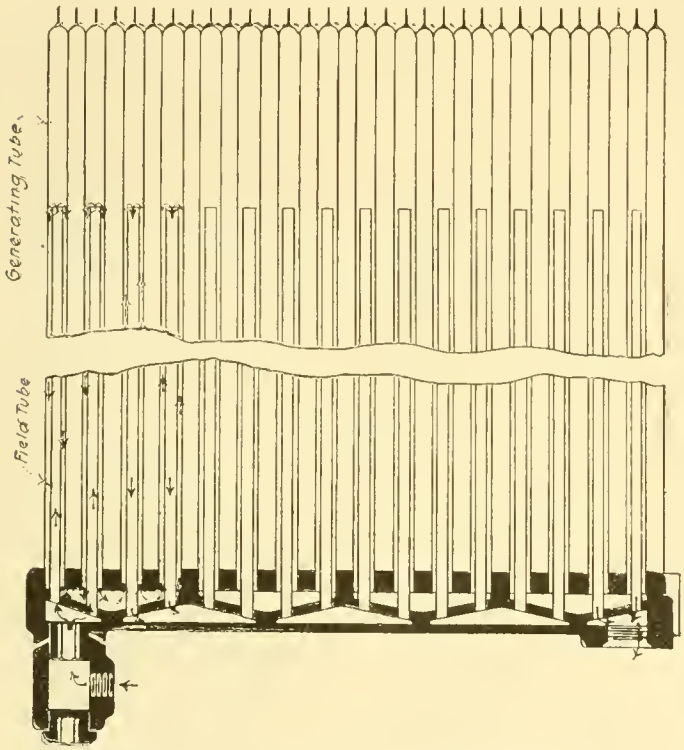

Fig. 4 Diagrammatic Section through Header and Tubes
Arrows show Course of Water Circulation

surface of the upper sets of tubes is blown from them by longitudinally directed steam jets situated near the ends of the tubes. Steam is supplied from the main steam pipe, and valves for the control of the jets are on the front of the boiler. The jets have proved a satisfactory method of keeping the surface relatively free from soot. The tubes at the sides of the furnace are practically free from soot, and it is probable that if any soot collects on them it eventually ignites. Exterior as well as interior surfaces of the boiler, therefore, are always clean, eliminating the periodic overhauling and cleaning.

THERMOSTATIC CONTROL

The expansion of one of the tubes of the last set at the side of the furnace under the varying temperatures of steam contained within it, is multiplied by means of levers and utilized as an automatic thermostatic control of both water and fuel supply. Arrangement is made so that the operator may easily and quickly adjust the thermostat to meet the demands. The slightest rise in temperature of the outgoing steam causes sufficient expansion of the tube to open the regulating valve on the front of the boiler and admit a greater quantity of water, thus lowering the temperature of the steam. In case the operation of the thermostat has not prevented the rise in temperature, as might happen under partial load or insufficient water supply, it will cut off the supply of fuel to the furnace. At low temperatures the supply of fuel is increased by this same thermostat.

Details of the thermostat. The expansion and contraction of the tube and the movement of the regulating valve is shown

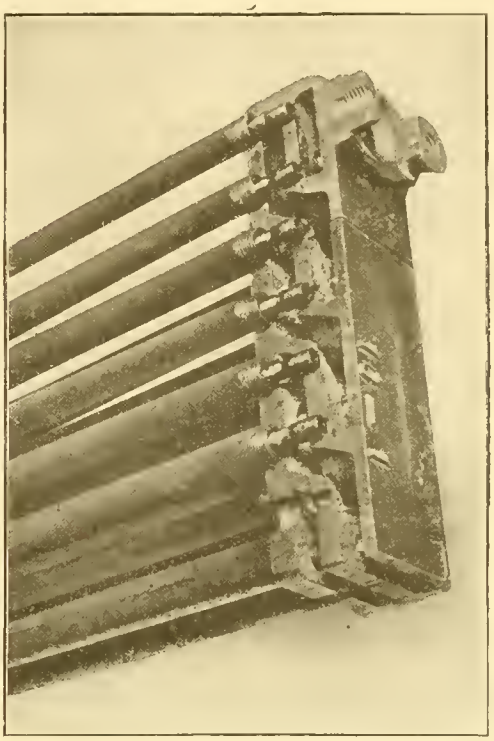

Fig. 5 Inserting Tubes in Header

by a gage, which is arbitrarily graduated for convenience in indicating the relative temperatures, and may be calibrated by means of a mercurial thermometer so that the operator may judge from it the temperature of the steam. Thus it might be determined that with a gage reading 2⅜ the temperature of the steam is 650 deg. fahr. Having determined the point for the temperature he desires, the operator can regulate the thermostat to maintain the gage at this point. This reading is checked occasionally, as changes in the frame, header or tube, due to wear or seasoning, may make corresponding changes in the calibration of the gage, so that some other point registers the 650 deg. which the operator is trying to maintain. This temperature gage serves the purpose of the water column of the ordinary boiler. The temperature of the steam delivered tells the operator whether or not the supply of water is adequate, as it is obvious that with too little water at full capacity the temperature of the steam will rise and indicate this condition on the gage.

Hand valve. The action of the automatic valve is fairly close, but, due to the fact that the regulator tube is not instantly affected, there occur periodic changes in temperature and pressure. A hand valve is provided for eliminating this action under normal loads. This valve is arranged to shut

off completely the supply of water when closed, and is marked with arbitrary graduations from which the operator may determine at what point it should be set for the best results. When the hand valve is closed too much, it is obvious that the supply of water may be so limited that the temperature will rise to a point where the fuel valve will close. When the valve is opened too much, there will be a periodic variation in the temperature of the steam due to the lag of the controlling thermostat. The point should be determined, therefore, which will allow the regulating valve to be opened all of the time, preventing the periodic variation in temperature due to too frequent shutting down of the fuel valve. The accuracy of adjusting this valve determines the accuracy of temperature control under full-load conditions. Experience has shown that on a 25 per cent load the valve does not require adjustment, but the temperature of the steam will be much less due to an over supply of water to a reduced fire. By readjustment of the valve the full-load temperature can be maintained at fractional loads. At less than 25 per cent capacity, a readjustment is necessary to prevent the periodic variation in temperature. The ordinary fireman can easily maintain a constant pressure and temperature by means of this hand valve.

OIL BURNER

A steam atomizer oil burner is arranged at the front of the boiler near the top of the inflow of air for combustion. The air is heated and carried in a general downward direction by the air duct, a sheet-metal addition to the front of the boiler having an S-shaped air channel. (See Fig. 3.) The quantity of air can be adjusted by dampers in this duct. Highly superheated steam is used to heat and vaporize the oil and to promote the velocity of the hydrocarbon mixture which issues from the burner tips. Very heavy Mexican oil, 11 Baumé can be used in this burner. A number of burner tips shoot the flame downward into a firebrick target at the lower rear end of the furnace. This refractory target or oven is designed to distribute the heat uniformly over the entire heating surface. Temperatures of 3800 deg. fahr. are obtained within this oven, but, as few bricks are used, the upkeep cost is small.

The intensity of the fire is easily controlled by increasing or decreasing the volume of steam used in atomizing the oil. The flame has the effect of a large blow torch, and as the velocity is carried to an extreme, considerable noise is experienced. This is not a detracting feature in marine practice, as it is confined to the fire room.

FURNACE JACKET

As the heating surface surrounds the furnace on all sides, the insulation of the jacket is easily accomplished. The insulating material is applied in plastic form and fills the entire space between the sheet-metal casing and the tubes themselves. While this system is preferred, the various methods of applying insulating material in boilers having sheet-metal jackets may be used, or brick settings may be installed where space, weight and vibration are not points for consideration.

EFFECT OF FORCING

The thermal efficiency of this type of boiler is affected in much the same manner as in boilers of other types, although the drop in the efficiency curve is not so pronounced at higher draft pressures and higher evaporative rates, due to the fact that when forced the economizer surface in the upper part of the boiler is correspondingly increased and the stack temperatures are relatively lower. More water is introduced, and the superheating surface is reduced nearly in proportion as the load is increased.

AN ANALYSIS OF MARINE SAFETY VALVES

With Suggestions for Repairs and Improvements

BY E. F. MAAS, PUGET SOUND, WASH.

Member of the Society

THE PURPOSE of this article is not to give a complete description of all marine safety valves to be found on the market today, but to analyze certain characteristics of

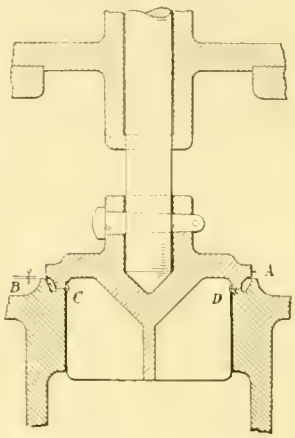

Fig. 1 Old Type of Safety Valve

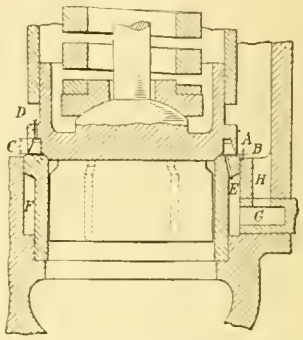

Fig. 2 Later Type of Valve with Adjustable Blow-Down

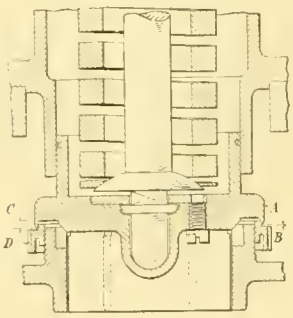

Fig. 3 Modern Safety Valve with Adjustable Blow-Down

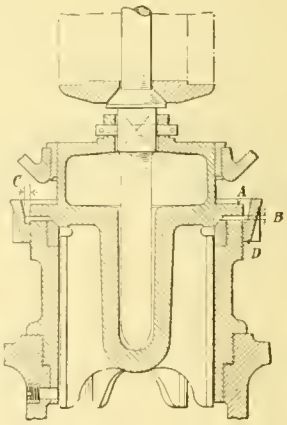

Fig. 4 Recent Type of Marine Safety Valve

some of the more common types, to indicate advantages and difficulties to be expected with them, and to point out helpful methods in repairing and improving old valves. The paper presents the results of observations made on valves under working conditions and during tests of repaired valves in the mechanical laboratory.

For presentation at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 5 to 8, 1916. The paper is here printed in abstract form, and advance copies of the complete paper may be obtained gratis upon application. All papers are subject to revision

Fig. 1 represents a valve of an obsolete design, probably not being made by any manufacturer today. This type is still to be found in many of the older ships and should be taken in consideration. Fig. 2 shows a later type of valve having attachment for adjusting the blow-down, an indispensable feature in a modern marine safety valve. Fig. 3 is much the same as Fig. 2, the main difference between them being in the design of the blow-down adjustment. Fig. 4 represents one of the latest and most successful designs at the present time. In Fig. 5 is shown a valve which has not yet fully emerged from the experimental stage, but one for which a preliminary analysis and test reports show great possibilities. Figs. 6 and 7 show modifications made to valves of the type represented by Fig. 3, these modifications having been applied during the repair of these valves in order to fit them for further service after their original working adjustment had been destroyed through long service or neglect in maintenance.

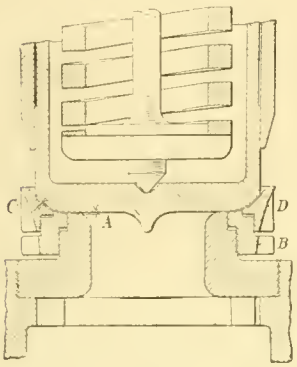

Fig. 5 Experimental Valve

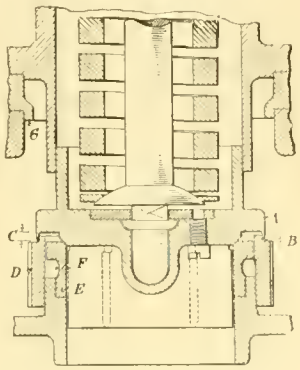

Fig. 6 Modified Safety Valve of Type 3

The features discussed in this paper are:

a Valve seat, flat or beveled, and tightness
b Pop of valve, amount of simmering before pop, and height of lift
c Closure of valve, and chattering at closure
d Blow-down of valve, and methods for adjusting
e Discharge capacity
f Repair and adjustment of old valves and improvements accomplished at slight expense

VALVE SEAT

A glance at the seven figures will disclose the fact that valves in Figs. 1 and 5 have flat seats, the other five having beveled seats. While there are good arguments on both sides, the experience of the author has been that a flat seat is just as easy to grind in and make tight as a beveled seat, and that the flat seat is more likely to stay tight. On account of the distortion of the valve seat, which will result from a slightly uneven expansion or from spring of the material under high pressure, the tightness of a beveled seat is seriously affected, and the more so the greater the bevel. A flat seat will remain steam-tight even after a considerable distortion has taken place, provided the valve has been carefully ground to its seat in the first place. For equal lifts, a flat-seat valve will have a greater discharge capacity, under conditions discussed later; a fact which will weigh in favor of the flat seat. It has been argued that a beveled seat, especially where the bevel is about 45 deg., will more easily rid itself of particles of scale lodged between the valve and its seat. Attention should be called to the custom where there is scale under the valve, of tightening the valve by turning the valve stem. Such practice is likely to have an effect directly opposite to what is desired. It is better to lift the valve from its seat by the easing gear and thus blow the scale from the valve seat. A steeper bevel than 45 deg. is inadvisable for a steam safety valve because of the tendency of the valve to stick. While only a few years ago most safety-valve specifications called for seats beveled at an angle of 45 deg., this has now been abandoned in many specifications, notably those of the U. S. Navy Department and various State boiler rules. It is the author's opinion that a change from the beveled to the flat seat will better the conditions affecting the working and repairing of marine safety valves.

POP OF VALVE

By "pop" of a safety valve is meant the instantaneous rise to almost full lift after the first tendency of the valve to move from its seat, or simmer. A satisfactory pop is essential in

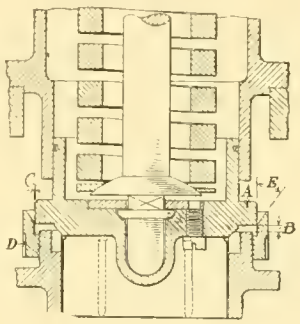

Fig. 7 Another Modified Valve of Type 3

a successful safety valve. The absence of the pop will mean a prolonged simmering of the valve, which will soon score both valve and seat, especially if steam is superheated. The pop of the valve in Fig. 1 is determined by the diameter of the flange *A*, the amount of the distance *B* and, to some extent, the shape of the surface *C*. It is assumed that the valve has been ground to its seat and made tight. A knowledge of the proper relation of these factors is necessary for the design of this valve. When this valve is refaced and reground it is of utmost importance that gages for the original shape of both valve and seat, and the proper distance between the two, should be furnished the machinist. A valve of this kind requires a long spring in order to give a satisfactory lift, on account of the comparatively small overhang of the flange *A* over the seating surface of the valve, limiting the available additional lifting force required after the valve has started from its seat.

In a valve such as shown in Fig. 2, the pop will depend on the diameter of the flange *A*, the amount of the distance *B*, the depth *C* of the main pop chamber, and the size and number of the holes *D*. Of these four items, *A* and *D* are determined by the manufacturer of the valve, and if rightly proportioned need not be altered in repairing the valve. Items *B* and *C* are affected by the wear and repair of the valve. The lip *A* should wear down in the same proportion as the valve and seat, but as this is very seldom the case, there arises the necessity for adjustment when the valve is overhauled. The depth of the pop chamber does not influence the pop as

greatly as does the distance between the flange lip and the valve bushing. The former, therefore, is checked only roughly, while the distance B must be absolutely correct.

In Figs. 3 and 6, the pop is decided by the three factors, size of flange A, distance B, and depth of pop chamber C. The distance B can be adjusted after the valves are assembled, by means of the blow-down ring, D. Thus it does not seem necessary to machine accurately the lip A in repairing these valves. Such is not always the case, however, as the adjusting of the distance B for a satisfactory pop may interfere with the adjustment for the desired blow-down. This will be explained in more detail later.

In valves of Figs. 4 and 7 the pop depends upon the size of the flange A, the distance between flange and valve seat B, and the width of the ring-shaped opening at C. In Fig. 4 the deciding factor is the distance B, whereas in Fig. 7 the pop will be determined mainly by the distance C. Therefore, in overhauling valve of Fig. 4, strict attention must be paid to the distance B in order to bring it back to its original value. In valve of Fig. 7 only a rough check of distance B need be made, and as the width of the ring area C has been fixed in making the valve parts, it need never be changed.

The pop in Fig. 5 depends upon the distances A and C, which can be regulated by means of the adjusting rings B and D. The inner ring should be screwed close to the valve disk without touching it. The outer ring furnishes the greater part of the additional lifting force.

BLOW-DOWN

For adjusting the blow-down, or difference in steam pressure under the valve at popping and at closure, there are two systems represented in the valve shown. Valve of Fig. 1 has no adjustment of the blow-down. The amount of blow-down desired must be decided on in advance, and the valve designed accordingly.

The arrangement in Fig. 2 for adjusting the blow-down is probably familiar to most steam engineers. When this valve discharges, part of the steam passes through the holes E drilled in the bushing and into the chamber F. The only exit from this chamber is through the bushing G and the passage H communicating with the discharge space of the valve casing. By turning the bushing and locking it in different positions, the size of this exit passage for the steam can be restricted, thereby regulating the pressure under the valve lip A. The holes D in the valve flange will have a similar influence on the blow-down. The size and number of these holes are generally proportioned to admit of a minimum blow-down of, say, 4 lb. A smaller blow-down than this should not be used in any safety valve, as it shortens the life of the valve and produces a tendency to chatter, without any additional advantages.

In all of the valves of Figs. 3 to 7 the adjustment of the blow-down is accomplished by means of the adjusting rings, D. Screwing this ring up will increase the blow-down and screwing down decrease it. The rings of Figs. 4 and 5 are especially adapted to give a minimum obstruction to the flow of steam and so increase the discharge capacity of the valve. It has been claimed for the ring of Fig. 5 that, in conjunction with the lower ring B, it has the effect of reducing the lifting force at very low lifts and increasing it as the lift increases. This is a most desirable feature in any safety valve.

The ring in Fig. 7 has been designed as an improvement on those of Figs. 3 and 6. It has already been pointed out that in these valves the pop is determined by the distance B; and that the position of the ring D determines the amount of the blow-down. Thus there are two factors to be considered in determining the proper position of these adjusting rings, and each of these factors may require a different setting of the ring. In such a case it is necessary to take out the valve disk and machine its lip A until the proper distance between this lip and the adjusting ring is obtained, after first determining the position of the adjusting ring for the desired blow-down. Such a procedure is tedious unless gages are available for the machinist. In order to eliminate much of the machine work in overhauling and adjusting this kind of valve, the modifications shown in Fig. 7 were devised. The lip of the valve disk has been cut away and the diameter of flange slightly reduced. The shape of the blow-down ring has been changed entirely and made somewhat similar to the one in Fig. 4. The feature of the ring in Fig. 7 determining the blow-down is the angle E. An angle of 36 deg., 30 min. has been found to give a range of blow-down of from 4 to 9 lb. The laboratory tests on this improved valve have given very good results as to popping and blow-down.

DISCHARGE CAPACITY

When steam under pressure is allowed to flow through an opening, the maximum discharge will be obtained when the pressure on the low-pressure side is equal to, or less than, 58 per cent of the pressure on the high-pressure side. Under such conditions, the pressure at the throat section, or most contracted part of the channel through which the steam is flowing, will be 58 per cent of the high pressure, regardless of how much the pressure in the discharge chamber falls below this value. The weight of steam discharged can then be calculated from the well-known Napier formula: *Flow in pounds per second = absolute pressure × area in square inches ÷ 70.* Valves in Figs. 1, 2, 4, 5 and 7 undoubtedly have their throat section at the inner circumference of the valve seat. Therefore, the area of opening at this section will determine the discharge capacity of the valve, provided that the resistance to the flow is not made great enough to raise the pressure in the valve casing above 58 per cent of the pressure under the valve seat. Based on Napier's formula, and making allowances for reductions of the free opening over the valve seat, caused by guide wings, the following approximate formulae, given by some manufacturers, are obtained for calculating the discharge capacity:

$$W = 149\ lpd \text{ for a flat seat}$$
$$W = 105\ lpd \text{ for a 45-deg. bevel seat}$$

where W = discharge in lb. per hour
l = lift of valve in inches
p = absolute pressure under valve disk in lb. per sq. in.
d = diameter of valve seat in inches

For equal lifts, then, the flat seat will give a greater discharge than the 45-deg. seat. The discharge capacity will be influenced to some extent by the smoothness of the approach to the throat section. On this account the valve of Fig. 5 should have an excellent discharge capacity. With the valves of Figs. 3 and 6 it is frequently found that the actual discharge capacity is considerably below that obtained from the above equations. This can be accounted for by the throttling, especially at lower lifts, taking place under the valve lips.

The paper concludes with paragraphs dealing with simmering before lift, essential to successful working; prevention of chatter at closure, and methods of repairing and adjusting existing valves to make them successful and satisfactory.

TEXTILE PAPERS

THE work of the Sub-Committee on Textiles is devoted to securing papers upon the mechanical engineering and allied features of the textile industry. The Sub-Committee contributes three important papers to the Annual Meeting this year, one of which, bearing upon the heating of mill buildings, is published below.

SPONTANEOUS IGNITION STUDIED BY MEANS OF PHOTOGRAPHIC PLATES

By FREDERICK J. HOXIE, BOSTON, MASS.

Member of the Society

SPONTANEOUS ignition is a much more common cause of fires than is generally supposed. Many familiar substances can ignite spontaneously at slightly elevated temperatures or if acted upon by strong sunlight. Fires from this source are in the class most dangerous to life and property, because they start at the least expected time and place, and when no one is near to extinguish them or to give the alarm. The study of this class of fires, therefore, offers an attractive field of usefulness for the fire-protection engineer; but the pursuit of such studies is beset by difficulties arising from a lack of exact knowledge of the chemistry of oxidation and lack of convenient methods of studying the early stages of combustion.

The ignition of a handful of excelsior with a match is familiar to all: the match raises the temperature of a small amount of the wood above its ignition point, which is about 500 deg. fahr.; the combustion of this wood then raises the temperature of the surrounding particles above their ignition point, and the flame spreads rapidly through the excelsior. If the excelsior is wet, or is pressed close against a cold surface, the velocity of combustion may not be sufficient to keep the surrounding temperature up to the ignition point, in which case it will smolder, and its flame or glowing coal will "go out." The effect of the flame from the match is to render the oxygen of the air, which at lower temperatures is inert, sufficiently active to combine with the wood.

OXYGEN CAN BE MADE ACTIVE BY SUNLIGHT AND ELECTRIC CHARGE AS WELL AS BY HEAT

This quickening of oxidation may be accomplished, although much less thoroughly, by sunlight or other light of short wave lengths, by an electric charge, or by radioactive materials. Oxygen in this condition is said to be activated, ionized, or, when in this state as a result of just emerging from a chemical combination, nascent.

On the other hand, the wood instead of the oxygen, may become activated. If the wood is partially rotted or charred, or is in intimate association with oxygen-carrying materials, it may be caused to ignite after a considerable time at a surrounding temperature below 300 deg. fahr., or very much below the temperature at which it can be ignited under normal conditions.

The sight of dry cotton or of the fine shavings of soft wood known in the trade as "excelsior" in contact with the oxygen of the atmosphere in sunlight with no apparent oxidation or combustion, is too familiar to attract attention. If such material should burst into flame spontaneously at the ordinary temperature of the air, this action would be regarded as little short of a miracle. Nevertheless, this cotton and excelsior are all the time very slowly burning or being oxidized at the ordinary atmospheric temperature, the velocity of this oxidation or slow combustion depending on the temperature, moisture, light and mineral or organic substances associated with the cotton or wood.

Cotton cloth which has been exposed for several months to sunlight and atmospheric moisture to the extent of so-called "dampness," exhibits on close inspection somewhat of the same charred appearance that it has after a few seconds' contact with a hot iron. The addition of certain mineral substances, known to chemists as catalyzers, such as iron and manganese, which can act as carriers of oxygen, accelerates

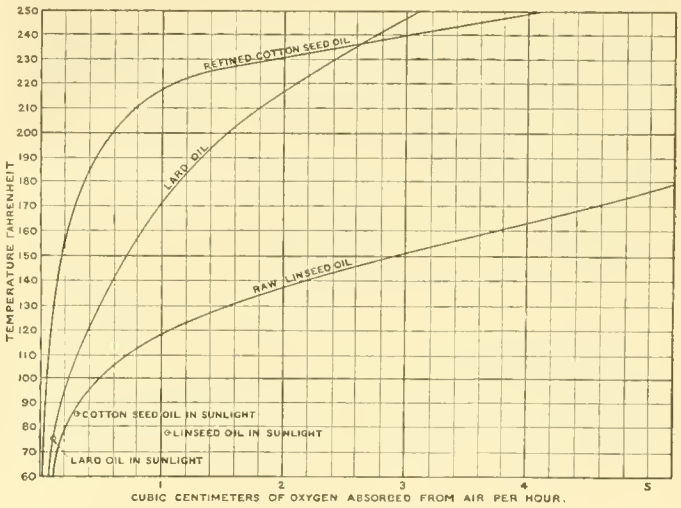

Fig. 1 Increase in Oxygen Absorption of Oils with Increase in Temperature

this action. This slow combustion liberates the same amount of heat per pound burned that would be liberated by the more familiar combustion with flame, but the heat is given off over such long periods of time that the resulting rise in temperature is not appreciable.

VELOCITY OF COMBUSTION INCREASES RAPIDLY WITH TEMPERATURE

If, however, the slowly burning substance is completely inclosed by material of high heat-insulating power, the heat generated by the combustion will be made to escape more slowly and the temperature will be increased proportionally. The velocity of combustion increases with the temperature and more rapidly than the first power of the temperature, as shown by the curves in Fig. 1 giving the rate of oxygen absorption, which is the first stage in combustion. On the other hand, the escape of heat will be more rapid with higher temperature and the same heat insulation; so that in most cases in common experience the velocity of combustion, the rise in

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temperature and the radiation of heat each soon comes to equilibrium.

In many cases where the substance is enclosed or shielded from atmospheric circulation, the exhaustion of the oxygen of the air in contact with the burning substance limits the oxidation. If, however, the heat insulation is sufficiently good and the necessary air supply is available, and if the temperature is sufficient to cause the combustion to proceed at a rate which increases more rapidly than the increase in the rate at which the heat is being radiated, ignition will result.

CURVE OF VELOCITY OF OXIDATION SIGNIFICANT

In this connection the form of the velocity-of-combustion curve gives the most significant characteristics of substances subject to spontaneous ignition. In studying this hazard it is important to know both the velocity of combustion of a given substance at the ordinary temperature of the air and *also the temperature at which this velocity commences to increase rapidly, as indicated by the hump on the velocity curve;* such, for example, as is found at 100 deg. fahr. for linseed oil and at 200 deg. for cottonseed oil. See Fig. 1.

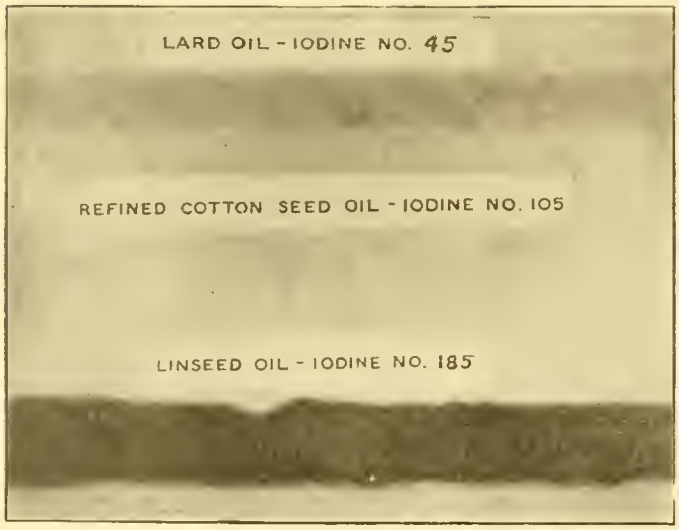

Fig. 2 Images Made on Photographic Plates by Oils of Fig. 1

To obtain practically this curve of the velocity of combustion for different substances at the ordinary temperature of the air is a difficult matter. To determine it by the rate of absorption of oxygen as shown in Fig. 1 is a troublesome and uncertain process, owing to the fact that there are doubtless many intermediate reactions between the combination of oxygen and wood or cotton or other hydrocarbons and the end products, which are carbonic acid and water. Therefore, any means of determining this curve or of *comparing the velocity of oxidation of substances of which the characteristics are unknown with that of substances of which the characteristics are known,* will be a valuable help in studying the mysterious mechanism of spontaneous ignition.

SUBSTANCES UNDERGOING AUTOMATIC OXIDATION GIVE OFF HYDROGEN PEROXIDE

Schoenbein showed that many substances undergoing automatic oxidation give off hydrogen peroxide.[1] Moritz Traube later pointed out that many of these substances *would not oxidize automatically except in the presence of water,*[1] and propounded the theory, which bears his name, that the hydrogen peroxide is formed by the combination of the oxidizable substance with the oxygen of water, the hydrogen of the water combining with free oxygen to form hydrogen peroxide. This cycle would make moisture a necessary part of an automatic oxidation, an equal number of molecules of water and oxygen being required.

Many examples can be cited of extremely slow oxidation and of oxidation once started which has practically stopped from the absence of water; noticeable among which are the linen cloths wrapped about the mummies of Egypt, which have oxidized but little in four thousand years, and also the wooden mummy cases.

HYDROGEN PEROXIDE CAN MAKE A DEVELOPABLE IMAGE ON A PHOTOGRAPHIC PLATE

The hydrogen peroxide given off by substances undergoing automatic oxidation can make a developable image on a photographic plate in the dark, and the intensity of this image appears to be about proportional to the velocity of oxidation. Oils subject to spontaneous ignition are found particularly active.

INTENSITY OF IMAGE PROPORTIONAL TO RATE OF OXIDATION

In order to determine whether the intensity of the image on the photographic plate is proportional to the velocity of oxidation, I have taken samples of raw linseed, refined cottonseed, and lard oils and have measured the rate of absorption of oxygen by means of the decrease in the volume of air in contact with the oil for short periods at temperatures from 60 to 250 deg. fahr. The results of my experiments are shown in Fig. 1. In Fig. 2 are shown the impressions made on photographic plates by placing the oils near them in the dark.

The photographic plate undoubtedly indicates only the first stage in the automatic oxidation reaction, namely, the absorption of oxygen by the unsaturated oils and the formation of hydrogen peroxide.[2] It is apparent from the lack of parallelism between the curves in Fig. 1 for lard oil, linseed and cottonseed oil that the rate of absorption at low temperature is not proportioned to the so-called iodine values[3] for these oils. The lard oil, with an iodine value less than the cottonseed, absorbed considerably more rapidly up to about 230 deg. fahr. Also the impression made by the lard oil on the plate is stronger than that by the cottonseed oil, which has more than double the iodine value. The photographic plate can only be used at low temperatures.

HUMP IN OXIDATION CURVE AN IMPORTANT FEATURE

A feature worthy of careful notice with reference to the spontaneous-ignition hazard is the decided hump in the absorption curves of linseed and cottonseed oil at 100 deg. and 200 deg. fahr., respectively; also the fact that lard oil at ordinary temperatures absorbs oxygen more rapidly and acts on the photographic plate more strongly than cottonseed oil.

[1] Gesammelte Abhandlungen von Moritz Traube (Berlin, 1899), p. 400.

[1] Ibid., p. 403.

[2] Kritische Studien über die Vorgäng der Autoxydation, C. Engler.

[3] The iodine number of an oil is the percentage of iodine which it can absorb. It represents the amount of oxygen which can be absorbed, while the photographic image represents the rate at which the oxygen is absorbed, which is the important factor in spontaneous ignition.

From the absorption curve of cottonseed oil it would be expected that the spontaneous-ignition danger from this oil would not be great at temperatures below 150 deg. fahr., and that linseed oil could be used for almost any purpose with comparative safety against spontaneous ignition at temperatures below 80 deg. fahr., if kept out of the sunlight; also that lard oil would be more hazardous than cottonseed oil at room temperatures.

SUNLIGHT INCREASES THE RATE OF OXIDATION

A potent factor in increasing the rate of oxidation at room temperature is light, not necessarily ultra-violet light, but ordinary sunlight which has passed through several thicknesses of lead glass so that most of the light of shorter wave length has been removed. This at 80 to 85 deg. fahr. increased the rate of absorption of oxygen by cottonseed and linseed oils by about ten times, while with lard oil it apparently had less effect.

Oils painted on glass and maintained at 120 deg. fahr. for several days while being exposed to a photographic plate showed a stronger activity than other similar samples maintained at 65 deg. fahr., in about the proportion indicated by the oxygen-absorption curves.

COLLOIDS AND CATALYZERS FUNDAMENTAL IN PLANT AND ANIMAL PHYSIOLOGY

Automatic oxidation and reduction at low temperatures are fundamental to the physiological reactions which go on in plants and animals, the mechanism by which these reactions are carried out being a combination of colloids and catalyzers. Gelatinous substances, starch and cellulose, act as the colloids, and iron and manganese compounds are chief among the catalyzers or carriers of oxygen. Dony-Henreault[1] has shown that many of the oxidizing reactions given by organic compounds known as oxidases can be duplicated by a combination of gum arabic, which is a colloid, and minute quantities of manganese.

Sunlight is not only an important factor in increasing the rate of oxidation and photographic activity of oils, but also the photographic activity of wood. I have extracted what was apparently one or more of the materials causing this photographic activity from wood shavings, and the impression which this made on a photographic plate had an intensity about equal to that made by olive oil. Moderate heating increases photographic activity, while strong heating destroys it.

In the hard pines there are at least three different substances which can cause this activity, namely, turpentine, resin, and the water-soluble substance mentioned above.

SPONTANEOUS IGNITION OF CHARCOAL

Spontaneous ignition of wood is doubtless intimately associated with spontaneous ignition of charcoal, and this phenomenon has a much wider field of interest than would appear at first sight. In dwellings and factories numerous fires originate in the woodwork near steam pipes or other heating appliances which are maintained at temperatures far below the ignition point of wood, and are due to spontaneous ignition of charcoal formed by slow combustion over long periods.

[1] Bull. Acad. Royal Belg., Class de Science, 1907, p. 536, 1908, pp. 105-163; 1909, pp. 342-409.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members are solicited by the Publication Committee.

THE USE OF POWDERED COAL AS A FUEL

To the Editor:

The statement made in Mr. Harrington's paper on page 796 of the October number of The Journal, that "all the steam-making installations are in plants of the manufacturers of powdered-coal equipment, or in plants very directly connected therewith," is erroneous. It may be of interest to learn of a very successful installation for burning powdered coal under a boiler which has been in continual and regular service in the American Locomotive Company's Schenectady plant since March, 1915. This furnace is believed to be entitled to a world's record for low cost of maintenance.

The chart in Fig. 1 was taken from an ordinary day's

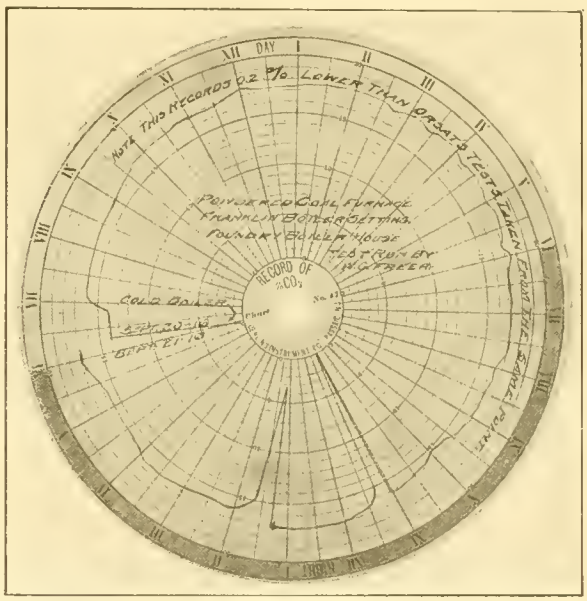

Fig. 1 CO_2 Chart of Powdered Coal Installation

run of this boiler, and shows that the CO_2 percentage rarely drops below 16 per cent and is oftener above 17 per cent. This recorder has been repeatedly checked by the Orsat apparatus, which gave 0.2 per cent higher CO_2, and sometimes indicated 18 per cent CO_2.

Several evaporative tests made by W. G. Freer, Mem.Am. Soc.M.E., showed that this extremely simple furnace, illustrated in Fig. 2, gave a materially higher evaporative efficiency than could be obtained from a duplicate Franklin boiler fired by mechanical stokers and supplied with feed water at the same temperature, and that it responded much more promptly to a sudden increased demand for steam than the adjoining stoker-fired boilers. An ordinary fireroom helper was readily taught to give the furnace all the attention ever required.

Previous to the installation of this furnace, between November, 1914, and March, 1915, several constructive revisions were made in a powdered-fuel furnace experimentally installed under the same boiler. Unfortunately, the brick arches and vertical walls completely failed to withstand the high-

temperature flames, and there were excessive accumulations of hard slag at the bottom of the furnace and deposits of unburned products around the tubes and in the gas passes.

Several years ago the writer concluded that the only way to prevent the destruction of vertical walls and arches in powdered-coal furnaces was not to have them, and substitute incandescent ignition surfaces formed by simple outwardly inclined walls which would be automatically maintained by a coating of protecting slag. After the failure of the vertical walls and the arches referred to, permission was granted by J. R. Magarvey, manager of the Schenectady works of the American Locomotive Company, to install the furnace shown in Fig. 2, which suggested itself, and is shown as originally installed. This furnace now has been in continual service for eighteen months without a single repair expense on the hopper-shaped furnace walls. These walls are coated with about 1 in. to 3 in. thickness of slag, and are seemingly in as good condition as at the time they were built. Only a small section of the old vertical wall which remained from the former furnaces was replaced at a cost of about five

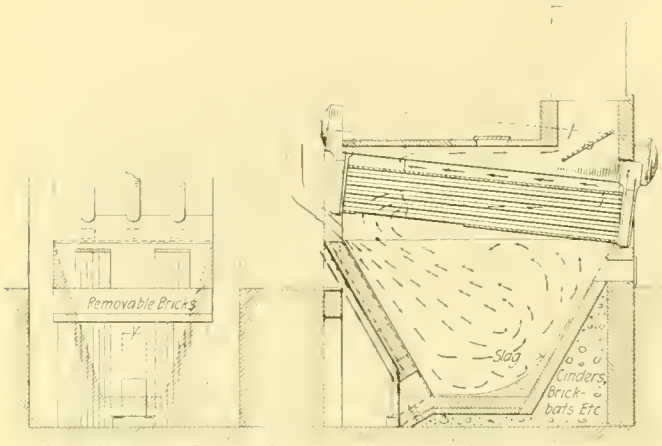

Fig. 2 Powdered Coal Furnace in Operation Since March, 1915

hours mason's labor; otherwise, there were no repairs with the exception of small fire-clay patches under the powdered-coal inlet tuyeres, which required about 30-min. work.

Fig. 3 shows the temporary construction of the 9-in. front slope wall which is supported by scrap boiler tubes. It has not been repaired since March, 1915. The fire pit openings are covered by temporary iron plates. Part of the brick were not laid in fire clay for convenience in removing for experiment. They were never removed since the installation.

The three original inlet tuyeres are yet in service and apparently may be in service for another year. This is particularly interesting, since they consist of three ordinary wrought-steel pipe nipples, 10 in. in diameter and 24 in. long, which, when originally installed, protruded downwardly a few inches into the furnace. After a short time the inner ends burned away and gave them their present form.

Powdered coal is fed by a screw feeder from a hopper into the air blast at a point about 3 ft. away from the furnace tuyeres. This distance may be very much more, but not less, for the purpose of thoroughly mixing the coal with a properly proportioned air blast that passes downwardly through the tuyeres at a pressure of ½ to 1½ oz.

A plurality of tuyeres and feeders is essential to good combustion, so as to reduce the effects of imperfect feeding of any one feeder or of flooding through a feeder from slips in the coal hopper. No particular form of feeders is necessary for successful operation. Fig. 4 shows a feeder set with eight outlets.

There is a very slight air inlet suction at the slag hole in the base of the furnace. In the furnace near the boiler the pressure is equal to atmospheric. In the gas passes the pressure is slightly less than atmospheric, an amount depending upon the resistance of friction to a flow of the gases into the uptake.

The lower row of water tubes was shielded by tiles for the purpose of giving sufficient heat-reflecting surface to maintain

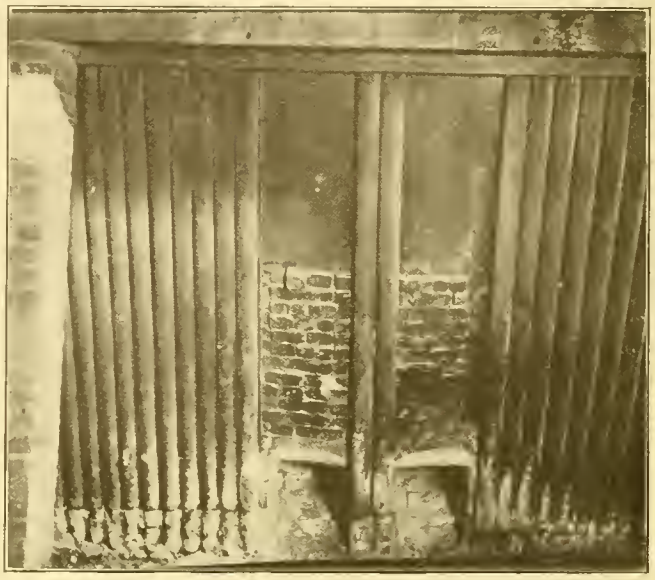

Fig. 3 Construction of Front Slope Wall

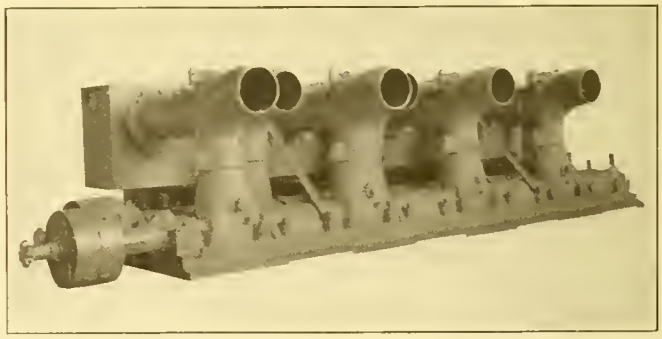

Fig. 4 Powdered Coal Feeder Set

the desired furnace temperature for the working capacity of the boiler. The amount of surface was determined by trial. During the first trial runs too many tiles caused an excessive furnace temperature and too strong an upward draft into the flue passes. On second trial, when for purpose of experiment nearly all the tiles were removed, the furnace temperature was too low. By several adjustments, Mr. Freer finally obtained the best results when approximately the lower back half of the water tubes was shielded as illustrated in Fig. 2. This amount of shielding gives ample freedom to the slowly upward flowing gases, and prevents all tendency to lift and deposit unconsumed fuel in the passes, which, therefore, do not require more cleaning than the passes in the adjoining mechanical-stoker-fed boilers. No trouble whatever is experienced

from coke or cinder-clogged water tubes; this is largely due to the hopper-shaped furnace, wherein all the downwardly jetted fuel and air from the three tuyeres is thoroughly blended and ignited in the confined space between the inclined and incandescent walls at the bottom of the furnace. Thereafter the resulting gases are permitted to freely expand as they slowly rise upward into the enlarged space under the boiler, in a manner which gives the flames a slow rolling movement from the bottom rearward, upward, then forward to meet the front end of the boiler, through the full length of a 30-ft. path, before coming in contact with heat absorbing surfaces. This insures perfect combustion, as indicated by the CO_2 diagrams.

Charles L. Heisler.

Schenectady, N. Y.

WATER FLOW THROUGH PIPE ORIFICES

To the Editor:

Professor Judd's paper on Experiments on Water Flow through Pipe Orifices[1] has cleared up the whole subject of flow through orifices located in a continuous pipe and has explained many apparent inconsistencies of former experiments.

A consideration of the results can lead one to no other conclusion than that the moving particles of fluid form the equivalent of a venturi tube, and that the form of this is as definite as though it were confined by a solid casing; for other experiments to which the writer has access show the same coefficients of discharge, or, if another form of expressing it is preferred, corresponding pressure drops for such different fluids as water, steam, air and gas when the ratio of diameter of orifice to diameter of pipe and distances of connections are the same. This phenomenon is more obvious for the larger ratios of diameter of orifice to diameter of pipe, because for any given pressure drop the velocity of approach and energy of the fluid will be greater under these conditions. Also the surface of the moving stream and the amount of dead fluid compared to the volume of the jet will both be less, so that as the ratio of the diameter of the orifice to that of the pipe diminishes, the factors tending to break up and obscure this complete restoration of velocity head as static pressure increase very rapidly. It is found, however, with the velocities now common in practice that if it be desired to use one recorder for measurement with a number of orifices, the orifices show a comparatively narrow range of variation in ratio of diameter compared to diameter of pipe. This of course is reasonable, as fluid velocities are based on permissible pressure drop, which is a function of velocity and density, and of course varies with different classes of service.

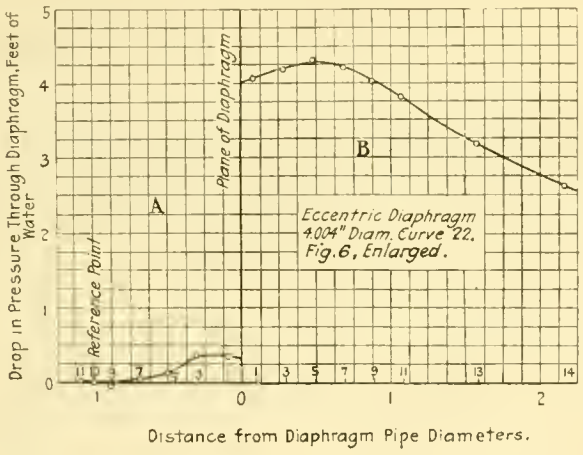

Fig. 1 Reproduction of Fig. 10, P. 714, The Journal, 1916

Professor Judd had an extremely difficult problem to plot his results so as to make it plain just what the curves represent, and in Figs 5 to 9, inclusive, he has taken the simplest method of showing the comparative readings at different ratios of flow. For the enlarged curves, for instance, Fig. 1, which is a reproduction of Fig. 10 of the paper, the writer prefers the curve plotted as shown in Fig. 2, everything being taken on the basis of pressure above or below that at A-10. In this way, if it is desired to ascertain the pressure drop between any two points it is only necessary to measure the total ordinate.

It seems curious that there should be a rise in pressure between the point A-10 and the orifice, but this is perhaps to be accounted for by the slowing up of a certain proportion of the fluid obstructed by the orifice and the transformation of the velocity of approach into static pressure. This reasoning is supported by the fact that the increase of pressure is most noticeable on the 90 per cent ratio orifice, less on the 80 per cent and almost disappears below the 70 per cent.

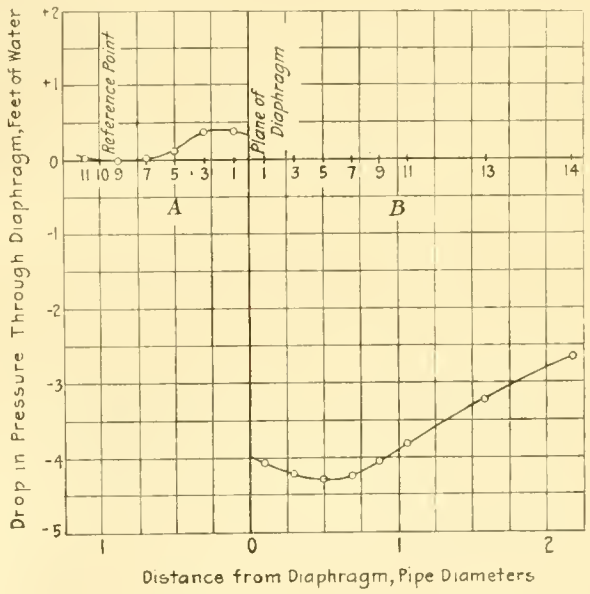

Fig. 2 Preferred Method of Plotting Curve Shown in Fig. 1

H. D. Fisher.

Boston, Mass.

[1]Presented at the Spring Meeting of the Society, New Orleans, April, 1916, and published in The Journal, September, 1916.

IMPACT OR SHEAR TESTS

To the Editor:

I should be glad to see a discussion in The Journal on the testing of materials by impact or shear.

The impact test on a notch bar has, of course, the objections that the notch cannot be held to great accuracy and that very small differences in it make a big difference in the results obtained. Attempts have been made to get away from this by substituting a shearing test, in which the foot pounds of

energy required to shear are given, as measured by the travel of a pendulum.

Last June Mr. D. J. McAdam, Jr., gave a talk before the American Society for Testing Materials dealing with this, pointing out that it was very strange that ingot iron or very low carbon steel showed greater energy necessary to shear than did the higher grade chrome-nickel alloy.

This phenomenon has been known for some time, but, unfortunately, the deduction is made that, therefore, the lower carbon steel or ingot iron is less brittle and better able to resist shear. It must be remembered, however, in connection with this, that an energy diagram is really the measure of a rectangle, and a rectangle may have a long horizontal side or it may have a long vertical side. In the case of the chrome-nickel alloy steels, this rectangle has a long vertical side, and it requires a very much greater initial pressure to shear than does the other, but the areas are almost exactly the same.

In my paper on A Study of an Axle Shaft for a Motor Truck, which appeared in the June, 1915, issue of The Journal, it was pointed out that tests are nearly always made as to how to break a piece of steel, whereas the engineer really wants to know how not to break it. If such impact tests could be carried out in a way that the specimen be not broken, or, at any rate, not for a very long time, it would be found that the chrome-nickel alloy would probably resist the blows better than would the other. In other words, testing above the elastic limit is of little value to the engineer. Strength tests, etc., should really be made below the elastic limit, or, at any rate, what is known as the elastic limit.

JOHN YOUNGER.

Buffalo, N. Y.

SAFETY CODE FOR CRANES

TO THE EDITOR:

I submit the following suggestions regarding the Proposed Code of Safety Standards for the Operation of Cranes which is to be presented at the forthcoming Annual Meeting by the Sub-Committee on Protection of Industrial Workers, and which was printed in the November issue of The Journal:

6 "*Where Access to the Crane Is Necessary, Steps or Stairs with Hand Rails Should Be Used.*"

Should also include "fixed ladders." This paragraph might well be omitted, as same subject is covered in more detail in Par. 8.

7 "*Platforms Should Be Provided for Changing and Repairing Truck Wheels on End Trucks and Provided With Stairways Leading to Them.*"

This does not seem practicable, and in many cases would require extensive building-construction changes to allow room for the "*stairways.*" Fixed ladders would take less room. Furthermore, in case of a breakdown, it might not be possible to move a crane to the repair platform.

10 "*Footwalks Should Be Placed Across the Ends of the Trolleys at Right Angles to the Bridge Walks and Shall Be Not Less Than Twelve (12) Inches in Width.*"

The words "*where practicable*" should be put after the word "*placed.*" It is obvious that many cranes cannot be so equipped.

14 (in part) "*Not Less Than Twelve (12) Inches Actual Clearance Should Be Allowed Between Highest Point of Crane and Overhead Trusses.*"

While this is desirable, it is frequently impracticable on small cranes of a capacity of five (5) tons or less, and which are generally installed in or underneath galleries and in other places with low headroom.

24 "*The Installation of Switchboard, Wiring and All Electrical Equipment, Must Fully Comply With the Industrial Board Standards.*"

The U. S. Bureau of Standards would be a better authority for rules for use in all states, than a Pennsylvania Board.

35 "*A Capacity Plate Showing the Maximum Capacity of Each Hoist in Pounds Shall Be Placed on Each Crane Girder in Such a Manner as to Be Clearly Legible from the Floor.*"

Where a crane is located in the main bay of a building, a "*plate*" large enough to show the capacity legibly would be expensive to make, so would suggest re-wording that paragraph as follows:

"*The maximum capacity of each hoist in pounds shall be painted, stenciled, or otherwise placed on each crane girder in such a manner as to be clearly legible from the floor.*"

37 "*Trolley Should Be Completely Floored.*"

The meaning of this paragraph is uncertain and it should be re-worded to make the meaning clear.

The Rules for Operators, Floormen and Repairmen are identical, or nearly so, with the Rules for Cranemen which were issued by the National Founders' Association over a year ago and which have been found to be very satisfactory.

M. W. ALEXANDER.

West Lynn, Mass.

[These suggestions have been acted upon by the Sub-Committee on Protection of Industrial Workers and will be incorporated in the Code as presented at the Annual Meeting. —EDITOR.]

THE MEASUREMENT OF VISCOSITY

TO THE EDITOR:

Having read the paper of Messrs. Hayes and Lewis, and its discussion in the August issue of THE JOURNAL, the writer concurs with Mr. Hayes in his reply to the criticisms made, but would add the following comments:

Mr. Hayes misunderstands Mr. Bingham's phraseology in regard to the plasticity of suspensions, which refers to samples of suspensions under test, not to the torsion wire itself. Mr. Bingham's conception of the threshold stress below which plastic substances do not exhibit ordinary viscous flow, is an important one, more fully set forth in Bureau of Standards Scientific Paper No. 278.

The authors' treatment of the errors of short capillaries overlaps considerably the treatment previously published by Flowers in a paper of the same title.

In the course of experiments on the change in viscosity under pressure, made at Harvard University during the past year, the writer has employed a torsion viscosimeter of which the outer cylinder consists of an ordinary test tube. Thus 30 cc. is a sufficiently large sample; and the container need not be cleaned, for, in changing samples, one test tube is removed and another inserted. The inner cylinder is slim enough so that end effects are small, and, therefore, the instrument can be designed mathematically so as to have any desired characteristics. A brief account of this work will appear in the Journal of the Washington Academy, probably in an early issue, under the title The Theory of the Torsion and Rolling-Ball Viscosimeters, and Their Use in Measuring the Effect of Pressure on Viscosity.

The paper of Hayes and Lewis is one of the most sensible and useful papers relating to lubrication which have come to

the writer's attention; and especially so because of the vivid manner in which Figs. 6 and 7 draw attention to the fact, which ought to be more familiar than it is, that the viscosity scales of short capillary and orifice instruments are far from proportional to efflux times. Their second contribution, which they state is in preparation, is therefore much to be anticipated.

M. D. Hersey.

Washington, D. C.

NOTES ON VISCOSIMETERS

To the Editor:

The original revolving-cup torsion viscosimeter seems to have been designed by Couette about 1890. The essential feature of this instrument, as distinguished from others of the same general type, is the use of stationary protecting caps over each end of the suspended cylinder to eliminate "end effects," thus rendering the calculations quite simple.

This is a high-grade scientific design, and, when properly constructed and operated, should be capable of giving exceedingly accurate results, expressed directly in C. G. S. units. However, owing to the high cost and the number of parts required, the instrument is hardly practical for general commercial use.

Several years ago the MacMichael viscosimeter was designed without previous knowledge of similar efforts along this line for practical use in a clay-working establishment. This instrument is quite simple in construction, is durable and is easily and quickly manipulated. One of these machines has been in constant use for several years, in the hands of unskilled laborers, and has given excellent service. Under these conditions readings ordinarily check within 1 per cent.

No attempt is made to calculate viscosities directly from measurements of the machine, as this would be extremely difficult, if not impossible. The method used is to calibrate the instrument with a standard testing sample of known viscosity, and assume that other readings are directly proportional in value. Through a wide range this does not seem to introduce serious errors.

For a standard testing fluid, a high-grade neutral mineral oil of high viscosity, such as some of the medicinal oils now on the market, is suggested, this oil to be supplied in metal containers by the U. S. Bureau of Standards, or some other recognized authority. The viscosity of these testing samples may be determined by means of the long capillary tube, which is sufficiently accurate for all practical purposes.

A cane-sugar solution of 7 parts by weight of sugar to 4 parts of cold water also gives good results. This should be tested after mixing, not depending on the weighed proportions to produce accurate results. Owing to its stickiness and tendency to form incrustations, this fluid is not so agreeable to use as an oil, but otherwise its properties are excellent.

In any type of instrument, whether capillary or torsional, a critical condition occurs at which turbulence takes place, and incorrect results are obtained. Reducing the speed, reducing the dimensions of parts, or increasing the viscosity of the fluid tends to check this action.

Also, in a freely suspended torsional instrument, at certain speeds and viscosities a pendulum-like oscillation of the suspended member occurs; this may increase rapidly and with violence, ruining the torsion wire unless checked. In the MacMichael instrument this is prevented by a suitably arranged, oil-filled dashpot, which also acts as a damper, to improve the general action of the suspended member.

The "spiral action" referred to in Messrs. Hayes and Lewis's paper, published in the August issue of The Journal, takes place also in the Hayes-Lewis machine, but as it occurs in a closed vessel it is not so easily seen. However, since this effect occurs equally with both the standard testing fluid and the sample being tested, and as the action itself is very moderate indeed, the errors introduced cannot be very serious. These spiral "end effects" are eliminated only in the Couette machine, as noted above.

The Hayes-Lewis machine appears to the writer to have neither the high-grade scientific features of the Couette instrument, nor the practical work-a-day features of some of the simpler designs.

Acknowledgment is hereby made of other torsional instruments recently brought to the attention of the writer, descriptions of which will probably appear in due time. However, none of these instruments seems particularly well adapted to general work, or to possess advantages over the models already described.

Torsion viscosimeters probably have an important field in colloidal chemistry, and in the measurement of suspensions, such as clay slips. Likewise, they are well adapted for the testing of oil under unusual conditions, such as at very high or very low temperatures. When properly built they are rapid, accurate, and easily manipulated. However, they are of necessity quite expensive, so that unless a very radical change occurs in public opinion, or a demand arises for a standard testing machine reading in absolute units, it is very doubtful whether they will ever supplant the short-tube commercial instruments now in general use.

R. F. MacMichael.

Pittsburgh, Pa.

WORK OF THE BOILER CODE COMMITTEE

The Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in The Journal, in order that anyone interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee as approved by the Council on November 10, 1916, in Cases Nos. 62, 90, 99, 100c and 104-112 inclusive. In this report, as previously, the names of inquirers have been omitted.

Case No. 62

Inquiry: Is there no specific rule in the Boiler Code for determining the maximum distance to be allowed between tubes and rivets attaching crowfeet to the braced surface, similar to the construction used in horizontal return tubular boilers?

Reply: The maximum distance to be allowed between the edges of tube holes and the centers of rivets attaching crowfeet of braces to the braced surface should be determined as given in Par. 203 for determining the distance between centers of rivets attaching the crowfeet of braces to the braced surface, using 135 for the value of *C*.

Case No. 87 (In the hands of the Committee)

Case No. 90

Inquiry: Can the limitation of copper content in firebox boiler plate steel as prescribed in Par. 25 of the Boiler Code be increased or removed entirely? It is claimed that this can be done without affecting the safety or serviceability of the boiler.

Reply: Appeal for relief from this requirement was made by certain steel manufacturing interests. This appeal has received the support of the Association of American Steel Manufacturers, and several representatives of large users of boiler plate steel, including those with whom this portion of the specifications originated, have signified their willingness that this requirement be eliminated entirely. Definite action by the Boiler Code Committee is deferred until the general conference for consideration of revisions of the Code, to be held December 8 and 9, when all interested parties will have opportunity to be heard.

Case No. 99

Inquiry: How shall the strength of angle irons used on the rear head below the tubes of a horizontal return tubular boiler be estimated in complying with Par. 201?

Reply: In calculating the strength of angle irons below the tubes in a horizontal return tubular boiler when used in pairs, if the outstanding legs of the two angles are fastened together so that they may act as one member in resisting the bending action produced by the load on the rivets attaching the angles to the head of the boiler, and provided that the spacing of these rivets attaching the angles to the head is approximately uniform, the angles may be figured as a single beam uniformly loaded and supported at the points where the through braces are attached.

Case No. 100*c*

Inquiry: May a cast iron Y-fitting be used on a boiler and comply with the requirements of the Boiler Code?

Reply: A Y-fitting cannot be riveted to a boiler shell unless made of bronze composition, steel cast, or plate steel, in accordance with Par. 268 of the Code.

Case No. 104

Inquiry: Is it permissible under the Boiler Code to use cast iron handhole plates? In view of the requirements of Par. 262, it would seem by inference that the use of such material is intended to be prohibited.

Reply: The Boiler Code does not prohibit the use of cast iron for handhole plates except for certain pressure and temperature limits as specified in the Code. (See Pars. 9 and 12.)

Case No. 105

Inquiry: *a.* Is there a rule in the Boiler Code which covers the staying of conical surfaces smaller than 38 in. in diameter, as specified in Par. 231?

b. Is the surface of a cone top smaller than 38 in. in diameter that is stayed, better construction than an unstayed surface?

c. Will you advise the thickness of plate necessary for a cone 35⅝ in. in diameter at the bottom, 17 in. at the top, and 29½ in. in height, when no stays are used and the boiler is to operate at 125 lb. pressure?

d. Can the value of staybolts be added to the value of plate in determining the maximum allowable working pressure on a cone top less than 38 in. in diameter?

Reply: *a.* Yes. Conical surfaces requiring staying must be braced or stayed as flat plates in accordance with Pars. 199 and 212 of the Boiler Code.

b. The comparative value of unstayed plates and stayed plates is a matter for the manufacturer to determine by calculation according to rules given in the Code.

c. The plate thickness in this case should be determined by Par. 239, formula *a*.

d. No.

Case No. 106

Inquiry: Must the longitudinal joint on the outer furnace sheet of a vertical tubular boiler, said sheet being properly stayed, comply with Par. 187?

Reply: The portion of the envelope of the boiler which is staybolted to the firebox sheet is not to be considered a part of the boiler shell referred to in Par. 187. The joint may be of less value and of a different type than that used on the barrel, but must result in a factor of safety of at least five.

Case No. 107 (In the hands of the Committee)

Case No. 108 (Annulled)

Case No. 109

Inquiry: *a.* Will the usual form of double riveted joints apply for manhole reinforcement as required in Par. 260 of the Boiler Code?

b. Must Par. 182 be complied with in the arrangement of rivets for such a joint?

Reply: *a.* The arrangement of rivets commonly used on double riveted joints is permitted for manhole reinforcement.

b. The requirement of Par. 182 must be complied with in the design of such a joint.

Case No. 110

Inquiry: Does Par. 317 of the Boiler Code require a check valve near the boiler and a valve or cock between the check valve and the boiler on each of the three feed connections to a three drum water tube boiler, or in the case of a battery of two boilers with three drums each, does it mean that each individual boiler shall have only one check and globe valve on the main feed pipe to each boiler?

Reply: Where a single boiler is concerned, one check valve and a valve and cock between the check and the boiler is all that is required. If more than one boiler is used, an additional globe valve placed outside the check valves on the branch to each boiler must be supplied, irrespective of the number of drums.

Case No. 111 (In the hands of the Committee)

Case No. 112

Inquiry: Is not a lap longitudinal joint on the shell of a type of boiler formed of concentric shells with radial fire tubes fitted between and expanded into the inner and outer shells and beaded over so that the tubes act as stays, in contradiction to the requirements of the Boiler Code?

Reply: A properly designed lap joint for the outer sheet, under the conditions named, where the outer sheet is properly stayed by the tubes, does not conflict with any requirement of the Code.

Society Affairs

Engineering Survey

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEES

OFFICERS AND COUNCIL, 1916

President

D. S. Jacobus

Past-Presidents

Members of the Council for 1916

Jesse M. Smith
Alex. C. Humphreys
W. F. M. Goss
James Hartness
John A. Brashear

Vice-Presidents

Terms expire December 1916

Henry Hess
George W. Dickie
James E. Sague

Terms expire December 1917

Wm. B. Jackson
J. Sellers Bancroft
Julian Kennedy

Managers

Terms expire December 1916

Arthur M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Spencer Miller
Max Toltz

Terms expire December 1918

John H. Barr
H. de B. Parsons
John A. Stevens

Chairman of Finance Committee

Robert M. Dixon

Treasurer

William H. Wiley

Honorary Secretary

Frederick R. Hutton

Secretary

Calvin W. Rice

Executive Committee of the Council

D. S. Jacobus, *Chairman*
John H. Barr
Arthur M. Greene, Jr.
Henry Hess
Spencer Miller
James E. Sague

COMMITTEES, ETC.

STANDING COMMITTEES

Chairmen

Finance, Robert M. Dixon
Meetings, H. L. Gantt
Publication, Irving E. Moultrop
Membership, Henry C. Meyer, Jr.
Library, John W. Lieb
House, William N. Dickinson
Research, R. J. S. Pigott
Public Relations (not appointed)
Constitution and By-Laws, Jesse M. Smith
Standardization, Henry Hess

SOCIETY REPRESENTATION

American Association Advancement of Science
American Society for Testing Materials, Modification Briggs Standard for Pipe Threads
Classification of Technical Literature
Conference Committee on Electrical Engineering Standards
Conference Committee of National Engineering Societies
Conference Committee on Cooperation in American Engineering Standards
Conference Committee to Determine Cost of Electric Power
Conservation
Engineer Reserve Corps
Engineering Foundation
Expert Testimony Committee
John Fritz Medal, Board of Award
Joseph A. Holmes Memorial
Naval Consulting Board of the United States
Standardization of Pipe and Pipe Fittings for Fire Protection
Trustees United Engineering Society

SPECIAL COMMITTEES

Chairmen

Administration, Robert M. Dixon
Am. Soc. M. E. Junior Prizes, Robert H. Fernald
Am. Soc. M. E. Student Prizes, Frederick R Hutton
Boiler Code Committee, John A. Stevens
Engineering Education
Filter Standardization, George W. Fuller
Increase of Membership, Irving E. Moultrop
Metric System, L. D. Burlingame
National Museum
Nominating Committee, Walter B. Snow
Patent Laws, Edward Weston
Pipe Threads International Standard, Edwin M. Herr
Power Tests, Geo. H. Barrus
Refrigeration, D. S. Jacobus
Research Committee, R. J. S. Pigott
- Sub-Committee on Bearing Metals, C. H. Bierbaum
- Sub-Committee on Fuel Oil, Raymond H. Danforth
- Sub-Committee on Lubrication, Albert Kingsbury
- Sub-Committee on Machine Tools, Leon P. Alford
- Sub-Committee on Safety Valves
- Sub-Committee on Steam-Flow Meters, R. J. S. Pigott
- Sub-Committee on Worm Gearing, Fred A. Halsey

Sections, Elliott H. Whitlock
Standard Flanges and Pipe Fittings, Henry G. Stott
Standards for Graphic Presentation, Willard C. Brinton
Standards for Machine Tools
Student Branches, Frederick R. Hutton
Tellers of Election, Robert H. Kirk
Tolerances in Screw Thread Fits, L. D. Burlingame

SECTIONS COMMITTEES

Chairmen and Secretaries

Atlanta, Earl F. Scott, Park A. Dallis
Birmingham, Roy E. Brakeman, Paul Wright
Boston, A. L. Williston, (Secretary not appointed)
Buffalo, John Younger, (Secretary not appointed)
Chicago, Joseph Harrington, R. E. Thayer
Cincinnati, F. A. Geier, John T. Faig
Detroit, M. E. Cooley, (Secretary not appointed)
Indianapolis, (not appointed)
Los Angeles, W. A. E. Noble, Ford W. Harris
Milwaukee, Edward Hutchens, F. H. Dorner
Minnesota, J. V. Martenis, D. M. Forfar
New Haven, H. B. Sargent, E. H. Lockwood
New Orleans, W. B. Gregory, H. L. Hutson
New York, H. R. Cobleigh, A. D. Blake
Philadelphia, Emmet B. Carter, Wm. R. Jones
St. Louis, H. R. Setz, L. A. Day
San Francisco, Frederick W. Gay, C. F. Braun
Worcester, Paul B. Morgan, Edgar H. Reed

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1916, and in the July, 1916, issue of The Journal.

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

COUNCIL NOTES

A MEETING of the Council was held on November 10, at which the following were present: D. S. Jacobus, *President;* John H. Barr, W. F. M. Goss, Arthur M. Greene, Jr., Frederick R. Hutton, W. B. Jackson, Charles T. Main, H. de B. Parsons, J. E. Sague, Jesse M. Smith, E. H. Whitlock, R. M. Dixon, *Chairman of the Finance Committee,* Calvin W. Rice, *Secretary,* and, by invitation, I. E. Moultrop, *Chairman of the Publication Committee.*

Boiler Code Committee. Interpretations of this Committee Nos. 62, 87, 90, 99, 100c and 104 to 112 inclusive were approved with slight corrections and ordered published. They appear elsewhere in this issue of The Journal.

The Journal. It was voted to approve an additional appropriation for the development of The Journal in accordance with the recommendation of the Publication and Finance Committees. These recommendations are published in the Report of the Publication Committee, which appears elsewhere in this issue.

Condensed Catalogues. A year ago the Council voted to discontinue the annual volume of Condensed Catalogues at the earliest practicable moment. Since that time, however, many members have expressed themselves as in favor of continuing the publication of this volume on account of its utility.

It was voted at this meeting that the question of continuance of Condensed Catalogues should be referred to letter ballot of the membership.

Committee on Filter Standardization. The report and recommendations of this committee were received and ordered printed. It will be distributed with other reports at the Annual Meeting and also published in The Journal.

The appointment of Prof. H. B. Langille as Honorary Chairman of the University of California Student Branch was announced by the President.

American Association for the Advancement of Science. An invitation from this Association for a joint meeting of its Engineering Section and the national engineering societies during the week of December 28, 1916 was accepted, and Dr. D. S. Jacobus and Mr. W. B. Jackson and the Society's representatives on the Advisory Council of the A.A.A.S. were requested to coöperate with the chairmen of the Committee on Meetings and of the New York Local Committee in carrying out the program.

CALVIN W. RICE,
Secretary.

SECRETARY'S CHAT WITH THE MEMBERS

THE President and the Secretary have had the privilege during the last month of visiting a number of the Sections and Student Branches of the Society. The enthusiasm in all places is magnificent and indicates that there is a movement on foot in the whole engineering profession which presages everything that is good for our profession and is a source of inspiration to the officers of the Society.

The most remarkable one feature of each of these gatherings is the spirit of coöperation. We are indebted to the work of the Industrial Census for bringing us in contact with the chemists, and we trust that they are now joined for all time with the engineers in all coöperative work for the good of our country and society generally.

It has been said more than once that the capacity for coöperation with respect to a nation is the gage of its civilization. What has, therefore, been said of the nation could be said probably with equal truth of a lesser organization.

In England, Sir Robert Hadfield, Mem.Am.Soc.M.E., Past-President of the Iron and Steel Institute of Great Britain, is proposing a scheme for increasing the scope of usefulness of the Institute, and similarly in Germany there has already been instituted an association of all the technical and scientific establishments of the German Empire, including engineers, architects, chemists, numbering in all sixty thousand, to such a degree that a Central European Institute is now contemplated. These coöperative movements in England and in Germany obviously have as their motives the protecting of the industries of the nations represented.

We, on our part, should not only protect the industries of our country for the benefit of the industries themselves, but our fundamental motive should be that after having protected and developed those interests we should devote them to the benefit of mankind. There is nothing inconsistent with the self-development and devotion to good works. Preparedness is the best insurance for peace.

The members of the societies brought together by Mr. W. L. Saunders, Mem.Am.Soc.M.E., to consider the formation of an organization of engineers and chemists which could bring its influence to bear on subjects of a civic character in which the profession is interested has resulted in the creation of an Organization Committee, of which the writer is secretary. Another meeting has been held, and a report of progress made to the officers and council of the societies participating in the Industrial Census. Included in this report of progress is a suggested form of organization, at present called, for lack of a better name, the Civil Scientific Alliance.

In the writer's individual opinion the scope of the present societies preferably should be enlarged, in distinction from forming a new organization to undertake civic work. The writer has corresponded with a large number of the officers of the Society and the Chairmen of its Sections and others throughout the United States and finds almost unanimous agreement with this view.

As a direct recommendation, and which expresses the earnest desire of the Council, the members of our Society in all parts of the world are encouraged to organize Sections of the So-

ciety, each section to be formed with the co-existing thought that it is to be only one of a group of sections, each representing some branch of the profession. These several groups, in turn, should be brought together under the auspices of some local engineering society, that organization to provide for the development of the professional spirit in the community. Of course, it is understood that in sparsely settled portions of the world these organizations cannot be obtained, and it may be that in some cases the members in several states will have to be brought together in order to form a section, in distinction from a number of cities. On the other hand, where there are a number of large communities very close together, the demarcation of the territory becomes somewhat difficult, and patience and a spirit of coöperation will have to be exercised by the members to assist the Committee on Sections to determine how best to group the members in their respective sections.

In every movement for such sections the spirit should be—how can we best develop the professional atmosphere in our community and how can we make that serve the community, and one's benefit in membership in an engineering society will be in proportion to his contribution to this movement.

Calvin W. Rice,
Secretary.

THE THIRTY-SEVENTH ANNUAL MEETING

NEW YORK CITY, DECEMBER 5 TO 8

THE success of the Annual Meeting will be measured entirely by the pleasure and benefit each member and guest who attends derives from it. After three months' work on the part of the Meetings Committee, taking care of the professional features, and the New York Section Committee, providing for the social events, all arrangements are satisfactorily completed. It remains for those who attend the meeting to take advantage of them, and to the extent to which they take such advantage will they be benefited.

The Society has now come to be a very large organization—its membership has doubled in six years, and is fast approaching the ten-thousand mark. Its headquarters are in the largest building of its kind in the world, which is also occupied by sister organizations as large as our own. It is natural, therefore, that members coming to the Engineering Societies Building for the first time will find themselves surrounded with unfamiliar faces. They can quickly overcome this by introducing themselves by emblem and by name to their fellow-members, who will, in their turn, appreciate such introduction. Name badges will be provided for all and may be obtained upon arrival at the registration desk; these, worn throughout the meeting, will furnish an effective means of identification and overcome the initial embarrassment of exchanging names. At every meeting many desirable acquaintances are formed, but unfortunately, due to the inertia of human nature, they do not usually materialize until toward the end of the meeting. As last year, an Acquaintanceship Committee has been appointed for each day, and the members of these committees will devote their especial attention to seeing that members get to know each other. The personnel of these committees, as well as of the Committee on President's Reception, Excursion Committee, Ladies' Reception Committee, etc., who will each take charge of their respective functions, will be found in the programs issued at the registration desk.

As last year, an Information Bureau will be maintained, located in a prominent place, where full particulars regarding any event may be obtained.

Below is given a brief account of the main features of the meeting, followed by the program. Members should note that all the gatherings will be informal.

OPENING FEATURES

Dr. D. S. Jacobus, who during his term in the highest executive office of the Society, has done much to promote the welfare of the organization and that of its individual members, a large number of whom he has met personally in the centers in which the Society's activities are established, will deliver his Presidential Address on Tuesday evening on the Relation of Education to Engineering. This will be given in the Auditorium of the building, and will be followed by a reception.

On Wednesday morning there will be a business meeting which all should make it a point to attend on account of the importance to every member of the Society that he keep informed on the business affairs of the Society and participate in their conduct. Junior and Student Prizes for the year will be awarded at this meeting.

This will be followed by a memorial meeting in honor of the memory of Dr. John E. Sweet, Past-President, Honorary Member and founder of the Society, who passed away on May 8, 1916.

Not only was Dr. Sweet a founder of the Society, but it may be said that he was also the founder of modern practice in machinery building in this country. He possessed an infallible intuition for mechanics; he had a wonderful appreciation of correctness in details, and his influence over men was remarkable.

Four years ago we commemorated his eightieth birthday by a dinner at the Annual Meeting, and many members of the younger generation had the special privilege of meeting him there. These will join with his "boys" who gathered with him year after year on the occasion of his birthday, and who now, feeling the loss of his endeared figure most of all, will pay this tribute to his memory.

PROFESSIONAL FEATURES

The technical papers to be presented and discussed at the eleven professional sessions are truly representative of the broad field of the Society's activities.

The main professional feature of this meeting will be the Valuation Session, which has been assigned to Thursday morning, and which all will have the opportunity of attending. The subject of valuation is a new one in the proceedings of the Society; it is a basic one to engineers, although it has received most discussion outside engineering circles. The session will appeal to a large proportion of the membership.

Special attention is called to the sessions under the auspices of Sub-Committees of the Committee on Meetings—the Railroad Session, the Gas Power Session, the Machine Shop Session, the Industrial Safety Session, and the Textile Session, and to the one in charge of the Boiler Code Committee.

As at previous meetings, those concerned with the problems of generation of power, as well as those engaged in the design and manufacture of tools and machinery, will find papers of interest to them. On account of the length of the program, papers of the nature of either of these are grouped into simultaneous sessions, and it remains for members to attend those sessions of first interest to them.

Comprehensive abstracts of papers to be presented were published in the November issue of The Journal and are continued in this issue. Pamphlet copies of any of the papers will be sent to members of the Society gratis upon application, in advance of the meeting. Written discussion of the papers is solicited, and should be sent to the Secretary before the meeting.

The following papers and reviews, also to be presented at the meeting, will be abstracted comprehensively in a later issue of The Journal.

ILLUSTRATED REVIEW OF THE WERKSPOOR MARINE DIESEL ENGINES

By Thomas O. Lisle

This paper reviews the results of six years' development of the Werkspoor Marine Diesel Engine. The firm of Werkspoor has to date completed the engines of twenty-four sea-going mercantile ships, representing a total of about 35,000 h.p.

Werkspoor was one of the first firms in the world to build Diesel-type engines on an extensive scale, having been building stationary motors of this class for over sixteen years. Despite this experience, and although they had also the benefit of about half a century's marine engine construction, their first attempts at building the machinery of motor ships were most modest. When the firm first turned its attention to marine Diesel engines, it decided that, unless the engine can be repaired in any port in the world where steam engines can be repaired, it is of no use to ocean-going ships. To this day they have adhered to this policy, consequently their engine is exactly similar to any of the marine steam engines.

The review will include illustrations taken from the engines of the twenty-four vessels constructed by the concern, showing how a number of important and distinctive features have been evolved.

THE DEVELOPMENT OF OUR FLEET AND NAVAL STATIONS

By William L. Cathcart

The author will give a rapid review of the broad subject of the development of our fleet and naval stations, a question of impelling interest to engineers. The topics he will consider are:

The Engineer a mighty factor in the sea power of our time.

Why we need a great Navy.

Our country is the richest, and, owing to its vast extent of coast line, the most vulnerable of all the great powers.

Strategic situation, Eastern coast.

The elements of naval strength are its ships and men and its shore stations. The location of these stations with regard to our possible battlegrounds of the future is of primary importance.

Strategic situation, Caribbean Sea.

Strategic situation, North Pacific Ocean.

The needs of our naval stations.

In the up-building and maintenance of our Navy, we need a large number of Navy Yards, with channels of approach dredged to full depth and with modern equipment for building and repairing both hulls and machinery of naval vessels.

The Passive Defense: Mines and Submarines.

For continuous effectiveness we need an almost completee reliance on a wall of mines and submarines for the defense of our shores. These weapons in turn require protection by shore batteries or the guns of a fleet.

How large should our Navy be?

Not for aggression, but to keep the peace, and to exert what Mahan called "the silent force of sea power," we need a great Navy.

Some Points as to Guns and Powders.

Modern battle ranges.

Is a vessel with twelve 14-in. guns more formidable at an 8-mile range than one with eight 16-in. guns?

Our Proposed Dreadnaughts.

The markmanship of our Navy.

A battleship is essentially but a mobile gun platform, and its ability to hit with that primary weapon, the gun, is virtually its sole reason for existence.

Fire-control methods.

The foundation of modern methods of Fire Control was laid by Rear Admiral B. A. Fiske of our Navy in his invention and successful application of the Telescopic Sight to naval guns in 1892.

Our Relative Naval Strength.

Admiral Fiske's Greeting.

There are no other men in the United States so immediately and directly powerful in developing the fleet and naval stations as the engineers. While the strategist estimates the general situation, and determines the application of the general principles of strategy to each situation as it arises; and, while the tactician handles the units of personnel and material in actual battle and in preparation for it, it is the engineer who provides the strategist and the tactician with the mechanism with which to carry out their respective and collective aims.

HEAT TREATMENT OF WROUGHT IRON CHAIN CABLE

By Frederic G. Coburn, W. W. Webster and E. L. Patch

Extensive investigations have been conducted at the Boston Navy Yard on methods for heat-treating power-forged chain cable, under the direction of Frederic G. Coburn, Naval Constructor. The work was done largely by W. W. Webster and E. L. Patch, assistant naval constructors and graduate students at the Massachusetts Institute of Technology.

All the chain cable for the Navy are made in the Smith shop of the U. S. Navy Yard, Boston.

Previous to July, 1914, this chain was hand-forged and came up to all requirements without heat treatment. At that time, however, the process of manufacture was changed by the introduction of power forging and test links repeatedly and consistently failed to come up to the required strength. The fracture almost invariably occurred across the welded quarter, not in the weld, and showed a rather coarse granular structure. The links showed little tendency to change shape and stretch before breaking, as did the hand-forged links.

It was evident that the unannealed links were too "stiff"; that is, while the material was strong enough in direct tension it was not ductile enough to get the full benefit of the tensile strength, on account of the shape of the link. Because of this stiffness, the shear across the bent quarter would reach its limiting value long before the direct stress. The annealing relieved this stiffness and produced a relation between the strength and ductility of the metal which greatly increased the strength of the link. It was evident that in order to obtain uniform and satisfactory results a systematic investigation of the whole subject of the heat treatment of wrought iron cable should be made to develop scientific methods to replace the cut-and-try methods formerly used.

Accordingly a complete laboratory was equipped for this purpose at the Navy Yard and systematic tests were conducted, first on the stock material used in the manufacture of chains and later upon links taken from the chains themselves. These tests included chemical analyses, tensile and impact tests, and metallographic examination. Preliminary to the tests on the full-sized chain links, large experiments were conducted on heat-treated specimens of the material.

The paper gives the results of several of these series of tests with conclusions.

THE DOWNFLOW TYPE OF STEAM BOILER

By John C. Parker

This paper describes the early experiments which demonstrated the possibility of circulating the water in boilers apparently contrary to the natural way, that is, downward rather than upward. From these there was developed the downflow boiler which was designed by the author and has been built by him for a number of years.

In the circulating system there are non-return valves which compel the circulation to proceed in the downward course and prevent reversal of the flow. The more the fire is forced, the more rapid is the flow through the tubes and the greater the steaming capacity.

Chief among the advantages claimed for the downflow principle is that the course of the water and steam are opposite to those of the flame and hot gases, consequently the hottest particles of each are in communication with the hottest particles of the other and there is a minimum difference of temperature between the adjacent particles of the two.

The tubes are formed into a number of vertical coils by connecting their ends together through junction boxes, and one of the special problems in the manufacture of this boiler was the design of these junction boxes. The paper describes these boxes, which are constructed of malleable iron.

An interesting feature of the boiler is that the changes in temperature from heating and cooling when cleaning and banking cause sufficient expansion and contraction to crack off large quantities of scale, and the force of the flow of the water and steam carries this scale out of the tubes and into the drum in which a pocket is provided to collect it.

Another interesting form of construction described in the paper is a double-ended design in which there are two furnaces back to back, the products of combustion from which unite and flow together through the same course as in a single-ended boiler. The advantage is that the entire floor space is utilized for grate surface, and at the same time long tubes and horizontal travel of the gases are retained. Several stations have been enabled to greatly increase their boiler capacity in this way without requiring any more boiler-room space.

AUTHORS OF THE PAPERS

The large number of papers this year makes them no less authoritative, as the following brief notes regarding authors will show:

Victor J. Azbe, Combustion Engineer, is at present in charge of the two modernly equipped boiler houses of the Anheuser-Busch Brewing Association, of St. Louis, Mo., containing boilers to the capacity of 12,600 h.p. He has given much time to the study of inefficiently operated boiler plants and to means for their improvement.

J. R. Bailey, Professor of Organic Chemistry, University of Texas, prior to his appointment spent several years in research work in European laboratories, receiving the degree of Ph.D. from the University of Munich. He has been a frequent contributor to domestic and foreign chemical journals, and in the course of his professional activities has done much water-analysis work both for the U. S. Government and for private clients.

Carl G. Barth, senior member of the firm of Carl G. Barth and Son, Consulting Engineers, Philadelphia, was one of the first engineers in the country to become associated with the late Frederick W. Taylor in the development of his system of factory management, and is at present actively engaged in installing that system in several important industries. Before taking up this line of work Mr. Barth spent some fifteen years as designer for several machine-tool builders in Philadelphia.

A. F. Batchelder has been connected with the railway department of the General Electric Company since its formation in 1895, serving respectively as engineer in charge of railway equipment repairs, designing engineer, and engineer of the railway locomotive department.

O. C. Berry, Assistant Professor of Experimental Engineering, Purdue University, since 1914, entered the employment of the Fairbanks-Morse Manufacturing Company, at Beloit, Wis., in 1906, where he became interested in gas-producer problems. Two years later he took up instruction work at the University of Wisconsin, where, as at Purdue later, laboratory facilities for investigation were placed at his disposal.

Geo. B. Brand, of the Remington Typewriter Works, Ilion, N. Y., for eighteen years has been identified with the development of typesetting and typewriting machines, and for a part of this time was in charge of cost and production at the Monarch Typewriter Works, Syracuse, N. Y.

L. P. Breckenridge, professor of mechanical engineering, Sheffield Scientific School, Yale University, since 1910, was previously engaged in engineering educational work at Lehigh University and the University of Illinois, being head of the experimental engineering laboratories at the latter institution, as he is now at Sheffield. His services in the capacity of expert are in much demand.

W. A. Buck was in the turbine research department of the General Electric Company in 1914. He was a fellow in steam and gas engineering at Kansas State Agricultural College from 1914 to 1916. He is now assistant instructor in steam and gas engineering at the Kansas college.

F. G. Coburn, Naval Constructor, U. S. N., now located at the U. S. Navy Yard, Boston, Mass., has been continuously in charge of navy-yard shop production, both at Mare Island and Philadelphia, since 1908. He has given much attention to management problems and introduced the task-and-bonus system of wage payment in the Philadelphia yard.

Robert F. Earhart, Professor of Physics, Ohio State University, has conducted numerous investigations, principally in the field of pure science. He collaborated with S. S. Wyer in preparing a paper entitled Deviation of Natural Gas from Boyle's Law, which was presented at the 1916 Spring Meeting of the Society.

W. S. Finlay, Jr., now Construction Engineer, Motive Power Department, Interborough Rapid Transit Company, and in charge of mechanical design and construction, has been engaged in similar work since 1904, barring the period 1910-1915, in which year he first became associated with the Interborough Company.

Henry L. Gantt, Consulting Engineer, was associated with the late Frederick W. Taylor in the initial stages of development of the latter's system of industrial management, and for more than ten years past has given his professional attention to administration, management, and other subjects which confront the industrial engineer. He has presented many valuable papers on management and kindred topics before the Society, and has otherwise embodied his ideas in published works that have become a part of the authoritative literature on the subject.

H. K. Hathaway entered the employment of the Midvale Steel Company at about the time the late Frederick W. Taylor was beginning the reorganization of the production methods and management of that concern, and has since been almost continuously connected with the development and extension of the Taylor system, giving much attention to its application in machine shops.

Frederick J. Hoxie has been Engineer and Special Inspector of the Associated Factory Mutual Insurance Companies, Boston, Mass., since 1907. Previous to that time he had about fifteen years of varied engineering experience, much of it involving work of an experimental nature.

E. F. Maas, in charge of machinery, electrical and ordnance drafting at the Puget Sound Navy Yard, has had 15 years' experience in the design of rolling-mill and marine machinery, and has given special attention to the latter.

Sanford A. Moss, Engineer in charge of the Turbine Research Department of the General Electric Company, during the course of his extended connection with that company has carried out a number of important investigations dealing with the mechanics of fluids and of rotating machine members, some of which have formed the subjects of papers presented by him before the Society.

John G. Morse, Chief Appraiser of the Associated Factory Mutual Fire Insurance Companies, has been engaged for more than 15 years in making insurance appraisals of industrial plants. The development of the present method of making rapid, complete and accurate appraisals is largely due to his efforts, and he has applied this system successfully to some of the largest textile, metal-working, paper- and rubber-manufacturing plants in the country.

John E. Muhlfeld, since graduation from Purdue University in 1893, has been almost continuously engaged in railway motive-power engineering, rising to the position of General Superintendent of Motive Power, Baltimore & Ohio Railroad. In 1911 he was made Vice-President and General Manager of the Kansas City Southern Railway. In the course of his work he has brought out original designs of heavy locomotives of different types, of passenger and freight cars, of power plants, etc.

Geo. A. Orrok from 1898 to the present year with the New York Edison Company and latterly its mechanical engineer, has given much attention to the subject of surface condensation, his researches in this line having formed the basis of several important papers presented before the Society and of numerous contributions to the technical press.

John C. Parker, General Manager of the manufacturing company bearing his name, has since 1897 been continuously engaged in the design, development and manufacture of the particular type of steam boiler described in his paper. Prior to that date his engineering interests centered on steam and gas engines.

G. Hawthorne Perkins has been head of the textile engineering department of the Lowell (Mass.) Textile School for a number of years. Prior to his assumption of the position, he devoted his attention to mill engineering and the design of textile machinery.

Charles Piez, President and Treasurer of the Link Belt Company, Chicago, entered the employ of the Link Belt Engineering Company, Philadelphia, in 1885 as draftsman, rising to the positions of general manager and chief engineer in 1906. Three years later he became president of the corporation with which he is now identified.

Reginald J. S. Pigott, now Power Engineer of the Bridgeport (Conn.) Arms Works of the Remington Arms-Union Metallic Cartridge Company, was for ten years connected with the Interborough Rapid Transit Company, of New York City, in the respective capacities of assistant engineer and mechanical construction engineer, where he was in charge of the design and construction of power stations, of tests and investigations of engines, turbines, stokers, etc., and of the calculation, layout, and installation of low-pressure turbines. His later work included the preliminary design and layout of the extension of the 74th Street power station for the 30,000-kw. units recently installed.

Walter N. Polakov during the past ten years has had a wide practice as consultant on power-plant operation and factory management. His earlier engineering experience was acquired in a number of Russian works of varied character.

Andrew A. Potter, Dean of the Division of Engineering and Professor of Steam and Gas Engineering, Kansas State Agricultural College, has been connected with that institution since 1905. In the two preceding years he carried out a number of thermodynamic investigations dealing with steam turbines and superheated steam in the laboratories of the General Electric Company. During his present incumbency he has done much consulting work along steam and gas engineering lines.

Arthur D. Pratt has been connected with the Babcock & Wilcox Company for the past ten years, serving in the latter half of that period as Assistant to the Advisory Engineer. He has specialized in superheater and economizer performance and in the laws governing heat transfer, and during the past few years has given particular attention to the utilization of waste heat and the development of the modern waste-heat boiler.

Donald B. Prentice, with the exception of one year spent in outside work, since his graduation from Sheffield Scientific School, Yale University, in 1910, has been assistant instructor in the mechanical engineering department of that institution.

Herbert B. Reynolds, Assistant Engineer, Motive Power Department, Interborough Rapid Transit Company, New York, for the past three years, has given much attention to testing and research work on boilers, turbines and air compressors in his previous connections with the Westinghouse and General Electric companies.

Henry G. Stott, since 1908 Superintendent of Motive Power, Interborough Rapid Transit Company, and New York Railroad Company, held a similar position with the Manhattan Railway Company for some years, prior to which he was engaged for some ten years in the construction and operation of electric-light plants.

Arthur N. Sheldon was graduated from Lawrence Scientific School, Harvard University, in 1899, and since that time has been connected in various capacities with the firm of F. P. Sheldon and Sons, Engineers and Architects, Providence, R. I.

Dr. Arthur C. Scott, President of the Scott Engineering Company, Dallas, Texas, has been engaged in consulting work in general engineering for the past ten or more years, and in the course of his practice has given considerable attention to water problems of the Southwest. For several years prior to 1911 he was professor of electrical engineering at the University of Texas.

Philip W. Swain, Instructor in Mechanical Engineering, Sheffield Scientific School, Yale University, was graduated from Syracuse University in 1911 and received the degree of M. E. from Yale in 1915. In addition to his classroom and laboratory instruction work he has found time to carry out considerable commercial research work in various lines.

Paul A. Talbot, president of the Talbot Boiler Company, New York, had his attention drawn to boiler problems at about the time of the Klondike gold rush, and in succeeding years carried out many experiments to determine the advantages to be gained by rapid forced circulation. The prototype of the boiler described in his paper was brought out in 1907, since which time Mr. Talbot has given his entire time to its development and manufacture.

ENTERTAINMENT FEATURES

The members' get-together, get-acquainted, have-a-good-time smoker, so successful last year, will be repeated. This will be held on Wednesday night on the fifth floor of the Engineering Societies Building, where there is now ample accommodation for the large attendance expected. Frank P. Gilbreth, Mem.Am.Soc.M.E., will give a talk on his experiences in Europe during the war.

Luncheons for members and guests will be served on Wednesday and Thursday at noon, also on the fifth floor. A charge of 50 cents per person will be made.

A popular lecture will be delivered in the Auditorium on Thursday evening, and this will be followed by the annual reunion and dance, given on the fifth floor. Tickets will be issued for the latter, and it will be necessary to secure these in advance at the registration desk.

Excursions have been arranged to points of exceptional interest in New York and vicinity. Times and places will be announced in the program given out at the meeting.

The ladies will be entertained at a musicale and tea on Wednesday afternoon.

A number of colleges in the vicinity of New York will hold reunions on Friday night. To these the members of the Society are invited. Particulars are given elsewhere in this issue.

PROGRAM OF THE ANNUAL MEETING

Tuesday, December 5

Conference of Local Sections. Luncheon of the official delegates from the Sections at Atlanta, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Indianapolis, Los Angeles, Minnesota, New Haven, New Orleans, New York, Philadelphia, St. Louis, San Francisco and Worcester, and the members of the Council of the Society. This will be followed by a business meeting to discuss plans of Section activities.

Registration Bureau opens 12 noon.

Council Meeting, 2 p.m.

Meeting of Sub-Committee on the Protection of Industrial Workers, 2 p.m.

Tuesday Evening

Presidential Address and Reception

Presidential Address by Dr. D. S. Jacobus, President of the Society, on the Relation of Education to Engineering. This will be followed by the annual report of the Tellers of Election of Officers, the introduction of the President-elect, and a reception to the President, President-elect, ladies, members and guests. This gathering will be informal.

Wednesday Morning, December 6

Morning sessions begin at 10 a.m. and afternoon sessions at 2 p.m. throughout the meeting.

Opening Session

Business Meeting.

Reports of the Council, Standing Committees and Special Committees. Constitutional Amendments and new business.

Award of Junior and Student Prizes.

John E. Sweet Memorial

The regular business of the first session will be suspended at 11 a.m., when there will be memorial exercises in honor of the memory of John E. Sweet, Past-President, Honorary Member and founder of the Society.

Miscellaneous Session

The Proportioning of Surface Condensers, George A. Orrok, Mem.Am.Soc.M.E.

The Testing of House-Heating Boilers, L. P. Breckenridge, Mem.Am.Soc.M.E., and D. B. Prentice, Jun.Am.Soc.M.E.

Water for Steam Boilers—Its Significance and Treatment, Arthur C. Scott, Mem.Am.Soc.M.E.,and J. R. Bailey.

The following eight papers will be presented by title without discussion at the meeting. Written discussion is solicited for publication and should be received by January 1.

Steam Safety Valves, George H. Clark
Contributed by the Boston Section

Efficiency of Propulsive Machinery and Late Developments in Naval Engineering, H. C. Dinger
Contributed by the Philadelphia Section

Standardization of Power Plant Operating Costs, Walter N. Polakov, Mem.Am.Soc.M.E.
Contributed by the New York Section

Tests of 30,000-Kw. Turbine, H. G. Stott, Mem.Am.Soc.M.E., and W. S. Finlay, Jr., Mem.Am.Soc.M.E.
Contributed by the New York Section

The Design and Test of a Large Reclamation Pumping Plant, G. C. Noble
Contributed by the San Francisco Section

Bearing Lubrication, Boynton M. Green

An Investigation of the Dynamic Pressure on Submerged Flat Plates, Howard E. Stevens

The Adaptability of the Internal Combustion Engine to Sugar Factories and Estates, M. Adam

Industrial Safety Session

Under the auspices of the Sub-Committee on Protection of Industrial Workers

Report on Safety Standards for the Operation of Cranes

Wednesday Afternoon

Miscellaneous Session

The Utilization of Waste Heat for Steam-Generating Purposes, Arthur D. Pratt, Mem.Am.Soc.M.E.

Graphic Methods of Analysis in the Design and Opera-

tion of Steam Power Plants, R. J. S. Pigott, Assoc-Mem.Am.Soc.M.E.

Power Plant Efficiency, Victor J. Azbe, Jun.Am.Soc.M.E.

Textile Session

Under the auspices of the Sub-Committee on Textiles

Heat Transmission Through Various Types of Sash, Arthur N. Sheldon, Mem.Am.Soc.M.E.

Spontaneous Ignition Studied by Means of Photographic Plates, Frederick J. Hoxie, Mem.Am.Soc.M.E.

Vibrations in Textile Mill Buildings, G. H. Perkins, Mem. Am.Soc.M.E.

Machine Shop Session

Under the auspices of the Sub-Committee on Machine Shop Practice

Standardization of Machine Tools, Carl G. Barth, Mem. Am.Soc.M.E.

A Proposed Plan for the Activities of the Machine Shop Section of The American Society of Mechanical Engineers, H. K. Hathaway, Mem.Am.Soc.M.E.

Conference of Local Sections—Meetings of official Section's delegates with officers of sections of sister societies.

During the afternoon a Musicale and Tea will be given in the rooms of the Society to the visiting ladies, members and guests under the auspices of the Ladies' Committee. This will be one of the important social features of the Annual Meeting and all are cordially invited to attend.

Conference of Student Branches.

Wednesday Evening

Smoker

The success of last year's smoker has decided the repeating of this form of entertainment for Wednesday evening. Entertainment will be provided, and a feature will be a short talk by Frank B. Gilbreth, Mem.Am.Soc.M.E., on his experiences in Europe during the war.

Thursday Morning, December 7

Valuation Session

Accurate Appraisals by Short Methods, J. G. Morse

Relation Between Perpetual Inventory Value and Appraisal Value, Charles Piez, Mem.Am.Soc.M.E.

Thursday Afternoon

Second Valuation Session

Valuation of Industrial Properties vs. Valuation of Industrial Methods, Walter N. Polakov, Mem.Am.Soc.M.E.

Productive Capacity a Measure of Value of an Industrial Property, H. L. Gantt, Mem.Am.Soc.M.E.

Conference of Local Sections—Meeting of official Section's delegates with Committee on Increase of Membership.

Excursions

Instead of providing for a large number of excursions, as in previous years, the New York Local Committee has arranged for a few of exceptional interest. Announcement of excursions will be made in the final program issued at the meeting.

Gas Power Session

Under the auspices of the Sub-Committee on Gas Power

A Gas Producer for Bituminous Fuel, O. C. Berry

Commercial Sampling and Gas Analysis, P. W. Swain, Jun.Am.Soc.M.E.

An Investigation of the Internal-Combustion Engine as Applied to Traction Engines, A. A. Potter, Mem.Am. Soc.M.E., and W. A. Buck

The Ratio of the Specific Heats and the Coefficient of Viscosity of Natural Gas from Typical Fields, Robert F. Earhart

Illustrated Review of the Werkspoor Marine Diesel Engines, Thomas O. Lisle

Thursday Evening

Lecture and Annual Reunion

The Committee has made arrangements for a Popular Lecture to be given in the Auditorium on Thursday evening.

Following the lecture, the members and guests are invited to adjourn to the fifth floor of the Engineering Societies Building for the Annual Reunion and Dance.

Friday Morning, December 8

Miscellaneous Session

The Impact Tube, Sanford A. Moss, Mem.Am.Soc.M.E.

Heat Treatment of Wrought Iron Chain Cable, F. G. Coburn, Mem.Am.Soc.M.E., W. W. Webster and E. L. Patch

The Flow of Air and Steam Through Orifices, Herbert B. Reynolds, Jun.Am.Soc.M.E.

Illustrated Review of the Development of Our Fleet and Naval Stations, W. L. Cathcart, Mem.Am.Soc.M.E.

Railroad Session

Under the auspices of the Sub-Committee on Railroads

Clasp Brakes for Heavy Passenger Equipment Cars, T. L. Burton

Pulverized Fuel for Locomotives, J. E. Muhlfeld, Mem.Am. Soc.M.E.

Mechanical Design of Electric Locomotives, A. F. Batchelder, Mem.Am.Soc.M.E.

Steam Boiler Session

Under the auspices of the Boiler Code Committee

An Analysis of the Working Parts of Safety Valves Met with in Marine Practice, with Suggestions for Repairs and Improvements, E. F. Maas, Mem.Am.Soc. M.E.

The Talbot Boiler, Paul A. Talbot

The Parker Boiler, John C. Parker, Mem.Am.Soc.M.E.

Friday Afternoon

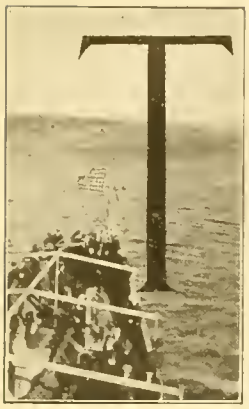
Public Hearing by the Boiler Code Committee. This is open to all persons interested, and upon request special invitations will be sent.

Saturday Morning, December 9

Public Hearing by Boiler Code Committee Continued.

JOINT "PREPAREDNESS" MEETING AT NEW LONDON

SATURDAY, NOVEMBER 11, 1916



THE members of the local Sections at Boston, New Haven, New York, and Worcester, members of the Providence Engineering Society, members of the Society at Meriden, Conn., and their friends, with guests from the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the Boston Society of Civil Engineers, the Brooklyn Engineers Club, the New York Engineers Club, the Providence Engineering Society, the Philadelphia Engineers Club, the engineering alumni and students of Brooklyn Polytechnic Institute, Brown University, Columbia University, Massachusetts Institute of Technology, New York University, Stevens Institute of Technology, Worcester Polytechnic Institute, and Yale University, took part in a joint excursion on November 11 to New London, Conn., to inspect the plant of The New London Ship and Engine Company, manufacturers of Diesel engines, and to witness a special exhibition of U. S. submarines under the personal direction of Rear Admiral A. W. Grant, commander of the submarine forces of the United States.

The excursion was a success, but the opportunity attracted a much larger number than had notified the committees on arrangements, and while every officer did his best to take care of the unusual situation, the facilities provided, and even the resources which could be requisitioned at the last minute, proved inadequate. More than 1,600 took part in the excursion, which is more than have attended even the largest general meeting ever held by the Society, that of last December.

While all the members of the various parties were not able

"FREEDOM OF THE SHIP" ON THE BUSHNELL

to see everything they had anticipated, at least every one had a good day's outing and the opportunity for increasing his acquaintanceship. The weather—usually an important one of the large number of variables on an excursion of this kind—was perfect, which probably accounted for the general spirit of good nature that prevailed in spite of the overcrowded conditions.

According to the original plans, the five train contingents from Boston, New York, New Haven, Providence, and Worcester, together with automobile parties from other centers, were all to arrive in New London just before noon, all lunch at the Hotel Mohican, and all visit the plant and witness the submarine exhibition together. Sending out invitations to participate brought in so many applications for tickets, however, that these plans had to be replaced and, as still more applications came in, replaced again. The lunch capacity of

"A.S.M.E. SPECIAL" FROM NEW YORK ARRIVES

the Mohican was augmented by that of the Crocker House, and when this did not suffice two sittings were arranged at each, but when the time came even these were not ample, and several of the party had to get their lunch elsewhere.

In the same way the arrangements for boats to carry the party to the submarine exhibition were insufficient.

The party from New York left the Grand Central Station at 8:36 a.m. by a special train of eleven coaches. This party numbered 641. At New Haven two coaches were attached to the train, with 130 members and guests of the New Haven Section.

The party from Boston, numbering 300, left South Station at 8:29 a.m., also by special train. This stopped at Providence and took on 160 members and guests of the Providence Engineering Society.

The party from Worcester came by regular train, leaving Worcester at 8:36 a.m.; this party numbered 120.

Besides these train parties, a number of members and their friends residing in the vicinity of New London attended, bringing the total above the 1,600 mark.

Immediately on arrival the members proceeded to the respective hotels to which they had been assigned for luncheon, and, as already mentioned, those who could not be accommodated at these places were asked to make their own arrangements.

The following were guests of the Society at luncheon at the Hotel Mohican:

Rear Admiral A. W. Grant, Commander of the submarine forces of the United States.

Commander Yates Sterling, in charge of the U. S. Submarine Base at New London.

Commander John K. Robinson, in charge of the Naval Training Station at Newport.

Mr. Gregory C. Davison, Vice-President of The New London Ship & Engine Company.

Mr. Charles H. Bedell, Electrical Engineer, Electric Boat Company.

Hon. Ernest E. Rogers, Mayor of New London.

Following the luncheon, the party was taken on board the *U. S. S. Bushnell* and the *U. S. S. Fulton,* both submarine tenders, the army transport steamer *General Nathanael Greene* and the New London Company's Diesel engine ferries *Nelseco* and *Helys,* all of which were provided for the trip down the Thames. The vessels proceeded down the river, accompanied by five submarines—2 "D" type and 3 "L" type boats.

L-43 Cleared Ready to Submerge

On the way down the river the captains of the vessels allowed their parties the "freedom of the ship," and every facility was afforded to see everything on board.

The vessels steamed to a point off Fishers Island at the mouth of the Thames River, where the submarines gave an exhibition of submerging and diving, and the party returned.

Arriving back opposite New London, all those on the *Greene, Nelseco, Helys* and *Fulton* and about half of those on the *Bushnell* were taken to the plant of The New London Ship & Engine Company, across the river at Groton, Conn., where they were shown the processes of manufacture of Diesel engines for submarines of the United States Navy.

The New London Ship & Engine Company is building the "Nelseco" Diesel 4-cycle engines for both naval and commercial vessels in units of 60 to 3,000 h.p. in the 4-cycle reversible gear type, directly reversible type and double-acting type. The engines have been furnished for installation in United States submarines and in submarines of many foreign nations, as well as in commercial vessels on both the Atlantic and Pacific coasts and in foreign countries.

In addition to the Diesel engines, the company manufactures all machinery installed in submarine torpedo boats of the Electric Boat Co. type.

When this company was organized five years ago the first buildings were the office building, 102 x 71 feet, and the two-story machine shop, 165 x 105 feet. Since then each building has had additions made to it and other buildings have been erected, a notable point being the modern, sanitary construction, with every provision for light and ventilation and the best working conditions in all departments. Well-kept lawns with attractive flower-beds present an inviting appearance around the office building, which fronts the street and with its additions makes a three-story, perfectly appointed brick building of 101 feet frontage and two wings 154 feet deep.

To the rear of the office building and a short distance from it are the machine shop, pattern shop and storehouse, pipe shop, power house and other buildings.

Successive additions to the machine shop, built of concrete and steel, have increased this to several times its original size, and it now is 600 feet long by 130 feet wide.

East of this is the store house and pattern shop, a wooden building, first built in 1911 and enlarged this year to its present size of 239 x 60 feet. Two pipe shops adjoin and connect with the machine shop on the west, furnishing the necessary facilities for this work in a building 204 x 65 feet.

Here also is the power house, first built in 1912 and increased in size this year to the dimensions of 93 x 112 feet.

At the southerly end of the plant is the new iron foundry, just completed and in operation in a building 178 x 85 feet. Adjoining this is the bronze foundry in a building 249 x 63 feet.

The time of the visit to the plant was particularly opportune, as the shops were full of work and engines of all sizes were on the testing floor. The party thus obtained a fairly

L-42 Running Alongside the Bushnell

representative idea of the processes and methods of construction of machinery for submarine service.

The visitors returned to New London on the company's private ferry in time for their respective trains.

On the return train journey each member of the New York party was served with a box lunch.

We may well be optimistic regarding the future of our Society, and may well come to the realization of the growth of its Sections when we contemplate the overwhelming response to this Preparedness Excursion—without question the largest meeting of its kind ever held or likely to be held for some time to come.

Too much praise and appreciation cannot be given to the officers of the United States Navy and of the New London Ship and Engine Company (Electric Boat Co.) for the uniform patience they displayed and for the courtesy they extended to our members and guests.

PUBLIC HEARING ON BOILER CODE

Announcement has been made in the October and November issues of The Journal of a public hearing on the Boiler Code, commencing Friday, December 8, 1916, at 2 p.m., in the Engineering Societies Building, New York, and continuing on Saturday and into the next week if occasion requires.

This hearing is in pursuance of the following recommendation of the Boiler Code Committee to the Council:

Your Committee recommends that you appoint a permanent Committee to make such revisions as may be found desirable in these Rules, and to modify them as the state of the art advances, and that such Committee should hold meetings at least once in two years at which all interested parties may be heard.

In view of several matters of considerable importance having arisen in connection with the revision period, a technical session of the Annual Meeting will be devoted to the Boiler Code Committee, at which three or more papers will be read that pertain to boiler questions under discussion. These are as follows: Safety Valves, by E. F. Maas; The Talbot Boiler, by P. A. Talbot, and the Parker Boiler, by John C. Parker. Another paper on the subject of the pencil electrode welding for boiler joints has also been offered. This session will be held Friday morning, December 8, beginning at 10 a.m., and it is hoped that all engineers interested in steam boiler problems and design will arrange to attend this session and discuss the papers.

The public hearing will follow immediately after this technical session on the boiler subjects and the Boiler Code Committee invites all who are interested in boiler subjects in general, and the A.S.M.E. Boiler Code in particular, will be in attendance and present their views.

SECTIONS' CONFERENCES AT ANNUAL MEETING

Those who have followed the affairs of the Society appreciate that our Sections are fast becoming one of the strongest elements in the life of our organization. Sections' meeting places are becoming the headquarters of the engineers in their vicinity. In their meetings the Sections are joining with the local branches of the other national organizations and are carrying out well the spirit of coöperation now dominant in the activities of the parent societies. They are contributing, through their meetings, valuable papers for the Society's publications. They are constituting a valuable medium for transmitting the influence of the Society to the mechanical engineering profession in various parts of the country. They are helping to increase the membership of the Society.

All the indications seem to justify the action taken by the Council two years ago, of inviting representatives from the Sections to come into personal contact with the Council and the management of the Society. With this end in view, the Society pays the railroad fare of one official delegate from each Section to each general meeting, and arranges conferences for the delegates.

These Sections' Conferences include "experience meetings," where delegates relate what their own Section is doing and hear what methods the other Sections are following. One meeting is held at which members of the Council are present; this is for the purpose of bringing the executive body of the Society into closer relationship with the membership.

The Conference at the coming Annual Meeting will begin with a luncheon at noon on Tuesday, December 5; the members of the Council will also be present at this luncheon. At 2 o'clock the first business session of the Conference will convene. On Wednesday, December 6, a second luncheon will be held, at which the officers of the sections of sister societies will be welcomed, and a second business session will be held Wednesday afternoon.

At the third luncheon on Thursday, December 7, the members of the Committee on Increase of Membership will meet the Sections' delegates and afterward join them in the discussion of matters of mutual interest.

STUDENT BRANCH CONFERENCE AT ANNUAL MEETING

One of the features of the Annual Meeting which has now become a permanent factor is the Conference of Student Branch representatives. Each of the forty Branches is invited to send a delegate to attend this Conference, which this year will be held on the afternoon of Wednesday, December 6, from 4.30 to 5.30 o'clock.

CORRECTION

Mr. F. P. Sheldon, author of the paper on Heat Transmission Through Various Types of Sash, calls attention to the following typographical errors in the abstract of this paper published in the November issue of The Journal:

Page 891, second column, line 8 should read "40 deg. *and* 70 deg."

Page 892, bottom of first column, "*Sample No. 2*" should read "*Sample No. 3*," and vice versa.

Page 893, first column, under *Proposition A, single-glazed steel sash*, "cost of heating system to supply *heating* loss only" should read "cost of heating system to supply *window* loss only."

Page 894, first column, fourth line under the heading "Internal Condensation in Double-Glazed Sash," delete "not."

LIBRARY NOTES

Dr. James Douglas, of New York, has presented $100,000 to the United Engineering Society, the income to be used for the benefit of the Library.

The Trustees of the Society have perfected plans for the development and the extension of the usefulness of this great Engineering Library and are endeavoring to secure endowments aggregating $1,000,000, the income to be used for the Library.

The plans of the Trustees having been submitted to and carefully examined by Dr. Douglas have been approved by him, and he has signified this approval by his gift of $100,000, which has just been made.

Now that the Library of the American Society of Civil Engineers has been united with the libraries of the Institutes of Mining, Mechanical and Electrical Engineers in the Engineering Societies Building, the combined library forms the greatest engineering collection in the world. It is the purpose of the Trustees to greatly extend its usefulness and it is hoped that the splendid endorsement which Dr. Douglas has given will stimulate other similar endowments until the necessary million dollars has been obtained.

REPORTS OF STANDING COMMITTEES

THE reports of Standing Committees for the fiscal year ended September 30, 1916, will be presented at the Annual Meeting as an appendix to the Annual Report of the Council of the Society's activities for the year. The Standing Committee reports are published below.

REPORT OF THE FINANCE COMMITTEE

The Finance Committee reports that the income of the Society for the year ending September 30, 1916, was $167,141.72. The total expenditures chargeable to income were $143,023.31, leaving an excess of income over expenditures of $24,118.41, this being a net balance after reserving $10,350.00 for obligations undertaken but not yet completed.

The expenditures of the Society per member for the fiscal year just closed are as follows:

General Salaries	$ 2.25
Headquarters, library, supplies, etc.	1.80
Committees on Membership and Increase of Membership	1.23
Sections	.90
Employment Bulletin	.23
Council contingencies	.41
House Committee	.24
Annual and Spring meetings	1.07
Year Book	.56
Journal and Condensed Catalogues	7.00
Transactions	2.08
Other activities	2.03
Making a total of	$19.80

The recommended Budget Appropriation for the year 1916-1917 is as follows:

Finance Com. Incl. Lib. Asst.		$32,400.00
Membership Committee		2,500,00
Council Contingencies	$2,000.00	
Mileage at 7c	2,000.00	
Employment Bul.	2,000.00	
		6,000.00
Sections		9,000.00
Inc. Membership Com.		6,500.00
House Committee—		
Depreciation	$2,500.00	
Other	975.00	
		3,475.00
Meetings Com.		9,000.00
Publication Com.		80,000.00
Research Com.		300.00
Student Branches		750.00
Junior Prizes		100.00
Sales Expenditures		10,000.00
John Fritz Medal		125.00
Total		$160,150.00

The estimated income for the year 1917 is $167,000.00.

The Committee takes pleasure in announcing that on July 1 last the Certificates of Indebtedness of the Society were paid and that the Society is out of debt.

Appended will be found reports of the accounts of the Society as shown in the book for the fiscal year ending September 30, 1916.

Respectfully submitted,

R. M. Dixon, *Chairman,*
W. H. Marshall,
Geo. M. Forrest,
A. E. Forstall,
Finance Committee.

REPORT OF ACCOUNTS

Mr. R. M. Dixon,
Chairman, Finance Committee.

Dear Sir:

In accordance with your instructions we have examined the books and accounts of The American Society of Mechanical Engineers for the twelve months ended September 30th, 1916.

The results of this examination are set forth in the three exhibits, attached hereto, as follows:

Exhibit A Balance Sheet, September 30, 1916.
Exhibit B Income and Expenses for the twelve months ended September 30, 1916.
Exhibit C Receipts and Disbursements for the twelve months ended September 30, 1916.

We hereby certify that the accompanying Balance Sheet is a true exhibit of its financial conditions as of September 30, 1916, and that the attached statements of Income and Expenses, and Receipts and Disbursements are correct.

Respectfully submitted,
(Signed) Wm. J. Struss & Co.,
Certified Public Accountants.

EXHIBIT A

Balance Sheet, September 30, 1916

RESOURCES

Equity in Society's Bldg., (No. 25 to 33 West 39th St.)	$353,346.62	
Equity in 1-3 Cost of Land (No. 25 to 33 West 39th St.)	180,000.00	
		$533,346.62
Library Books	13,000.00	
Furniture and Fixtures	5,000.00	
		18,000.00
Stores, including plates and finished publications		20,051.67
Trust Fund Investment		
New York City 3½'s 1954 (par $45,000)	39,696.81	
St. Louis, Peoria & N. W. 1st 5's 1948 (par $10,000)	10,613.89	
United N. J. Canal Co. (par $1,000)	970.00	
Cash in Banks representing Trust Funds	6,568.71	
		57,849.41
Cash in Banks for General Purposes	44,283.43	
Petty Cash, on hand	500.00	
		44,783.43

Accounts Receivable		
Membership Dues	14,392.34	
Initiation Fees	2,005.00	
Sales of Publications, Advertising, etc.	27,336.93	
		43,734.27
Advance payments		2,907.14
		$720,672.54

LIABILITIES

Trust Funds		
Life Membership Fund	$45,343.81	
Library Development	4,902.71	
Weeks Legacy	1,957.00	
Initiation Fee	2,352.90	
Junior and Student Prizes	2,000.00	
Melville Fund	1,084.00	
Hunt Memorial	208.99	
		$ 57,849.41
Dues and Initiation Fees paid in advance	821.57	
Initiation Fees uncollected	2,005.00	
Unexpended Appropriation 1915-16	7,301.69	
Unapportioned Revenue	27,166.72	
		37,294.98
Capital Investment	551,346.62	
Surplus and Reserve	74,166.20	
		625,512.82
Annual Meeting Social		15.33
		$720,672.54

EXHIBIT B

INCOME AND EXPENSES FOR THE TWELVE MONTHS ENDED SEPTEMBER 30, 1916

INCOME

Membership Fees	$97,561.87	
Sales—Gross receipts	13,488.97	
Advertising	51,855.26	
Interest and Discount	4,235.62	
Total		$167,141.72

EXPENSES

Finance Committee		
Office Administration	20,344.77	
Occupancy Building	4,800.00	
Library	4,021.55	
		29,166.32
Membership Committee		2,366.82
Council		
Contingencies	2,050.44	
Mileage	975.10	
Employment Bulletin	1,645.78	
		4,671.32
Sections Committee		6,432.07
Increase of Membership Committee		6,498.70
House Committee		1,697.94
Meetings Committee		7,725.12
Publication Committee		
Advertising	26,703.23	
Journal Text	24,056.61	
Revises	335.90	
Transactions	15,668.83	
Year Book	3,988.72	
		70,753.29
Sales		
General	6,346.24	
Boiler Code	2,021.43	
Power Test Code	1,207.41	
Society History	1,004.00	
		10,579.08
Research Committee	232.28	
Students' Committee	787.02	
Junior Prize	59.96	
Library Service	250.00	
John Fritz Medal	3.39	
Engineering Congress	1,800.00	
Total		$143,023.31
Excess of Income over Expenses		24,118.41

Note: The item of Total Expenses includes $10,350.00 not yet paid to complete work already in progress, chargeable to this year's activities.

EXHIBIT C

RECEIPTS AND DISBURSEMENTS FOR THE TWELVE MONTHS ENDED SEPTEMBER 30, 1916

RECEIPTS

Membership Dues	$96,332.85	
Initiation Fees	20,100.00	
Membership Dues paid in advance	1,327.32	
Sales of Publications, Badges, Advertising, etc.	67,488.86	
Interest	3,398.76	
City of East Orange Loan	20,000.00	
	$208,647.79	
Cash on hand and in Banks—General and Trust Funds, September 30, 1915	40,707.56	
		$249,355.35

DISBURSEMENTS

Disbursements for General Purposes	$143,903.21	
Certificates of Indebtedness redeemed	54,100.00	
	$198,003.21	
Cash on hand and in Banks—General and Trust Funds, September 30, 1916	51,352.14	
		$249,355.35

REPORT OF COMMITTEE ON MEETINGS

The attendance at the last Annual Meeting was the largest in the history of the Society, the total registration reaching 1,437. Seven sessions were held, of which four were in charge of sub-committees. There were 23 papers, exclusive of six from the Local Sections assigned to be read by title.

During the first session, there were memorial exercises in honor of the memory of our distinguished Past-President, Dr. Frederick W. Taylor. The other sessions were purely technical, one of which was on the general subject of industrial safety, now receiving attention throughout the country. The widespread interest in the various activities of the Society was evident by the numerous committee meetings throughout the Annual Meeting, including several conferences by local committees.

The smoker, held in place of the usual lecture on Wednesday evening, received general approval, but the large attendance badly overcrowded the Society's rooms. The chairman is pleased to report that the committee has since taken action which has resulted in the remodeling of the fifth floor of the Engineering Societies Building, with a new floor suitable for dancing.

The Spring Meeting at New Orleans, April 11 to 14, afforded an opportunity to visit a section of the country having distinctive engineering features, and the meeting, including the stop-over at Birmingham, was most successful. A notable feature was the discussion on Industrial Preparedness, which drew out many practical suggestions and valuable contributions from every part of the country.

Comparing the coming Annual Meeting with that of a year ago, we find that there will be eleven sessions, of which six are in charge of sub-committees. There will be 32 papers, exclusive of four from the local Sections to be read by title. One session designed to be of interest to the membership generally, has been arranged on The Valuation of Industrial Property. Following the regular business session there will be memorial exercises in honor of the memory of John E. Sweet, Past-President, Honorary Member and founder of the Society. This year for the first time the reunion and dance of Thursday evening will be in the Engineering Societies Building as a result of the remodeling of the fifth floor.

H. L. Gantt, *Chairman*,
R. H. Fernald,
John H. Barr,
L. P. Alford,
D. S. Kimball.

REPORT OF PUBLICATION COMMITTEE

The publications of the year have been The Journal, issued monthly, the annual volume of Transactions, the Year Book, the sixth annual volume of Condensed Catalogues, and the Power Test Code (reprinted from vol. 37 of Transactions).

The Journal

In its Annual Report for 1915, your committee made the following recommendations respecting The Journal:

That The Journal shall contain:

(*a*) All of the papers and discussions presented at regular meetings of the Society, preferably in substantially complete form, or adequately abstracted, according to the character of the paper, as soon after the meetings as possible.
(*b*) Papers, or abstracts, with discussion, presented at meetings of Local Sections.
(*c*) Announcements and reports upon Society affairs and incidents, employment bulletin, library notes, personal notes, etc.
(*d*) Department for contributed discussion on papers previously published, or new matter.
(*e*) Members' correspondence department, including suggestions on Society affairs.
(*f*) Review of world's technical press.
(*g*) Reviews of technical books, by experts selected by the committee.

In respect to the accomplishment of those recommendations, we have to report as follows:

(*a*) The papers and discussions presented at general meetings have been abstracted to approximately one-half of their original length, this being the largest fraction allowable under the existing appropriation.
(*b*) The Sections held about 100 meetings during the year, but the material presented at all of these was not of the nature for publication. As the result of our regular solicitation, from month to month, twenty-three papers were received from Sections; twenty-one were published in The Journal and two were held over on account of lack of space.
(*c*) The Society Affairs Section has averaged twenty-eight pages. The amount of material available for this department has increased steadily and material is now being held out for lack of space.
(*d*) and (*e*) The Correspondence Departments, started in January, 1916, are now quite pretentious. We are now averaging four contributions per issue.
(*f*) The scope of the Engineering Survey Section has been increased, but appropriations have not allowed development to the point of the committee's recommendation, *i.e.*, to cover the world's technical press. As a compromise, important articles not abstracted have been listed monthly.
(*g*) Appropriation has not been sufficient to undertake book reviews. Preliminary work for this department has been done, and the reviews can be started as soon as funds are available.

The scope of the Society's work has broadened so rapidly since the committee made its recommendations that we need to increase the scope of The Journal even beyond that recommended. We propose to now extend these recommendations as follows:

PROPOSED SCOPE OF THE JOURNAL

Technical Section.

Papers and Discussions presented at Spring and Annual Meetings and at Local Meetings.
Technical Correspondence, including brief original articles on subjects not related to papers and now precluded by lack of appropriation.
Technical Items of Interest. Pages or paragraphs from other publications referring to the subject-matter of the current technical section.
Summaries of Engineering Information, such as:
Lists of Books on certain subjects, such as those in the current technical section.

Synopses of Current Researches.

Lists and Synopses of Engineering Standards. This is greatly needed by engineers generally, and is matter so important and of such great magnitude as to require special provisions for its adequate handling.

Society Affairs.

Announcements, Reports of Meetings, Special Articles, such as Biographical Sketches. Committee Reports, Section and Student Branch News, Communications, Applications for Membership, Necrology, General Notes, etc., substantially as conducted now.

Engineering Survey.

Review of the World's Technical Literature, extended and improved as previously recommended by the Committee, and classified.
Selected classified lists of leading articles in current periodicals.
Reports, Synopses and Lists of Researches conducted by governmental, industrial and collegiate laboratories, to be secured by editorial staff by personal solicitation and from coöperation with the National Research Council.
Review of Important Events secured through the Local Sections and from regularly appointed correspondents, from individual members and from the technical and daily press.
Reports of Meetings of Engineering Societies closely related to the field of mechanical engineers, these reports to be prepared by representatives of The Journal in actual attendance at the meetings.

Miscellaneous Department.

Employment Bulletin.
Book Reviews.
Personals.
Library Notes and Accessions.

Transactions

Volume 37 of Transactions, issued during the summer to standing members in 1915, was the largest ever published by the Society, containing nearly 1600 pages.

The volume recorded the affairs of the Society during 1915, and included a general review of the work of the Society for this year, given in the Annual Report of the Council. It contained a calendar of all the meetings of the Society—general meetings and local meetings—held during the year; and the papers, with discussion, presented at the Spring Meeting in Buffalo, April, 1915, the Annual Meeting in New York, December, 1915, and the additional general meeting in San Francisco, September, 1915, in connection with the International Engineering Congress 1915. Papers read at local meetings and presented subsequently at a general meeting were also included. The reports of special committees received by the Council during 1915 and ordered published were published in the volume; of special note among these is the report of the Power Test Committee.

The Year Book

The rapid growth in membership of the Society has forced the Committee to again give attention to the problem of the size of the Year Book.

Six years ago, when the pocket list of members—the small-size Year Book—was adopted, the total membership in the Society was 3680; this allowed a volume of 310 pages, with an average of sixteen names on a page. At the present rate of increase of membership, the 1917 volume will contain nearly 8000 members.

The 1916 Year Book included an alphabetical register of 6931 names printed within the space of 254 pages, and a geographical list occupying 142 pages. This conservation of space was accomplished by using a condensed, but perfectly clear, face of type and by careful editing of entries and use of abbreviations.

The new arrangement will probably serve for two years more, when the Committee will have to again give consideration to the matter, as both further reduction in type and further abbreviation of words will sacrifice clearness.

Condensed Catalogues

The sixth annual volume of Condensed Catalogues contained data concerning the products of 267 firms, and a Classified Directory Section listing the products of 2500 manufacturers classified under 2000 different subject headings. The Engineering Data Section, a feature commenced in the 1915 volume, was continued, and contained 40 pages of data selected from Volume 37 of Transactions and from The Journal for 1915.

Power Test Report

As stated above, this report was included in the current volume of Transactions. Your Committee anticipated a large demand for copies of the report, and so had fifteen hundred reprints bound and issued as a publication of the Society. Over one thousand copies of this publication have been sold to date.

I. E. Moultrop, *Chairman*,
Fred. R. Low,
Fred. J. Miller,
Henry Hess,
C. I. Earll.

REPORT OF MEMBERSHIP COMMITTEE

The Committee on membership held ten meetings during the year 1915-1916.

The number of applications considered in the transaction of its work and a summary showing the action taken, follows:

Applications pending Oct. 1, 1915	492
Applications received during fiscal year	1387
Total	1879

The following action was taken on these applications:

Recommended for membership	1143
Recommended for membership (special cases)	14
Deferred indefinitely	6
Deferred	14
Denied promotion	2
In regular course of procedure (seven of which are held for special investigation)	700
Total	1879
Reinstatements and Reconsiderations pending	9

Those recommended for membership were divided into the following gradings:

Members	371
Promotion to Member	58
Associates	37
Associate-Members	236
Promotion to Assoc.-Mem.	46
Juniors	395
Total	1143

The reinstatement of sixteen members was recommended to the Council.

Under B 16, it was recommended to the Council that the dues of seventeen members be permanently remitted.

Henry C. Meyer, Jr., *Chairman*,
L. R. Pomeroy,
Hosea Webster,
Charles E. Lucke,
Fred J. Miller.

REPORT OF RESEARCH COMMITTEE

A new *Sub-Committee for the Consideration of Bearing Metals* has been instituted, headed by Mr. C. H. Bierbaum as chairman. Prof. H. Diederichs and Mr. John A. Capp have been appointed on this committee.

The Centigrade Thermometric Scale and the Metric System. The question of the adoption of the centigrade scale, as proposed by a member of Congress, without the accompanying change to the metric system of other weights and measures, was referred to the Research Committee; the question was referred back to the Council with the recommendation that it be turned over to the Joint Committee on the adoption of the Metric System, together with the expressed opinion that such a change was absolutely undesirable, in that it would cause worse confusion than we have at present. It was pointed out that we have many advocates for both systems, the present weight of opinion being apparently in favor of the English system of weights and measures. As far as we are aware, no engineer would be willing to support a combination of the two.

The Sub-Committee on the Clinkering of Coal (Prof. Lionel S. Marks, *chairman*) has been suspended until the research which is at present under way by the Bureau of Mines and

the Bureau of Standards shall have been completed, which will take about another year.

The Sub-Committee on Flow Meters (R. J. S. Pigott, *chairman*). This committee has prepared a bibliography of their references and is making a compendium abstracted from the references. Experiments have been carried out on the relative accuracy of five commercial makes of flow meters; special tests being carried on in relation to the internal friction of recording mechanism and the peculiarities of the individual machines. As all of these meters (twenty-eight in number) are in regular service, operating records on the troubles with them are also being accumulated. The results of these tests, part of which will be made by the CO_2 method advanced by Mr. E. G. Bailey and part by a Thomas electric meter method, will be published during the year.

Sub-Committee on Fuel Oil (Prof. Danforth, *chairman*). This committee has prepared a questionnaire on the subject of fuel oil, which is at the present time about one-half completed.

Sub-Committee on Lubrication (Mr. Albert Kingsbury, *chairman*). A bibliography of the references on lubrication has been prepared.

Sub-Committee on the Cutting Action of Machine Tools (Mr. L. P. Alford, *chairman*). Correspondence has been taken up with the Bureau of Standards, but due to pressure of other work in the Bureau and lack of facilities, has come to nothing. Efforts are being made to develop interest in other quarters.

Sub-Committee on Materials of Electrical Engineering (Mr. R. D. Mershon, *chairman*). This committee was suspended for a year during the activities of the members on Preparedness work.

Sub-Committee on Safety Valves. Several papers were produced on the subject of safety valves as the result of efforts of this committee. The resignation of Prof. E. F. Miller, the chairman, halts progress for the present, particularly as the immediate grounds have been covered.

Sub-Committee on Worm Gearing (Mr. Fred. A. Halsey, *chairman*). The work of this committee is at a standstill for the present, due to lack of funds to undertake the actual research work required. Work will probably not be taken up again for another year.

Work for 1916. At the meeting held September 15, a plan was put forward to insure a certain amount of work being covered by the various sub-committees. Bibliographies will be prepared on all those subjects requiring reference work, and from these bibliographies a compendium of the subject undertaken will be reported; this work is to be completed during the ensuing year. It is possible experimental work will be undertaken: in the case of the Flow Meters Committee this is at present under way.

The present method of action of the Research Committee is almost entirely by correspondence. Meetings of the main committee and the chairmen of the sub-committees are held three times a year only; all other work being carried on by correspondence between the members of committee and the chairmen of the sub-committees. A monthly progress report is also requested to keep the members of the Standing Committee in touch continually with the work being done by various sub-committees.

R. J. S. Pigott, *Chairman*,
Richard H. Rice,
R. D. Mershon,
A. M. Greene, Jr.,
Carl C. Thomas.

REPORT OF LIBRARY COMMITTEE

During the year ended September 30, 1916, there were added to the library of the Society 579 volumes and 161 pamphlets. The United Engineering Society Library, the joint collection of which the Society's Library is now a part, had on the above date 49,702 volumes and pamphlets.

The duplicate collection of some 12,000 volumes has been listed and sold, and the proceeds, $2,500.00, have been added to the endowment fund of the Library.

The American Society of Civil Engineers having, by a large majority vote of its membership, accepted the invitation to become a Founder Society, the library of this Society will be incorporated in the joint library as soon as proper shelving can be provided.

The attendance during the year was 13,981.

The research work done by the Library Service Bureau has increased greatly in volume. Requests for information have come from 68 localities in 23 foreign countries, and from 239 localities in the United States.

John W. Lieb, *Chairman*,
Leonard Waldo,
Jesse M. Smith,
W. M. McFarland,
The Secretary.

REPORT OF HOUSE COMMITTEE

The House Committee has held its regular meetings during the past year, and, most fortunately, a full attendance has been present at each meeting.

At the expiration of the fire insurance policies, which have been taken out for a three-year term, a new rate was made, which increased the insurance premium to some 300 per cent. A special meeting was immediately called and arrangements were made to cover the effects of the Society by special insurance until this most unusual occurrence could be investigated.

It was found that the classification under which the previous policies had been written would no longer be accepted, and after five or six months of constant application a series of reductions was obtained which lowered the new rate materially, but still left it 60 per cent above what the Society had previously paid.

While dealing with this insurance matter it also developed that, owing to the nature of some of the insured property, in the event of loss by fire, an opportunity would be immediately presented for a decided difference of opinion as to the amount of claim which the insurance company would recognize. This being the case, a schedule was prepared separating the purely commercial property from that whose value could not be so classed, and this schedule has been placed in the hands of the insurance broker with a view to having it accepted by the insurance company and filed as a part of the insurance policies covering property on the eleventh floor. The property of the Society on the twelfth and fourteenth floors is of commercial nature, and the property of the Society in the Library is not under the House Committee's jurisdiction.

With the decision of the American Society of Civil Engineers to change its headquarters to the Engineering Societies Building, a problem was presented to the House Committee due to certain changes in the building essential to the carrying of the additional three floors. Four steel columns were necessitated from the foundation to the roof of the original struc-

ture and one of these columns passes directly through the Board Room of the Society in a location most inconvenient to the symmetrical arrangement of the rooms.

A number of plans were prepared, and after careful consideration it was decided to change the arrangement of the partitions and to install a cabinet in such a way that the available floor space would not be diminished to any material extent and the symmetry of the rooms would be maintained.

At the time this change is made the three rooms, including the Secretary's office, will be redecorated with a warmer tint than is now on the walls, and the reception hall will also be redecorated in harmony with these rooms. It had been hoped that the building changes would be completed in season to permit the use of the rooms being redecorated prior to the annual meeting of the Society in December. However, owing to the delays in the structural work, it has been deemed unwise to attempt this, as confusion might result during convention week.

Those who attended the President's Reception last year will recall the crowded conditions of the rooms and the confusion resulting during the early part of the evening. Having this in mind, and also that the membership has increased some 700 during the past year, the House Committee finally decided to hold the President's Reception on the fifth floor of the Engineering Societies Building. This marks quite an innovation, and before reaching this decision careful consideration was given to the sentiment which has existed as to the propriety of not holding this function in the Society's own rooms, but the physical impossibility of properly accommodating a large attendance at this function determined the change.

Steps were immediately taken with a view to rendering the fifth floor more suitable to such an occasion. With the generous coöperation of the Board of Trustees of United Engineering Society, the partitions have been changed between the two large assembly rooms and a hardwood floor laid in the larger of these rooms. With these added facilities thus available and the consequent opportunity to enlarge upon the social features of this occasion, it is hoped that this most important evening of the annual convention will be rendered even more enjoyable than those which have afforded an enthusiastic membership opportunity to meet the incoming president in past years.

Pictures of the following Honorary Members have been added during the year: B. F. Isherwood, Dr. Ing. Oscar von Miller, O. Hallauer, Jos. Hirsch, Henry Léauté, F. Reuleaux and Ambrose Swasey.

William N. Dickinson, *Chairman*,
Frederick A. Scheffler,
James W. Nelson,
Orrie P. Cummings,
Maxwell M. Upson.

REPORT OF STANDARDIZATION COMMITTEE

The Committee on Bureau of Engineering Standards was a special one appointed to consider and make recommendations on the unification of the general work of standardization within The American Society of Mechanical Engineers, and to consider and make recommendations also looking toward the coöperation of all engineering societies, national as well as international, on all matters dealing with standards.

The work of that Committee culminated in a report that it made to Council and through Council to the membership. This report was published and then adopted by the membership. With that adoption the Committee's work was done and the Committee was discharged.

In order to make effective the work of the special committee and realizing that the activities involved would be continuous, the present Standing Committee on Standardization was provided for by an amendment to the Constitution.

It has not been considered advisable to bring the various committees on special standards that were appointed before your Standing Committee on Standards under the new rules, but all new committees are being appointed and made up in accordance with the lines laid down.

It is gratifying to know that other engineering societies have also realized the desirability of coöperation in this work of standardization; the American Institute of Electrical Engineers in particular is active, and a mutual consideration by the various societies is now being given to this subject.

Henry Hess, *Chairman*,
H. L. Gantt,
Henry G. Stott,
Carl Schwartz,
Wm. F. Kiesel, Jr.

COLLEGE REUNIONS DURING ANNUAL MEETING

As has been customary during the past few years, the New York Alumni Associations of various colleges where technical courses are given will hold reunions during the Annual Meeting. The following colleges are among those which have planned reunions for College Reunion night, which this year will be on December 8. Complete details are omitted on account of lack of space, but will be included in the final program.

BROWN UNIVERSITY

The Brown University Alumni will hold an informal banquet at the Brown University Club, 44 West 44th Street, on Friday evening, December 8, at 6.30 p.m. Prof. William H. Kenerson will be toastmaster. All alumni interested in engineering and desiring to attend are requested to communicate with Francis P. Davis, 195 Broadway, New York City.

CORNELL UNIVERSITY

The Mechanical Engineering Alumni of Cornell University will hold an informal dinner at Cornell Club, 65 Park Avenue, New York City, at 6.30 p.m. Further information may be had from William F. Hunt, 115 Broadway, New York.

LEHIGH UNIVERSITY

The Lehigh Club of New York will hold an informal dinner and smoker at the Machinery Club, 50 Church Street, New York, at 6.30 p.m., at which Alvan Macauley, Lehigh '92, President of the Packard Motor Car Company, will be the Guest of Honor. Further information may be had from Mr. deCourcy Browne, Room 2203, Equitable Building, 120 Broadway, New York City.

BROOKLYN POLYTECHNIC INSTITUTE

The Mechanical Engineering Alumni of the Polytechnic Institute of Brooklyn will hold a reunion at the Engineering Societies Building, at which Frank Gilbreth, Mem.Am.Soc. M.E., will deliver his lecture on Motion Study for Crippled Soldiers. An informal reception and dance will follow. Further details may be obtained from H. A. Brandt, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. (Main 4314.)

APPLICATIONS FOR MEMBERSHIP

MEMBERS are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, and those in the third under Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. Unless objection is made to any of the candidates posted by January 10, 1917, and providing satisfactory replies have been received from the required number of references, these candidates will be balloted upon by the Council. Those elected will be notified about February 15, 1917.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ADAMS, EARL E., Western Representative, Metals Production Equipment Co., Springfield, Mass.

BILYEU, WILLIAM F., Manager Feed-Water Heater Dept., Warren Webster & Co., Camden, N. J.

BERGLAND, ERIC L., Engineering Dept., Light, Heat & Pwr. Div., E. I. du Pont de Nemours & Co., Wilmington, Del.

BRAGG, SUMNER B., Foreman, Nosing French Shells, Midvale Steel Co., Philadelphia, Pa.

BREEZE, ALFRED, Vice-President, The Cincinnati Ball Crank Co., Cincinnati, Ohio

CHAPIN, WARREN W., Assistant Structural Engineer, Carrere & Hastings, New York

COONLEY, HOWARD, President, Walworth Manufacturing Co., Boston, Mass.

DOW, HERBERT W., with Nordberg Manufacturing Co., Milwaukee, Wis.

EISLER, CHARLES, Chief Designer, Westinghouse Lamp Co., Bloomfield, N. J.

EK, ALMA, Master Mechanic, Braden Copper Co., Rancagua, Chile, S. A.

EVANS, GEORGE A., Assistant to Mechanical Engineer, Public Service Electric Co., Newark, N. J.

FISHLEIGH, WALTER T., Associate Professor Automobile Engineering, University of Michigan, Ann Arbor, Mich.

GRATIOT, JAMES T., Manager Machinery Department, Fairbanks, Morse & Co., Denver, Colo.

GROSSHEIM, M. K., Designing Draftsman, Harry Bentz Eng. Co., New York

HALL, LOUIS J., President, Columbian Brass Foundry, Freeport, L. I., N. Y.

KELLEY, AUGUSTUS N., Superintendent, The Modern Foundry Co., Oakley, Cincinnati, Ohio

LACKNER, RAYMOND A., General Manager, Neely Nut & Bolt Co., Pittsburgh, Pa.

LEWIS, KENNETH B., Manager Dept. of Wire Drawing Equipment, Morgan Construction Co., Worcester, Mass.

LIDBURY, FRANK A., Works Manager, Oldbury Electro Chemical Co., Niagara Falls, N. Y.

McGINNIS, CRAWFORD P., Special Rep., Pyle National Co., Chicago, Ill.

McINTIRE, CHARLES V., Assistant Engineer, Otto Coking Co., Inc., New York

McLEAN, ALVA W., with The American Well Works, Aurora, Ill.

MEIER, CHARLES, with The Cincinnati Planer Co., Oakley, Cincinnati, Ohio

MELNIKOFF, NICHOLAS P., Chief Engineer, Cabinet of His Majesty the Emperor of Russia, Petrograd, Russia

METZ, ELLWOOD A., Chief Draftsman, Thurlow Steel Works, Inc., Chester, Pa.

PAIGE, HARRISON N., Motive Power Department, Mount Lyell Mining & Railway Co., Ltd., Queenstown, Tasmania, Australia

ROGERS, CLARENCE M., Civil Engineer, Daytona, Fla.

RUSSELL, ALBERT B., Works Manager, Library Bureau, Ilion, N. Y.

SMITH, WILLIAM, Mechanical Engineer, Henry Disston & Sons, Inc., Tacony, Pa.

TALIAFERRO, ROBERT R., with Carrier Air Conditioning Co., Cincinnati, Ohio

TONNE, HERMAN A., Machine Designer, The Standard Shade Roller Corp., Ogdensburg, N. Y.

UNDERHILL, CHARLES R., Chief Electrical Engineer, The Acme Wire Co., New Haven, Conn.

WATT, HAROLD W., Engineer, Electric Distribution, Westchester Lighting Co., Mount Vernon, N. Y.

WILSON, THOMAS, Western Editor "Power," Hill Publishing Co., Chicago, Ill.

YOUNG, WILLIAM J., Engineer, Hydraulic Turbine Corp., Camden, N. Y.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BINNS, GEORGE W., with Cincinnati Milling Machine Co., Cincinnati, Ohio

COOK, HOWARD B., with the Warner Elevator Manufacturing Co., Cincinnati, Ohio

FALLOWS, ERNEST, Mechanical Superintendent, Jenckes Spinning Co., Pawtucket, R. I.

HARRISON, CLIFFORD E., Inspector, The American Engineering Co., Philadelphia, Pa.

KUEHN, HUGO R., Mechanical Engineer, Illinois Steel Co., Joliet, Ill.

LINN, SUE SHING, Draftsman, The American Locomotive Co., Schenectady, N. Y.

McKAIG, ALVIN W., Chief Engineer, George F. Shevlin Mfg. Co., Saratoga Springs, N. Y.

MAGDEBURGER, EDWARD C., Designing Engineer, Busch-Sulzer Bros.—Diesel Engine Co., St. Louis, Mo.

MALONE, JOSH G., Draftsman, Mirck & Co., Rahway, N. J.

MIDDLETON, NATHAN A., Engineer, Hornblower & Weeks, Boston, Mass.

MOORE, JAMES W., Engineer, American Cast Iron Pipe Co., Birmingham, Ala.

NICHOLS, ALLEN E., Designing Engineer, Bureau of Waste Disposal, City of Chicago, Ill.

OVERSTRUD, MELVIN, Production Engineer, Minneapolis Steel & Machinery Co., Minneapolis, Minn.

SEAVEY, C. LAWRENCE, Industrial Engineer, Remington Typewriter Works, Ilion, N. Y.

FOR CONSIDERATION AS JUNIOR

BAKER, PHILIP C., Designing, Engineering Dept., Board of Water Commissioners, Detroit, Mich.

BEEKMAN, HENRY M., Engineering Dept., Primary Battery Div., Thomas A. Edison, Inc., Bloomfield, N. J.

BILLINGTON, RONALD V., Draftsman, Great Western Sugar Co., Denver, Colo.

BRAKES, JAMES, JR., Instructor in Mechanical Engineering Lab., Syracuse University, Syracuse, N. Y.

COOKE, EUGENE L., Assistant to Engineer of Tests, New York Edison Co., New York

DILLEY, JESSE R., Mechanical Engineer, Remington Arms-Union Metallic Cartridge Co., Bridgeport, Conn.

FRANCIS, HARRIS S., Foreman Production Dept., Safety Car Heating & Lighting Co., Jersey City, N. J.

GAILLARD, DAVID S., Superintendent, Experimental Plant, American Cyananid Co., New York

HORNER, BENJAMIN B., Engineer, Consolidated Water Power & Paper Co., Grand Rapids, Wis.

LANE, ABBOTT A., Inspector of Aeroplanes and Motors, United States Signal Service at Large, Washington, D. C.

LLOYD, ANTELL A., Inspector, American Ammunition Co., New York

PENN, MARION, Assistant Div. Superintendent, Public Service Electric Co., Elizabeth, N. J.

POIRIER, AUSTIN E., Assistant to Millwright, Works Engineer's Office, Union Metallic Cartridge Co., Bridgeport, Conn.

RIDER, DAVID S., Assistant Engineer, Power Plant, Scovill Mfg. Co., Waterbury, Conn.

STEDMAN, HAROLD W., Foreman, Electrical Department, Chase Metal Works, Waterville, Conn.

SUTERMEISTER, FREDERICK, Assistant Mechanical Engineer, Chelsea Fibre Mills, Brooklyn, N. Y.

VINNEDGE, EARLE W., with Worthington Pump & Machinery Co., Cincinnati, Ohio

WARREN, WILLIAM H., Efficiency Engineer, Inspiration Consolidated Copper Co., Miami, Ariz.

WILLIAMS, GEORGE L., Mechanical Engineer, Empire Zinc Co., Hanover, N. M.

APPLICATIONS FOR CHANGE OF GRADING

BAILEY, HAZIL H., Resident Engineer, E. W. Clark & Co., Management Corp., Columbus, Ohio

BAILEY, WILLIAM J., District Manager, United Coal Corp., Philadelphia, Pa.

BORDEN, WILLIAM H., Operator, Pacific Gas & Electric Co., San Francisco, Cal.

BOYD, W. WALLACE, Chief Engineer, Buffalo Scale Co., Buffalo, N. Y.

MACDONALD, JAMES V., Member of Firm, Ranald H. Macdonald & Co., New York

ROSE, FRED W., Consulting Engineer, Rose & Harris, Engineers, Minneapolis, Minn.

SMITH, ROY H., Treasurer, The Falls Rivet Co., Kent, Ohio

WEBER, ERWIN L., Consulting Engineer, Seattle, Wash.

SUMMARY

New Applications	68
Applications for change of grading: Promotion from Junior	8
Total	76

GEOGRAPHICAL LIST

Alabama
Birmingham—Moore, J. W.
Arizona
Miami—Warren, W. H.
California
San Francisco—Borden, W. H. (J.)
Colorado
Denver—Billington, R. V.
Gratiot, J. T.
Connecticut
Bridgeport—Dilley, J. R.
Poirier, A. E.
New Haven—Underhill, C. R.
Waterbury—Rider, D. S.
Waterville—Stedman, H. W.
Delaware
Wilmington—Bergland, E. L.
District of Columbia
Washington—Lane, A. A.
Florida
Daytona—Rogers, C. M.
Illinois
Aurora—McLean, A. W.
Chicago—McGinnis, C. P.
Nichols, A. E.
Wilson, T.
Joliet—Kuehn, H. R.
Massachusetts
Boston—Coonley, H.
Middleton, N. A.
Springfield—Adams, E. E.
Worcester—Lewis, K. B.
Michigan
Ann Arbor—Fishleigh, W. T.
Detroit—Baker, P. C.
Minnesota
Minneapolis—Overstrud, M.
Rose, F. W.
Missouri
St. Louis—Magdeburger, E. C.
New Jersey
Bloomfield—Beekman, H. M.
Eisler, C.
Camden—Bilyeu, W. F.
Elizabeth—Penn, M.
Jersey City—Francis, H. S.
Newark—Evans, G. A.
Rahway—Malone, J. G.
New Mexico
Hanover—Williams G. L.
New York
Brooklyn—Sutermeister, F.
Buffalo—Boyd, W. W. (J.)
Camden—Young, W. J.
Freeport—Hall, L. J.
Ilion—Russell, A. B.
Seavey, C. L.
Mount Vernon—Watt, H. W.
New York—Chapin, W. W.
Cooke, E. L.
Gaillard, D. S.
Grossheim, M. K.
Lloyd, A. A.
McIntyre, C. V.
Macdonald, J. V.
Niagara Falls—Lidbury, F. A.
Ogdensburg—Tonne, H. A.
Saratoga Springs—McKaig, A. W.
Schenectady—Linn, S. S.
Syracuse—Brakes, J., Jr.
Ohio
Cincinnati—Binns, G. W.
Breeze, A.
Cook, H. B.
Kelley, A. N.
Meier, C.
Taliaferro, R. R.
Vinnedge, E. W.
Columbus—Bailey, H. H. (J.)
Kent—Smith, R. H.
Pennsylvania
Chester—Metz, E. A.
Philadelphia—Bailey, H. H. (J.)
Philadelphia—Bragg, S. B.
Harrison, C. E.
Pittsburgh—Lackner, R. A.
Tacony—Smith, W.
Rhode Island
Pawtucket—Fallows, E.
Washington
Seattle—Weber, E. L. (J.)
Wisconsin
Grand Rapids—Horner, B. B.
Milwaukee—Dow, H. W.
Australia
Queenstown—Paige, H. N.
Chile, S. A.
Rancagua—Ek, A.
Russia
Petrograd—Melnikoff, N. P.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary and items should be received by the 18th of the month in order to appear in the succeeding issue of The Journal.

CHANGES OF POSITION

M. R. JONAS has accepted a position with the By-Product Coke Works of the River Furnace Company of Cleveland, O., in the capacity of test engineer.

P. S. STEENSTRUP, formerly associated with the export department of the Hupp Motor Car Company of Detroit, Mich., has become affiliated with the General Motors Export Company of the same city.

ALBERT C. DICKERMAN, formerly affiliated with Warren B. Lewis, consulting engineer of Providence, R. I., is now associated with the engineering department of the Sayles Finishing Plants, Saylesville, R. I.

RALPH M. FERRY has assumed the duties of superintendent of the Northern Aluminum Company, Ltd., Toronto, Ont., Canada. He was formerly associated with the U. S. Aluminum Company, New Kensington, Pa.

H. O. C. ISENBERG, until recently in the employ of the Ferro Machine and Foundry Company, Cleveland, O., has become connected with the Scripps Booth Company of Detroit, Mich., in the capacity of chief engineer.

JOHN S. REPKO, JR., formerly assistant maintenance engineer of the Bosch Magneto Company, Springfield, Mass., has accepted a position with the Guanica Central Sugar Company, Porto Rico, as assistant mechanical engineer.

JOHN A. MCCRARY has accepted a position with the C and R Department of the Navy Yard, Washington, D. C. He was formerly draftsman and assistant to general superintendent of The Mathieson Alkali Works, Saltville, Va.

FRANK J. BRYANT has severed his connection with the Andrew McLean Company, Passaic, N. J., and has assumed the position of New Jersey manager of the Huber Hand Stoker Company, with headquarters in Passaic, N. J.

ALDEN W. BALDWIN, formerly with the engineering department of The Deane Steam Pump Plant, Holyoke, Mass., is now an instructor in mechanical engineering in the Towne Scientific School, University of Pennsylvania, Philadelphia, Pa.

SURREY W. SLATER, formerly assistant superintendent of the holder distribution department of The Brooklyn Union Gas Company, Brooklyn, N. Y., has been appointed engineer of The St. Maurice Pulp and Paper Company, Cap Magdeleine, Que., Canada.

HARRY A. NADLER has assumed the duties of factory superintendent of Central Fortuna, Porto Rico. He was, until lately, associated with the Guanica Centrale Sagar Company, Ensenada, Porto Rico, in the capacity of assistant chief engineer.

C. A. BLACK, who for many years has been superintendent of dredg-

ing in the second district consisting of the northern half of the Panama Canal and Gatun Dam, was on September 1, when all dredging districts were combined, promoted to superintendent of the entire dredging division with headquarters at Paraiso.

ANNOUNCEMENTS

E. Gybbon Spilsbury has gone to Cuba on professional work and will be absent about three weeks.

James Guthrie, until recently in the employ of the Curtiss Aeroplane and Motor Corporation, Buffalo, N. Y., has opened a consulting engineering office in Cleveland, O.

F. H. Ballou, traveling engineer of the Great Wetsern Sugar Company, Denver, Colo., has been transferred to the Montana district, Billings, Mont., in the capacity of assistant engineer.

Sanford E. Thompson announces the opening of new offices and laboratory in the Federal Street Building, Boston, Mass. These replace both the Newton Highlands and the Milk Street offices.

R. G. Clyne, for the past seven years with the Western Cartridge Company of East Alton, Ill., as mechanical engineer, has resigned and will go into business for himself in St. Louis, Mo., designing and building special machinery. He has devoted over 26 years to this class of work.

APPOINTMENTS

J. Harland Billings is now lecturer, in charge of the machine design department, at the University of Toronto, Toronto, Ont., Canada.

J. R. Bolgiano has been assigned by the Emerson Company, with whom he is associated, to the efficiency department of the Dayton Malleable Iron Company.

L. H. Blood, mechanical superintendent of the Wood and Brooks Company, Buffalo, N. Y., has become associated with the Lodge and Shipley Machine Tool Company, Cincinnati, O.

Benjamin E. Bosler, formerly assistant superintendent of shops of the Cambria Steel Company, Johnstown, Pa., has been appointed superintendent of the mechanical department of the company.

AUTHORS OF PAPERS, ETC.

C. H. Bierbaum presented a paper on Graphite at the November 29 meeting of The Engineering Society of Buffalo.

Douglas T. Hamilton delivered an address on Gages and Their Relation to Interchangeable Manufacture before the Springfield Society, Springfield, Vt., on November 14.

B. Nagy presented a paper on Hydrated Lime—Its Use in Concrete and Mortars, at the November 3 meeting of The Detroit Engineering Society.

Russell Huff will present a paper entitled A Plea for the Four Cylinder Engine, at the December 13 meeting of The Engineering Society of Buffalo.

W. L. R. Emmet presented a paper on Alquist Gearing for Ship Propulsion at the 24th general meeting of The Society of Naval Architects and Marine Engineers, held in New York, November 16 and 17.

Frederic G. Conurn presented a paper on The Power Forging of Chain Cables at the November 16 and 17 meeting of The Society of Naval Architects and Marine Engineers.

L. W. Helmreich, head of the department of electrical engineering of The David Ranken, Jr., School of Mechanical Trades, St. Louis, Mo., gave a talk on the purpose and scope of the school at the November 1 meeting of The Engineers' Club of St. Louis. The meeting which was held at the School, was followed by an inspection of the shops and laboratories.

NECROLOGY

FRANK EDSON SHEDD

Frank Edson Shedd was born in Sharon, New Hampshire, July 18, 1856; attended the Conant High School of East Jaffrey, New Hampshire, and graduated from Dartmouth College in the Class of 1880. After a year of teaching as principal of a High School he was in the service of the United States Coast and Geodetic Survey for a year, his work being on the charting of the coast of Maine.

In 1882 he left the government service to take up civil engineering in Lowell. In 1886 he had charge of the erection of the Washington Mills at Lawrence, Mass., at that time one of the largest mill-construction propositions that had then been undertaken, and now owned by the American Woolen Company. In April, 1887, he became a member of the staff of Lockwood, Greene & Co., who designed the Washington Mills, and two years later was made first assistant to Mr. Stephen Greene, then the sole member of the firm, and has ever since maintained an intimate connection with that organization. On January 1, 1901, upon the incorporation of Lockwood, Greene & Co., Mr. Shedd became a director and the vice-president of the firm, both of which positions he held until his death.

Mr. Shedd was a civil engineer of high standing, had designed many large mills and hydraulic plants in various parts of the United States and Canada and was considered one of the leading authorities in this country on hydraulic developments.

He was a man of varied interests; a member of the American Society of Civil Engineers; the Boston Society of Civil Engineers and The American Society of Mechanical Engineers.

JOHN E. MCINTOSH

John E. McIntosh was born at Cayuga, N. Y., on February 17, 1858, and died on September 17, 1916. He was educated at Cayuga, at the St. John School, Mantius, N. Y., and at Columbia University. He founded the McIntosh & Seymour Co. about 1885 and was president of this concern until his retirement from business a few years ago. His invention of a flywheel governor made possible the beginning of the company. Mr. McIntosh had great ability as a practical mechanic and also as a boat builder, having built several large boats for his own use.

He was a member of the Citizens' League of Auburn, the City Club of New York, City Club of Auburn, Owasco Country Club, Technology Club of Syracuse, Atlantic Deeper Waterways Association, Auburn Chamber of Commerce, and was National Chancellor of the Chamber of Commerce of the United States. He also served one term as Mayor of the City of Auburn. Mr. McIntosh became a member of the Society in 1901.

JOHN VANDERVEER BEEKMAN

John Vanderveer Beekman was born in Peacock, Morris Co., N. J., on February 7, 1842, and received his education in the district schools near his home. For four years he served an apprenticeship at Dunham & Staats Iron Works, at Raritan, N. J. He then went to Brooklyn, where he remained for six years with the South Brooklyn Engine Works. For two years following this he engaged in business for himself, having a general machine shop in Brooklyn which was afterwards organized as the Pioneer Iron Works of which he was manager. Finally he became interested in the Lidgerwood Manufacturing Company, manufacturers of hoisting engines and boilers. He was well known in engineering circles and was the inventor of many devices now in use on hoisting engines. He was a member of the Machinery Club, and also of the Plainfield Country

Club, and the Hydewood and Stamford Golf Clubs. He became a member of the Society in 1889.

Mr. Beekman died at his home in Plainfield, N. J., on September 11, 1916.

EMIL HERTER

Emil Herter was born in New York City on January 16, 1860, and received his education in the public schools of New York. From 1874 to 1880 he served an apprenticeship with Gustav Burger, and from 1881 to 1883 held a position in the drawing room of the Rider Hot Air Engine Company at Walden, N. Y., and with J. H. Wright at Bridgeport, Conn. From 1883 to 1884 he worked in the shop of the Colts Patent Fire Arm Company. His other practical experience included positions as patternmaker and machinist with the Goshen Foundry & Gas Machine Co. at Goshen, N. Y., draftsman with Brown & Hall, New York City, and Adams & Richards, New Brunswick, N. J. He had charge of erecting machinery at the Niles Tool Works, Hamilton, O., and following that worked as draftsman with the E. W. Bliss Company in Brooklyn. From 1890 to 1892 he had charge of machine shop work in the Schenectady branch of the Edison General Electric Company. After this he held the position of chief draftsman with the New Jersey & Pennsylvania Concentrating Works. At the time of his death he was chief mechanical engineer with the Edison Storage Battery Company, working on many of Mr. Edison's most important inventions.

Mr. Herter became a member of the Society in 1894. He died on August 23, 1916.

THEODORE NEWELL ELY

Theodore Newell Ely was born at Watertown, N. Y., on June 23, 1846, and died at his home at Bryn Mawr on October 28, 1916. He received the degree of C. E. at Rensselaer Polytechnic Institute in 1866, and the honorary degree of M. A. from Yale University in 1897, and that of Sc. D. from Hamilton College in 1904.

Mr. Ely's entire business career was spent in the employ of the Pennsylvania Railroad, the engineering department of which he entered in 1868. From 1903 to 1910 he was chief of motive power of the lines east and west of Pittsburgh and Erie, and at the time of his retirement in 1911 was chief of the whole system.

He was also a director of the Pennsylvania Steel and the Cambria Steel Companies, and was a member of the Permanent Commission of the International Railway Congress, a member and president since 1904 of the Eastern Railway Association, and a member of the American Railway Association, the American Society of Civil Engineers, the American Institute of Mining Engineers, the Institute of Civil Engineers of Great Britain, the American Philosophical Society, the American Historical Association, and The Franklin Institute.

Mr. Ely was a fellow of the American Association for the Advancement of Science, vice-president of the American Academy in Rome, and was an honorary member of the American Institute of Architects. He belonged to the Century, University, and Engineers' Clubs of New York, the Philadelphia and Engineers' Club of Philadelphia, and the Metropolitan Club of Washington. He was known for his interest in art and music, and was a director of the Philadelphia Academy of Fine Arts and a trustee of the Drexel Institute and the Philadelphia Commercial Museum. Mr. Ely became a member of the Society in 1880.

SOCIETY MEETINGS

MEETINGS of the Society are now being held regularly at established Sections at Atlanta, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Indianapolis, Los Angeles, St. Paul and Minneapolis (Minnesota Section), New Haven, New Orleans, New York, Philadelphia, St. Louis, San Francisco and Worcester; also the Providence Engineering Society, which is affiliated with our Society, holds regular meetings. Sections are in prospect at Baltimore, Erie, Kansas City, Meriden and Rochester.

It is of the highest importance in the development of the monthly meetings of the Society, both of the Sections and of the Student Branches, that comprehensive reports of these meetings be published in The Journal regularly. Secretaries of the Sections and Student Branches are urged to make every effort to get the complete reports of their meetings to the office of the Society as quickly as possible after the meetings are held, and also, where possible, copies of the papers presented should be sent in; if desired, the copy of the paper will be returned after examination. Reports of meetings must be received before the 18th of the month in order to appear in the next issue of The Journal.

PROVIDENCE, OCTOBER 25

A meeting of the Providence Engineering Society was held on October 25. This was the first general meeting of the new Society and a large number attended. Forty-one new members were elected and eleven new applications were received. Professor Kennison, Mem.Am.Soc.M.E., of Brown University, gave an instructive talk on Iron—from the Ore to the Finished Article, which was illustrated by moving pictures of the various processes.

Albert E. Thornley,
Section Secretary.

BUFFALO, OCTOBER 18

The Engineering Society of Buffalo held its first meeting for season 1916-17 on October 18. A dinner in which about 150 members participated, was a feature. After the dinner, Dr. D. S. Jacobus, President of the Society, gave an address emphasizing the importance of coöperation between the national societies and local groups.

Mr. Rice said that there was a tendency today in the profession toward better recognition of the qualifications of the engineer in the administration of municipalities and mentioned particularly the City of Cleveland. He also stated that the professional engineer is taking a leading part in the industrial preparedness question.

S. J. Foley,
Corresponding Secretary.

ST. LOUIS, OCTOBER 14

The first meeting of the St. Louis Section for the season 1916-17 was held on October 14; about 40 members were pres-

ent. The speaker of the evening was L. C. Nordmeyer, Mem. Am.Soc.M.E., who had just returned from an eighteen-months' sojourn in China where he was supervising the construction and starting up of a large plant for storing and preparing eggs for export shipment. The recounting of some of his personal experiences as well as his description of Chinese life in various phases was very interesting.

H. R. Setz,
Section Chairman.

ST. LOUIS, OCTOBER 18

At the October 18 meeting of the St. Louis Section of the Society, a paper was presented by E. R. Fish, Mem.Am.Soc. M.E., on Standardized Boiler Construction. He called attention to the meaning and importance of the Boiler Code recently issued by the Society which is more and more becoming the recognized standard to state authorities and inspection companies.

In the discussion which followed, representatives of inspection companies explained why there had at first been some opposition on their part towards this new code, but stated that they had now adjusted themselves to the new condition.

H. R. Setz,
Section Chairman.

NEW YORK, NOVEMBER 14

A meeting of the New York Section was held on the evening of November 14 in the auditorium of the Engineering Societies Building. The chairman introduced Baron Shiba, head of the mechanical enegineering department of the Imperial University of Tokyo and past-president of the Japanese Society of Mechanical Engineers, who brought greetings from the engineers of Japan to the Society, and who received the greetings of our members in return. The chairman then introduced Mr. Charles H. Bedell, electrical engineer of the Electric Boat Company, New London, Conn., who delivered an illustrated lecture on submarines. This lecture had been specially arranged as a sequel to the joint excursion of the New York, New Haven, Boston, Worcester and Providence Sections on Saturday, November 11.

The speaker introduced his subject in a very interesting way by comparing the capabilities of the *Nautilus* of Jules Verne with what we are able to do today. With the aid of lantern slides he then reviewed the history of the submarine, following with a complete description of the interior of a modern vessel. He showed numerous pictures of the latest types of submarines, including a number of American boats, some late type English submarines, and the German merchant submarine *Deutschland*, showing photographs of the interior of the latter and comparing it with fighting vessels. He concluded with an illustrated review of submarines in operation, showing vessels awash, partially and wholly submerged and diving, and an exposition of the defensive use of submarines for the protection of our coasts.

The speaker has had over twenty years' experience with submarines, and throughout his lecture he recited many interesting incidents in connection with this, so that his audience of 500 were well entertained during the whole evening.

The meeting was preceded by an informal dinner at Offer's Restaurant, 38th St. and 6th Ave., at which fifty were present.

A. D. Blake,
Section Secretary.

STUDENT BRANCHES

CARNEGIE INSTITUTE OF TECHNOLOGY

The Student Branch of the Carnegie Institute of Technology held its first meeting on October 18. H. A. Madison, Chairman of the Branch, in his opening address said that a new feature would be instituted in the Branch this year in the form of a "Suggestion Box," into which any member or non-member can drop suggestions as to subjects or speakers. He felt that this would be very valuable and hoped that a large number of students would make use of it.

The speaker of the evening was C. W. Starker of the Educational Department of the Westinghouse Electric and Manufacturing Company. His subject was Electric Drives in Mechanical Engineering, and he gave a very interesting illustrated lecture on Westinghouse motors of all sizes, from the smallest size for dentists' use to motors of 30,000 h.p. The illustrations included applications on the Great Lakes. Mr. Starker also pointed out the advantages from the use of the different types of motors on their special class of work.

J. H. Davis,
Branch Corresponding Secretary.

CASE SCHOOL OF APPLIED SCIENCE

Calvin W. Rice, Secretary of the Society, addressed the Student Branch of the Case School of Applied Science at its meeting on October 17 on The Recognition of the Engineering Profession. He told of the organization of the scientific and industrial resources of the nation, urged a higher motive for scientific researches and councils and spoke of the increasing necessity for the engineering profession to assume its proper place in public affairs.

At a meeting of the Branch on November 1 the students were addressed by Professor R. H. Danforth on Fuel Combustion for Gas, for fuel oil, for pulverized coal and for bulk coal. The lecture was illustrated by lantern slides.

A. Treuhaft,
Branch Corresponding Secretary.

COLORADO AGRICULTURAL COLLEGE

A meeting of the Colorado Agricultural College Student Branch was held October 16, at which the following officers for the year were elected: George Law, president; Max Gorton, vice-president, and Edwin Johnson, secretary-treasurer. Professor L. D. Crain was recommended to the Society for Honorary Chairman.

Following the election of officers Professor Crain gave a talk, explaining the object of the Student Branch and the benefits the students will derive from membership in it.

Coy Hoffman gave a paper on the new boiler plant of the Ford Automobile Company, calling particular attention to the great efficiency of floor space, saving in cost of building per boiler horsepower and saving in fuel cost.

Edwin Johnson,
Branch Secretary.

LEHIGH UNIVERSITY

The first meeting of the Student Branch of Lehigh University was held on October 26. A. H. Langenheim, '17, spoke on the subject of The Layout of an Alkali Plant at Niagara Falls. Several diagrams were used by him to make his descriptions clearer. He explained how alkalis and chlorine are manufactured by an electrolytic process in which the raw brine is decomposed by a strong current, thus producing the gas and leaving a dilute solution of the alkali, which is concentrated by evaporation. The operation must be carried on with great care, due to the danger of handling the products.

J. E. Frobisher, '17, read a paper by S. T. Harleman, M.E., '01, superintendent of the Crucible Department of the Bethlehem Steel Company, who could not be present at the meeting. This paper dealt with the early history of the steel in-

dustry and the development of steel making, and included a discussion of the ancient wool steel and finishing with the modern processes, such as crucible, open hearth, Bessemer and the recent electric types. Each of these methods was taken up in turn and their advantages considered.

F. M. Porter,
Branch Secretary.

PURDUE UNIVERSITY

A joint meeting with the Student Branch of the A.I.E.E. of Purdue University was held on October 24, at which Charles Cottingham gave talks entitled A Trip through the Krupp Gun Works, Manufacture of Paper and The Panama Canal built before your eyes. The slides showing the Krupp Works were very impressive because of the immenseness of the different operations. The point emphasized in the manufacture of paper was that the raw product was practically the same for all grades of paper, the difference in the product being introduced in the methods of manufacture.

G. A. Ruess,
Branch Corresponding Secretary.

UNIVERSITY OF ILLINOIS

The regular meeting of the Student Branch of the University of Illinois was held on October 12. Following a short business meeting, F. E. Evans talked on Manufacturing Methods at the Overland Automobile Factory. His talk dealt principally with the work of the assembling department of the factory and gave a chronological outline of the assembling process. It was supplemented by a fifteen-minute discussion of questions put to him regarding details of work in the Overland factory.

At a meeting of the Branch on October 26, V. S. Day spoke on Power Absorbing Dynamometers. The talk included a history of the absorption brake, classification of the different types of brakes and constructional features of the friction brake, and water and electric brakes. A short theoretical development of the horsepower formula concluded the talk.

V. S. Day,
Branch Chairman.

WASHINGTON UNIVERSITY

A meeting of the Washington University Student Branch was held on October 25, at which E. H. Tenney, assistant to the chief engineer of the power plant of the Union Electric Light and Power Company, of St. Louis, Mo., gave an illustrated lecture on the construction of the Ashley Street plant of the above company, showing the tunnels, piping and installation of turbines and engines. There were also slides showing the method for reconstructing a part of the plant.

The total output of the plant at the present time is about 56,000 kw., and when additions are made the output will be about 81,000 kw.

Walter Henry Kurtz,
Branch Corresponding Secretary.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping anyone desiring engineering services. The Society acts only as a clearing house in these matters.

POSITIONS AVAILABLE

In forwarding applications, stamps should be enclosed for transmittal to advertisers; applications from non-members should be accompanied by a letter of reference or introduction from a member, such reference letter to be filed with the Society. Copy for notices must be in hand by the 18th of the month.

ESTIMATOR, young man, technical graduate with experience in foundry and pattern work and familiar with cast iron and steel, to take charge of estimating department for large foundry. Location Maryland. 397

SALESMEN ON POWER PLANT EQUIPMENT, commission basis. Equipment consists of boilers, engines, forced-draft blowers, pumps and elevators. 402

EXPERIENCED MAN on twist drills, one thoroughly familiar with twist drill making machines and able to assist in designs for new factory; to be placed in charge of department as soon as started. 413

ESTIMATOR, a plant in western New York manufacturing steel plate tanks and receptacles, desires services of estimator for this class of work. In first letter please state age, experience, training, whether single or married, salary expected, present employment. Correspondence confidential. 634

Three or four recent GRADUATE MECHANICAL ENGINEERS required on tests, inspection of materials, writing of specifications, etc. Salary $18 per week. 635

GRADUATE ENGINEER thoroughly familiar with materials of automobile construction, shop practice and costs, desired by large automobile manufacturer. Good opportunity for man capable of reducing costs. State age, experience, references and salary expected. Location New York State. 636

PRODUCTION ENGINEER, preferably young mechanical engineer with good machine-shop experience in costs, efficiency engineering, and factory management, thorough knowledge of modern methods in securing increased output and decreased costs. Salary according to experience and ability. Location Boston, Mass. 640

YOUNG ENGINEER, some experience in modern factory transportation; should be familiar with handling methods, and with use of lift trucks, cranes, conveyors, etc. Location Connecticut. 641

WORKS MANAGER, unusual opportunity for right man, 35-45, must be graduate engineer and have thoroughly demonstrated ability as machine designer and production man. Good organizer and hustler preferably with ability to invest $5,000 at the end of 3 months if satisfactory. 642

MECHANICAL ENGINEER for inspecting various lines of machinery with different manufacturers. Headquarters New York. 643

ENGINEERING EDITOR for established technical monthly published in New York City. Man preferably 25 to 30 years old, either mechanical or electrical engineering graduate with some experience in publishing business. Salary $25 a week and a share in the profits. Must be an enthusiastic writer, energetic, willing to attend conventions, speaking when necessary. Should desire to make publishing his life work, and be ready to start immediately. 644

TECHNICAL GRADUATE having several years successful general engineering experience in industrial plant, to act as assistant to plant engineer; must be keen observer, aggressive, have originality and initiative. State age, experience, references and salary received. Name confidential. Location Detroit. 648

FOUR YOUNG ENGINEERS, about 25 years of age, technical graduates. Two for technical commercial work and two for office side of work. Some mechanical and electrical experience. 651

MECHANICAL, ELECTRICAL and COMMERCIAL ENGINEERING FIRM in New York desires to engage a business-getter to call on prospective clients, attend to publicity work and generally develop business. Man about 30 years of age with technical education and some selling experience desired. Drawing account and expenses will be allowed and liberal percentage on the business developed. Reply fully stating age, experience and qualifications. 655

DRAFTSMAN, on plant layout and machine design. 656

ASSISTANT TO POWER ENGINEER of large industrial plant. Technical graduate. For general power testing and inspection. Must be familiar with testing steam and electrical equipment. Salary $1,000 to $1,200. 660

CHIEF ENGINEER to take charge of power plant in Greater New York; 800-h.p. boilers, engines, etc., and general equipment. Desire references, experience, nationality. Salary $40 to $50 per week. 662

EXPERIENCED PUMP DRAFTSMAN. Salary $22 to $26 a week according to ability. Permanent position. 664

HEATING AND VENTILATING ENGINEER, young technical graduate, with three or four years' experience. Location Ohio. 665

SUPERINTENDENT for an automobile tire factory, who understands compounding, and is experienced in machinery and installation. Location Minnesota. 666

SUPERINTENDENT or MASTER MECHANIC for large industrial plant; competent to handle the mechanical departments of company having 9,000 employees. Location Ohio. 667

MECHANICAL DRAFTSMAN, experienced on general engineering work, preferably including some structural experience. Location South Bethlehem, Pa. 668

YOUNG ENGINEER to go to England; must be competent to undertake all variety of engineering, both in England and countries on the continent. Apply by letter. 675

INSTRUCTORS for school of mechanical trades in Iowa. Salaries $1,000 to $1,200 per year; promotion dependent to large extent upon the commercial work which can be turned out during the year.

(a) Energetic young man with some business ability to take charge of automobile department; must know his subject thoroughly and be able to build up the department educationally and commercially, as the department is doing a large repair business. Competent to teach in automobile lines, including electric cranking, lighting and ignition course, be able to organize material and work in such way that a maximum number of students can be handled with minimum teaching force and expense.

(b) Man to handle foundry and machine shop and possibly forge. 676

PLANNING DEPARTMENT AND TIME STUDY MEN. A well established firm can offer exceptional opportunities for effective and interesting work to engineering graduates who have had substantial experience with modern industrial accounting, with special reference to time study the determination of standard tasks and planning and scheduling production. In reply state age, education, experience, present and expected salary. 679

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be in hand by the 18th of the month, and the form of the notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

ENGINEERING EXECUTIVE or confidential position by man just completing standardization proposition. Practical and theoretical experience. Would consider connecting with new enterprise, development or installation of new project or system, or taking charge of engineering or confidential interests of individual or corporation. Best references of ability, standing, etc. Will go anywhere. L-398

SALES MANAGER, EXECUTIVE or MANUFACTURERS' AGENT. Associate-Member, age 40. Seventeen years experience in boilers, stokers and kindred lines. Has international reputation as master salesman. Diplomatic, forceful and energetic and accustomed to meeting the men "higher up." Desires connection with manufacturers requiring representation in Central and Northwest with headquarters in Chicago. Intimately acquainted with largest corporations and industrial concerns in this section. L-399

JUNIOR MEMBER. Stevens graduate. Varied experience as safety engineer, designer and test engineer on power-plant equipment and assistant to chief engineer on ordnance and munitions. Desires to associate with engineering firm where technical and business knowledge can be used to advantage. Vicinity New York preferred. Salary secondary to opportunity. Available immediately. L-400

WESTERN REPRESENTATIVE. Member, practical machinist, Stevens graduate; engineering business and buying experience. Easterner with residence of ten years in the West. Age 36, married. Now employed by mechanical-engineering contracting concern. Desires change and solicits position as Pacific Coast representative of Eastern manufacturer. Salary and commission basis. Would consider two non-conflicting lines. References. L-401

EXECUTIVE. Desires position in medium-size city in Middle West as manager or assistant manager and superintendent of electric power company or similar position with manufacturing company. Graduate M. E., age 34. Eleven years experience in manufacture, construction, operation and sale of power-plant machinery; thoroughly experienced in managing departments. L-402

STEAM OR DIESEL ENGINES, electrical equipment, air compressors and pumping engines. Member experienced in these lines and at present holding responsible position desires change. L-403

EXECUTIVE ENGINEER. Desires position as works manager, production manager, superintendent inspection or other executive position. Technical education. Fifteen years' experience handling men and production in large plants, conveying machinery, automobile axles, typewriters, ball and roller bearings, wire wheels and artificial leather. Familiar with scientific management. L-404

TECHNICAL GRADUATE. Junior Member. M. E., Class of '15. Age 27, four years' machine shop experience. Desires position with future. Now employed. Location not essential. L-405

M. E. GRADUATE, 1916. Desires position where technical training will be of service and advancement will be commensurate with services rendered. At present employed. L-406

SALES MANAGER, SALESMAN or EXECUTIVE ENGINEER. Technical graduate, thoroughly experienced in shop methods, testing and design of power-plant equipment, and with wide experience and successful record of salesmanship in mechanical lines. New York or Middle West preferred. At present employed. L-407

FACTORY MANAGER. American, age 36. Graduate M. E. Desires to make a change. Has held successfully positions of machinist's apprentice, foreman, inspector, erector, chief draftsman, assistant superintendent, superintendent and factory manager. At present employed. L-408

MECHANICAL ENGINEER. Junior Member. Age 29. Six years experience in machine-shop, mill and power-plant work. Designing, testing and superintending construction. New York City or eastern location preferred. L-409

WORKS MANAGER, SUPERINTENDENT or PLANT MANAGER. M. E. Lehigh University. Several years' experience in management of mechanical department of railroad, coal mining and industrial corporations; extensive experience as plant engineer in mechanical, electrical and construction lines for large manufacturing plants. Good organizer and executive. Qualified to fill position of works manager of industrial plant, manager of coal-mining property, superintendent of motive power of railroad, or plant engineer for large manufacturing or mining company. L-410

MECHANICAL AND COMBUSTION ENGINEER. Junior Member, age 28. Technical graduate and has had three years' experience in steam and combustion engineering. At present employed in 40,000-kva. railway power station. References furnished on request. Location immaterial. L-411

MECHANICAL ENGINEER. Junior Member, age 31, married. Ten years' experience in design, construction and operation of mechanical equipment for power plants, will consider position as sales engineer on salary and commission basis. Location Philadelphia; available January 1. Present salary $135 per month. L-412

MECHANICAL AND MINING ENGINEER. Member, technical graduate, age 47. Many years practical experience in consulting, designing, construction and operation of power plants, copper and lead smelters, crushing and concentrating plants, economical handling of materials, or SALES ENGINEER, handling equipment for above named plants. At present employed, desires to make change as no opportunity for further advancement or responsibility is afforded. Location anywhere if healthy. References. Salary $6,000. L-413

CHIEF ENGINEER, SUPERINTENDENT OF CONSTRUCTION General master mechanic, maintenance engineer, twenty years' technical training and practical experience as machinist, pipe fitter, machine-shop foreman, draftsman, designer, chief draftsman, superintendent of construction and acting chief engineer on all classes of general plant design, details, construction, rebuilding, improvements and auxiliaries. L-414

MANUFACTURERS' REPRESENTATIVE or AGENT on commission basis for power-plant equipment, machine tools, machinery, or heavy hardware. Graduate mechanical engineer, ten years' experience as New York district manager for well known firm manufacturing mechanical equipment. Would like to hear from firms who desire to increase their sales in the East. Highest references; can prove ability and success in sales engineering with record of increased business. L-415

EXECUTIVE: Graduate mechanical engineer, six years designing, manufacturing and selling experience. At present on the road but wishes to obtain position without travel. Tactful, systematic and conscientious; excellent references. L-416

ASSISTANT TO EXECUTIVE OR CONSULTING ENGINEER: Junior member, Cornell graduate. Age 27. Experienced in fuel and combustion engineering; testing of boilers, engines, stokers, and meters, etc.; cost distribution and operation, maintenance, construction and inspection work in connection with service plants supplying compressed air, refrigeration, steam and hot water heat. L-417

WORKS MANAGER OR EXECUTIVE ENGINEER technical graduate, with varied experience in office, sales and executive work in shop and factory, desires position of representative capacity touching the executive and commercial side of business. Employed. L-418

ACCESSIONS TO THE LIBRARY

A List of Books and Pamphlets Added During the Past Month to the Library of the Society and of the United Engineering Society, Engineering Societies Building, New York

LIBRARY ACCESSIONS

American Institute of Architects. Proceedings of Annual Convention. 47-49. *v.p. 1913-1915.* Gift of Institute.

American Society of Agricultural Engineers. Transactions. vol. IX. *Ames, 1916.* Gift of Society.

American Society of Mechanical Engineers. Transactions. vol. 37, 1915. *New York, 1916.*

Automobile Performance Formulae, H. K. Thomas. Edited by John Younger. *1916.* Gift of John Younger.

Cincinnati (Ohio) Water Works Department. Annual Report 1915. *Cincinnati, 1915.* Gift of Water Works Department.

New York City. Board of Water Supply. 10th Annual Report, 1915. *New York, 1915.* Gift of J. Waldo Smith.

Personal Reminiscences of James Mapes Dodge, Charles Piez. 1916. *Chicago, 1916.* Gift of Link Belt Co.

Western Association of Electrical Inspectors. Proceedings of 11th Annual Meeting, 1916.

——— Yearbook. August 1916. *Chicago, 1916.* Gift of Wm. S. Boyd.

EXCHANGES

American Railway Master Mechanics' Association. Report of the Proceedings of the 48th Annual Convention, 1915. *Chicago, 1915.*

Canadian Society of Civil Engineers. Report of Annual Meeting. vol. 28, 1914. *Montreal, 1914.*

TRADE CATALOGUES

Berger Mfg. Co., *Canton, Ohio.* Bulletin no. 12. Metal lumber.

Chicago Pneumatic Tool Co., *Chicago-New York.* Bulletin 34-X. Giant gas engines.

Diamond Power Specialty Co., *Detroit, Mich.* Power notes. *September-October 1916.*

Flannery Bolt Co., *Pittsburgh, Pa.* Staybolts. *October 1916.*

Glasgow Iron Co., *Pottstown, Pa.* Catalog, 1916. Iron and steel plates, muck bars and flanged and pressed work.

Leschen, A. & Sons Rope Co., *St. Louis, Mo.* Leschen's Hercules. *October 1916.*

Roebling, J. A. Sons Co., *Trenton, N. J.* Wire rope. v. 1. no. 4. *1916.*

Stow Manufacturing Co., *Binghamton, N. Y.* Bulletin no. 100. Electric motors.

——— no. 101. Electric tools.

——— no. 102. Flexible shaft.

Swenson Evaporator Co., *Chicago, Ill.* Evaporators. Single and multiple effects.

Texas Company, *Houston, Chicago, New York.* Texaco Star. *October 1916.*

United Engineering & Foundry Co., *Pittsburgh, Pa.* Bulletin M. "United" merchant mills.

Wagner Electric Mfg. Co., *St. Louis, Mo.* Bulletin 113. A synopsis.

Walworth Mfg. Co., *Boston, Mass.* Walworth Log. *October 1916.*

ADDITIONS BY THE UNITED ENGINEERING SOCIETY

American Petroleum Industry, R. F. Bacon and W. A. Hamor. vols. 1-2. *New York, 1916.*

Applied Electricity for Practical Men, A. J. Rowland. *New York, 1916.*

Chemical Engineering Catalog. 1916 edition. *New York, 1916.* Gift of Chemical Catalog Company.

Chemical Study of Illinois Coals. Coal Mining Investigations. Bulletin no. 3. *Urbana, 1916.*

City Managers' Association. Proceedings, 1915. *Niagara Falls, 1915.* Gift of Association.

Coal Resources of District VI—Illinois. Coal Mining Investgations. Bulletin no. 15. *Urbana, 1916.*

Coke Industry of New South Wales. New South Wales Geological Survey. Mineral Resources, no. 23. *Sydney, 1916.*

Concise Technical Physics. *New York, 1916.*

Congress and the Railways. Railway Business Association. Bulletin no. 19.

Electrical Engineering—Advanced Course, E. J. Berg. *New York, 1916.*

Engineering Manual of the American Electric Railway Engineering Association. Revised December 1915.

Flotation Process, H. A. Megraw. *New York, 1916.*

Franklin Institute. Year Book 1916. *Philadelphia, 1916.*

Geology and Mineral Resources of the Yilgarn Goldfield. Western Australia Geological Survey. Bulletin no. 63. *Perth, 1915.*

Die gesteinsbildenen Mineralien, Ernest Weinschenk. *Freiburg, 1901.*

Handbook of Machine Shop Electricity, C. E. Clewell. *New York, 1916.*

International Engineering Congress, 1915. vol. VIII—Mining Engineering. *San Francisco, 1915.*

Japan Imperial Geological Survey. Geological Map. Division V. *Tokyo, 1916.*

——— Mineral Map. Division V. *Tokyo, 1916.*

List of Inspected Electrical Appliances, Published by Underwriters Laboratories. April 1916. *Chicago, 1916.*

List of References on Valuation of Railways. August 1, 1916. Gift of Bureau of Railway Economics.

Los Angeles. Department of Public Service. Complete Report on Construction of the Los Angeles Aqueduct. *Los Angeles, 1916.*

Manual of Bibliography, W. T. Rogers. *London, 1891.* Gift of Arthur Worischek.

Mechanism of Men-of-War, R. C. Oldknow. *London, 1896.*

Method for Measuring the Viscosity of Blast Furnace Slag at High Temperatures. U. S. Bureau of Mines. Technical paper 157. *Washington, 1916.*

Metodo di Richerche Sperimentali con Modelli Intorno Alle Qualita Evolutive delle Navi, Nino Pecorraro. *Genova, 1916.* Gift of Rivista Marittima.

Mining Operations in the Province of Quebec, 1915. Report on. *Quebec, 1916.*

National Fire Protection Association. Year Book. August 1916. Gift of National Fire Protection Association.

The New Tyranny, S. O. Dunn. Address before the Railway Signal Association, September 13, 1916.

Preliminary Oil Report on Southern Illinois. Extract from Bulletin no. 35, Ill. State Geological Survey. *Urbana, 1916.*

Principles of Alternating Current Machinery, R. R. Lawrence, *New York, 1916.*

Public Utilities Reports. 1916-D. *Rochester, 1916.*

Railroads and the Public, G. E. Ide. *August 1916.* Gift of Bureau of Railway Economics.

Railway Freight Rates, M. H. Robinson. *New Haven.* Gift of Bureau of Railway Economics.

Rescue and Recovery Operations in Mines after Fires and Explosions, J. W. Paul and H. M. Wolfin. *Washington, 1916.*

Selling Passenger Service. An address by G. D. Dixon, delivered before the American Association of Traveling Passenger Agents, October 2, 1916.

Statistics of the Mineral Production of Alabama for 1913. Alabama Geological Survey. Bulletin no. 15. *University, 1914.*

Tributes to Frederick W. Taylor. Gift of F. W. Taylor Co-operators.

Underground Wastes in Oil and Gas Fields and Methods of Prevention. U. S. Bureau of Mines. Technical paper 130. *Washington, 1916.*

Union of South Africa. General Report of the Miners' Phthisis Prevention Committee. *Pretoria, 1916.*

U. S. Bureau of Census. Financial Statistics of States, 1915. *Washington, 1916.*

U. S. Census Bureau. Mortality Statistics, 1914. *Washington, 1916.*

ENGINEERING SURVEY

A Review of Engineering Publications in All Languages. All the leading periodicals of the engineering world, embracing over 1000 different publications, are received at the Library. These are systematically examined for review each month in the Survey.

SUBJECTS OF ABSTRACTS

ARRANGED IN THE ORDER OF THEIR APPEARANCE IN THE SURVEY.

AUTOMOBILE ENGINE RATING.
PISTON SPEED VS. R.P.M. AS BASIS OF ENGINE RATING.
AUTOMOBILE ENGINE OUTPUT CURVES, PLOTTING.
LARGE CYLINDERS VS. SMALL CYLINDERS AND OUTPUT.
ESTIMATING MAXIMUM AUTOMOBILE ENGINE POWER.
VACUUM BRAKE FOR AUTOMOBILES.
BALANCED AUTOMATIC CONTROL VALVE FOR VACUUM BRAKES.
OVERHEAD TRAVELING CRANES.
TRACTIVE EFFORT OF OVERHEAD TRAVELERS.
ANGLE OF REPOSE, OVERHEAD TRAVELERS.
CAST IRON, THERMAL REACTIONS.
CAST IRON, EXPANSION-TEMPERATURE CURVES.
CAST IRON, HEGGIE TESTS.
AEROPLANE CONSTRUCTION, MATERIALS USED IN.
AEROPLANE WOODS, PHYSICAL PROPERTIES.
AEROPLANE STEEL TUBING, PHYSICAL PROPERTIES.
STEEL TUBING, THIN WALLED, IN AEROPLANES.
STEEL TUBING, NICKEL VS. LOW-CARBON.
AEROPLANES JOINTS AND WIRE CONNECTIONS, STRENGTH.
MILD-STEEL BARS, EFFECT OF COLD TWISTING.
GATING OF CASTINGS.
COAL (ILLINOIS), SPECIFIC GRAVITY STUDIES.
COAL, BITUMINOUS, CLINKERING OF.
COAL, CHART OF COST ON THE HEAT-VALUE BASIS.
SCHAPHORST CHART FOR DETERMINING COST OF COAL.
HYDRAULIC FLOW FORMULAE.
PISTON RINGS.
HIGH-SPEED STEEL VS. OBTURATOR RINGS.
RINGS IN ALUMINUM PISTONS.
RINGS OF THE BRITISH CHUCK & PISTON RING CO.
METAL BOLTS, LATERAL BENDING RESISTANCE.
LAG SCREWS, LATERAL BENDING RESISTANCE.
VICKERS SURFACE-HARDENING PROCESS.
STRAINER FOR SUDS PUMPS.
SPRINGFIELD MODEL 1903 SERVICE RIFLE.
SPRINGFIELD RIFLE, FIXED BASE.
SPRINGFIELD RIFLE, FINAL BARREL OPERATIONS.
BROWNING RIFLE BARRELS.
MECHANICAL STOKING ON LOCOMOTIVES.
LUBRICATION OF LOCOMOTIVES AND COST OF OPERATION.
SUPERHEATING ON LOCOMOTIVES.
LOCOMOTIVE ARCHES AND BOILER EFFICIENCY.
BOILER OPERATION, STANDARDIZATION OF.
BOILER ROOM, SAVINGS IN.
SAFETY-VALVE AREAS.
MASSACHUSETTS FORMULA FOR SAFETY VALVES.
UNITED STATES GOVERNMENT RULE FOR SAFETY VALVES.
PHILADELPHIA RULE FOR SAFETY VALVES.
A. S. M. E. BOILER CODE RULE FOR SAFETY VALVES.
CANADIAN RULE FOR SAFETY VALVES.
BOILER CORROSION BY MAGNESIUM CHLORIDE.
MAGNESIUM CHLORIDE, DETECTION OF.
AUTOMATIC BALANCED VALVE ON STEAM TURBINES FOR PROTECTING AGAINST LOSS OF VACUUM.
WOMEN, EMPLOYMENT IN GREAT BRITAIN.

In the section Steam Engineering will be found an abstract of an article on standardization of boiler operating conditions. There is nothing striking in this article except the big lesson that it teaches. Subsequent to the appointment of a boiler-room foreman three years ago, the boiler-room efficiency has been increased 40 per cent. Now if somebody patented a new process of steam generation increasing the efficiency of the boilers by 40 per cent, nine plants out of ten would probably have found it worth while to rebuild entirely their machinery, and to consign the existing equipment to the scrap heap. In this case a saving of 40 per cent has been attained practically exclusively by the application of common sense and system, and at the cost of a few indicating and recording instruments.

Of course, the lesson of this article will not apply to every steam plant, because in order to effect a saving of 40 per cent by such methods as were employed in this instance there must have been, in the first place, a loss of 40 per cent, and, fortunately, it cannot be assumed that any large part of our boiler-rooms are operated at such a loss.

There is, however, scarcely any doubt but that in a good many plants the application of some methods like the ones described here might bring rather unexpected results in the way of increase of efficiency and saving of fuel and materials.

This is all the more important, as we are apparently approaching a period of intense competition, both in the home and world markets, when any saving however small becomes worth striving for.

THIS MONTH'S ARTICLES

Methods of practical engine rating are discussed with the view of developing a formula more corresponding to actual conditions than apparently the engine-rating formula of the British Institution of Automobile Engineers. Among other things, the writer shows how widely divergent results may be obtained by plotting curves of automobile engines with different stroke-bore ratios—horsepower against piston speed on one hand, and horsepower against speed in revolutions on the other hand. The comparative efficiency of engines with large and small cylinders and of various types is likewise discussed.

A vacuum brake for automobiles is described with an interesting balanced automatic control valve. In connection with the description of a power plant in Ohio, mention is made of an improvement in underfeed stokers, namely, the incorporation of an automatic self-cleaning clinker attachment.

In the section Engineering Materials data are reported on tests by James S. Macgregor, of Columbia University, of various kinds of timber used in aeroplane construction, as well as on steel tubing. As regards the latter, the writer deems it inadvisable to use very thin-walled tubes with wall thicknesses less than 5 per cent of the outside diameter. As to the material used for tubing, the author does not believe that 3½ per cent nickel steel is much better for tubing than 0.35 per cent carbon steel with, say, 0.6 per cent manganese.

Thermal reactions of cast iron is the subject of a paper pre-

sented by Prof. Thomas Turner, of the University of Birmingham, England, to the recent meeting of the American Foundrymen's Association in Cleveland. The paper is essentially of an experimental nature, and presents interesting data on the points of arrest in cast iron as a function of its impurities, and also as a function of the thickness of the casting.

The effect of cold-twisting on the properties of mild-steel bars has been experimentally investigated at the laboratory of the University of Colorado. This subject is of particular interest because of the extensive use of cold-twisted bars as reinforcing elements in concrete.

A brief abstract discusses the influence of gating on castings.

An abstract of an investigation of the specific-gravity relations of Illinois coal will be found in the section Fuels and Firing. In the section Munitions attention is called to the continuation of the description of the manufacture of the Springfield Model 1903 Service Rifle, from *The American Machinist.*

The factors influencing the results of laboratory fusion of ash are investigated by F. C. Hubley, who recommends incorporation in specifications for a standard test, of a reference to the maximum amount of carbon to be allowed to remain in the sample after incineration.

New hydraulic formulae are reported from a review of a book recently published in England. While the abstract is necessarily brief, particular attention is called to the book itself.

The piston-ring design with particular reference to small gasoline-engine sizes (aero and automobile engines) is discussed in an article abstracted from a British publication. The writer considers it inadvisable to arbitrarily proportion the gap as one-tenth or one-twelfth the diameter of the ring, and states that the gap should be calculated on the basis of stress in the metal, which depends as much on thickness as on diameter. Among other things he cites a case when a reduction of the pressure exerted by the rings increased the speed of a car five miles per hour. The best is to adopt rings of minimum pressure compatible with gas-tightness, and many rings in use today are stronger than they need be.

Data on the lateral bending resistance of metal bolts and lag screws are reported from tests recently made at the Rose Polytechnic Institute by Prof. H. A. Thomas. In the section Machine Shop is described a strainer for suds pumps for use in supplying coolant to machine tools.

In the same section are present data on the Vickers surface-hardening process, especially suitable for dealing with parts of which it is desired to surface-harden only a small portion.

G. H. Boot shows that the accepted theoretical formula as generally used to calculate the pull required to traverse the load with hand-operated overhead traveling cranes is not correct. Among other things, experiments have been made to determine the angle of repose, and the data are presented in the form of a table covering 2½ in., 5-in. and 10-in. diameter rollers.

The subjects of mechanical stoking, lubrication of locomotives, superheating, and the use of brick arches, are discussed in abstracts of committee reports presented at a recent meeting of the Traveling Engineers' Association in Chicago. All through these reports and the other papers presented at the meeting, prominently, like a red thread in a white cloth, passes the dominant idea of the necessity of devising means for coping with the increased weights of trains and increased amount of steam necessary to pull them in on time.

In the section Steam Engineering attention is called to the article on boiler corrosion by magnesium chloride, abstracted from *The Railway Engineer.* Among other things, this article gives simple means for detecting the presence of magnesium chloride.

J. E. Terman, in one of his popular articles running under the general title of Visits of Inspector Brown, discusses and compares the various formulae for safety-valve areas.

Statistical data on the employment of women in Great Britain are given in an abstract from a British publication. Among other things, it presents data on the efficiency of women and the amount of work which they can handle. It is significant in this connection that competent authorities stated their conviction that what women lacked in quantity of work they made up in quality. The same authorities expressed their surprise at the amount of work women could get through if they had sufficient wages to feed and clothe themselves properly. So far the employment of women is confined to work of a repetitive kind, but from what women did on such work it appears likely that under different conditions they might be able to do much more responsible work.

Attention is called to the bibliographical notes on conveying coal through pipes, at the end of the Selected Articles section.

Aeronautics

See ENGINEERING MATERIALS

Automobiles

PRACTICAL ENGINE RATING, Edward G. Ingram

Discussion of previous attempts at developing a rating formula and of various considerations bearing on this subject. The writer considers the formula of the British Institution of Automobile Engineers for automobile-engine rating erroneous because this formula takes piston speed as a basis of rating.

The British formula necessitates the determination of the piston speed in feet per minute at maximum output, instead of the r.p.m. Where the piston speed is already known, the formula may be used, but it is practically useless where the piston speed is unknown and must be determined for engines of various displacements and stroke-bore ratios. In its attempt to find the piston speed at maximum power of engines of different stroke-bore ratios, the British Committee represented it by the equation $s = 600(r + 1)$ ft. per min. This formula, however, gives excessively different speeds of revolution to engines having the same stroke-bore ratio but different displacements. Thus, assuming equal efficiency of engines of the same displacement, maximum power should be reached at the same number of r.p.m., no matter what the stroke-bore ratio, yet the piston speed given by the formula will give different speeds of revolution with engines of different stroke-bore ratios.

Further, the British Committee decided that the mean effective pressure would vary with the size of the cylinder, but it has been shown since that the average m.e.p. is more nearly the same for cylinders of all sizes. Actually, if the average number of r.p.m. had been considered instead of the piston speed, and if the average m.e.p. had been determined with relation to piston displacement and not to the bore, the Committee would have obtained a much more satisfactory formula than the one arrived at, which was: brake horsepower $= 0.45 \times (b - 1.18)(1 + b)$.

It is much better to plot the horsepower against r.p.m., instead of against piston speed in feet per minute. For ex-

ample, in Fig. 1A are shown imaginary curves of two engines of the same displacement but with different stroke-bore ratios, in which power is plotted against piston speed. The engines are assumed to be of the same general construction, so that the power developed will be essentially the same at any given number of r.p.m. up to the maximum. But at any point where both engines are developing the same amount of power the piston speeds will be different, so that the curves will never coincide. If, however, the curves are plotted against r.p.m., one curve will represent both engines, as shown in Fig. B. If these two engines were placed in identical cars, the same gear ratio would be used for both, and the cars would make the same number of miles per hour when the engines were developing the same power. The piston speed, however, would

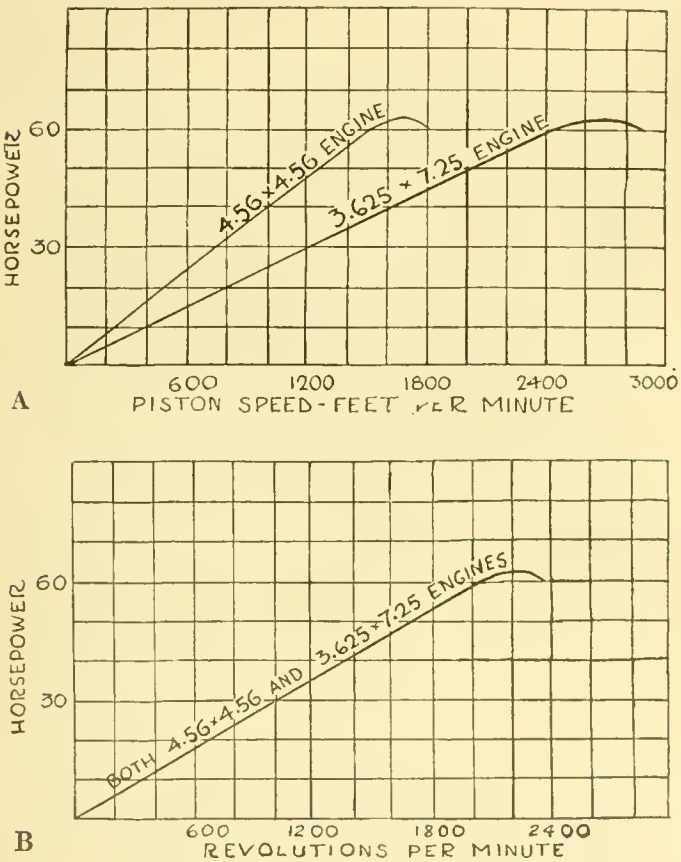


Fig. 1 A, Imaginary Power Curves Plotted Against Piston Speed

B, Curves of Engines in Fig. A Plotted Against R.P.M.

bear no direct relation to the engine output or to the car speed, but would depend upon the stroke-bore ratio. On the other hand, comparing engines on the basis of horsepower per cubic inch of displacement is really the same as considering each to be of the same total displacement, no matter what is the real displacement.

From this the author proceeds to the comparison of different engines, and finds a wide variation in the power developed per cubic inch of displacement by various makes of engines.

He finds also that the tendency is for engines with large cylinders to be less efficient than those with small cylinders, this tendency being more marked in the case of cylinders of over 74 cu. in. displacement. But while engines with large cylinders are less efficient at high speeds of revolution, there appears to be a tendency for them to be more efficient at low speeds, which may be due to the better thermal efficiency, though just why this should be more apparent at low speeds is not altogether clear.

Further, there is apparently a tendency for the small-cylinder engine to develop maximum power at a very high speed of revolution, which seems consistent, since the small cylinder is better off with regard to volumetric efficiency. A characteristic of the Knight stock-car engines is high power efficiency at low revolution speed, even where the cylinders are small, and, besides, maximum power is reached at rather low speed compared to the poppet-valve engines. This may be due partly to higher thermal efficiency and partly to better volumetric efficiency within the engine's speed range. Some engines have been developed so as to give an abnormally high power. In this case the curve is very high at high speeds of revolution and quite low at low speeds, which probably indicates that the valve timing is such as to favor high maximum revolutions at the expense of a slight comparative inefficiency at low speeds.

A fair idea of the maximum power developed by the average touring-car engine of today can be obtained by multiplying

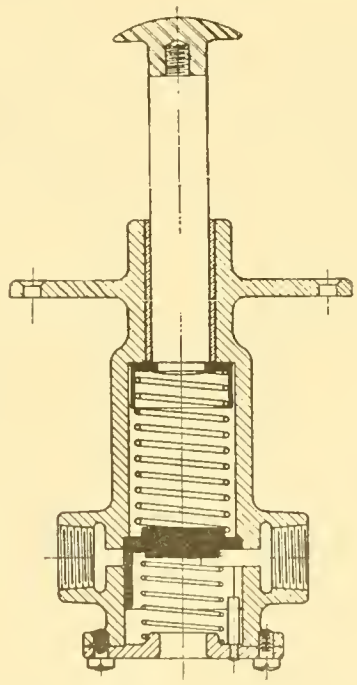


Fig. 2 Section of Balanced Automatic Control Valve

the total piston displacement by 0.17. While many efficient small-cylinder engines will give much greater power than this, and while very-large-cylinder engines or engines of inefficient construction may fall below this output, the rule will give more satisfactory results than those obtained from the rating formula now in general use. (*The Automobile*, vol. 35, no. 17, p. 700, October 26, 1916, 4 pp., 4 figs. *gp.*)

Vacuum Brake for Automobiles

Description of an air brake for automobiles, recently placed on the market by the Prest-O-Lite Co. of Indianapolis, Ind.

This brake utilizes the suction prevailing in the intake manifold, the difference between manifold pressure and atmospheric pressure being intensified by the use of a large piston. It is stated that a pressure of about 10 lb. per sq. in. is available, as a rule, and this is used on a piston of 7 in.

diameter with an available stroke of 4 in. A system of levers reduces the travel and multiplies the force correspondingly, so that a powerful pull on the brake-operating rod is obtained. A little valve is placed in the pipe line connecting the intake manifold with the brake piston, and this valve can be operated either by foot or by hand. To give different amounts of pull on the brake rod, the valve is opened by pressing down on a spring, which in turn presses on the valve. The lower side of the valve is exposed to atmospheric pressure continuously, and the upper side of the valve is exposed to the pressure existing within the brake cylinder. Thus, when the valve-operating lever is moved, it presses on the spring and opens the valve. Instantly the pressure back of the valve drops, and the atmospheric pressure on the other side of the valve forces it up against the spring, so cutting off the suction. In this way the depression of the brake cylinder is made proportional to the amount of movement given to the valve operating lever or pedal. Directly the operating lever is released, the valve is lifted right back, and this admits atmospheric pressure to the cylinder, thus releasing the brake instantly. Fig. 2 shows a section of the balanced automatic

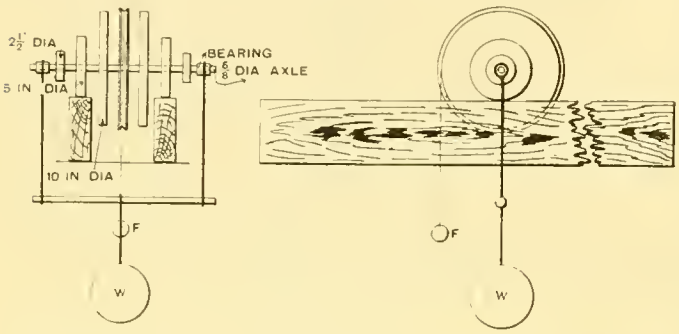


Fig. 3 Experimental Apparatus for Testing Overhead Travelers

control valve. It is stated that practically the only wearing portions of the whole outfit are the cup leathers.

The author states that the device has been fitted to several cars. (*The Automobile*, vol. 35, no. 13, p. 774, November 2, 1916. 2 pp., 3 figs. *d.*)

Cranes

Tractive Effort of Overhead Travelers, G. H. Boot

The author attempts to show that the accepted theoretical formula as generally used to calculate the pull required to traverse the load with hand-operated overhead traveling cranes, runners, or like appliances, is not correct.

In calculating the pull required to travel the load with all hand-operated gears, the effort required must always be kept within predetermined limits. The pull must be so proportioned that a continuous movement may be obtained, that is, the hand chain must be pulled with a hand-over-hand motion; otherwise the crane will be moved in a series of jerks, and the static friction will have to be overcome at each pull of the hand chain, entailing a considerable amount of additional exertion.

The chief point to be noted in the case of hand-operated appliances is that the static friction, or the tractive effort to move the load from rest, is considerably more than that required after the load has attained a certain speed. The next point, and the one particularly in question, is as to the influence of the diameter of the traveling wheels on the resulting pull. The usual formula for tractive effort is

$$F = \frac{W}{R}(\mu r + f)$$

where F = the tractive effort, W = total load, R = radius of wheel, μ = coefficient of journal friction, f = coefficient of rolling friction, and r = radius of axle.

This expression assumes that the tractive effort is inversely proportional to the diameter of the wheel, other conditions being the same, but from actual tests on railway cars it was found that with wheels 34 in. and 43 in. in diameter the static tractive effort with a load of 32 tons was 22.46 lb. and 20.54 lb. per ton, respectively, while from the above formula it should be as 34:43, that is, for the 43-in. wheel, 17.7 lb. instead of 20.54 lb., which makes a difference of 15 per cent. If a hand wheel be introduced similar to that used on band cranes, the expression becomes such as to show that where the radius of the hand wheel is constant, the pull required to travel the load is the same for any diameter of wheel, which does not agree with the experimental data given above. Further, from tests on actual cranes it appears that the pull required is not the same for any diameter of wheel.

The author made a series of tests which confirm these facts. The experimental apparatus used is diagrammatically shown in Fig. 3, the rollers being of wood upon wooden rails.

A further experiment to determine the angle of repose, that is, the combined angle of journal and rolling friction for the 2½-in., 5-in., and 10-in. diameter rollers was carried out by raising one end of the rails until the load rolled slowly down the incline, being started by a slight vibration of the apparatus. The combined friction angles were found to be the same for each load of 20, 30, and 40 lb., respectively, on the same size wheel, but the angles for each size wheel differ, as shown in Table 1.

TABLE 1. DATA OF ANGLE-OF-REPOSE TESTS

Diameter of roller, in.	10	5	2½
Length of rail, in.	45	45	45
Rise, in.	0.75	1.22	2.14
Angle ϕ	1°	1°35	2°45
Tan $\phi = \frac{\text{Rise}}{\text{Length}}$	0.0165	0.0272	0.0475

The experiments indicated that in this particular case f is not constant, but varies approximately as the square root of the diameter of the roller, $2R$, so that $f_1\sqrt{2R} = f$.

The formula then becomes

$$F = \frac{W}{D}(\mu r + f_1\sqrt{2R})$$

where D = radius of hand wheel.

The original article contains the curves plotted from results with the experimental apparatus. (*Machinery* [London], vol. 8, no. 211, p. 869, October 12, 1916. 2 pp., 2 figs. *etA.*)

Engineering Materials

Thermal Reactions of Cast Iron, Prof. Thomas Turner

The writer, who is professor of metallurgy in the University of Birmingham, England, explains the various phenomena of expansion and contraction of cast iron at different stages of cooling, based on previous work of W. J. Keep, of Detroit, and on tests made by the writer himself, with the assistance of Dr. O. F. Hudson.

Among the facts ascertained in these experiments were the following:

1 That most metals and a number of alloys give a regular contraction in the cast bar.

2 That with white cast iron, free from phosphorus, there is only one small expansion, and one temperature arrest, which occurs at about 670 deg. cent.

3 That with gray cast iron, free from phosphorus, there are two well-marked expansions, and two distinct temperature arrests, which occur at about 1,135 and 695 deg. cent., respectively.

4 That with increase of silicon these arrest points occur at higher temperatures and nearer together. In other words, though both are raised, the lower, or pearlite point, is raised more than the upper, or iron carbide eutectic point.

5 That the addition of a small quantity of manganese, together with silicon, diminishes the rise in the pearlite point and leads to a more complete decomposition of the pearlite carbide; in other words, to the production of fine-grained graphite from the combined carbon.

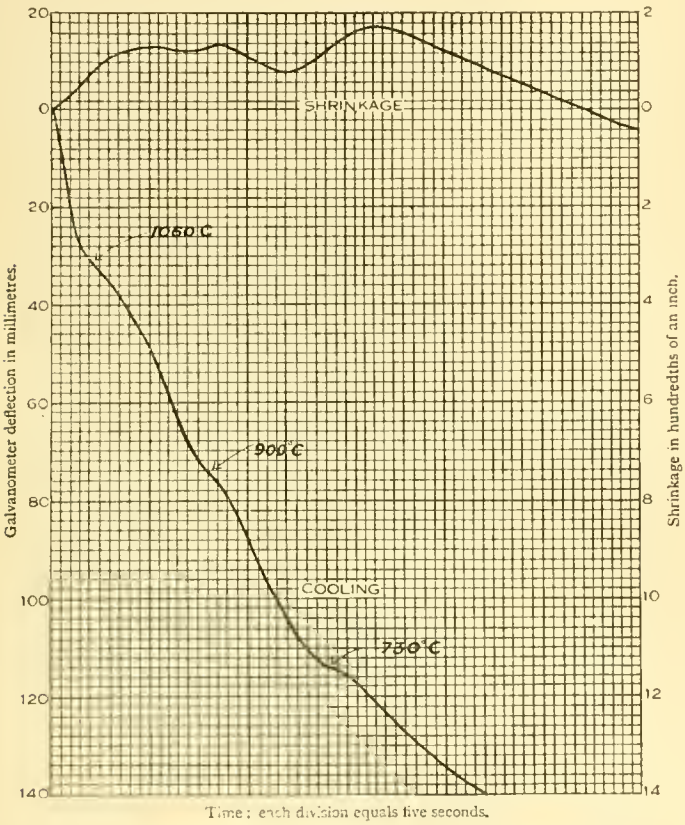


Fig. 4 Expansion-Temperature Curve for Gray Phosphoric Iron

6 That in gray irons containing phosphorus there is an additional, or third, arrest, which occurs at a temperature between those given, or at about 900 deg. cent. A typical expansion curve and the corresponding temperature curve for gray phosphoric iron are given in Fig. 4.

The most important of the conclusions which were derived from these experiments have since been confirmed by other investigations. More recently, Mr. Heggie of Birmingham has conducted a number of tests with the object of ascertaining whether, in actual practice, with varying thicknesses of castings, the expansions follow in the same order as in the earlier experiments of the writer. The tests were made with a rectangular casting of special pattern. It was cast in sand in the ordinary way, but arrangements were made for recording the changes of length of the two sides during cooling (in this casting one side was much thicker than the other). It was found that the expansions in the thin bar were similar to those in the thick bar, and occurred in the same order, but since the thin bar cooled more rapidly, its second expansion occurred while the thick bar was contracting after its first expansion. Hence, while one side of the frame was expanding, the other was contracting, and internal strains were set up in the casting. Positive and negative effects followed, until at length the thin side was uniformly contracting after its third expansion, while the thick side was markedly expanding at about 700 deg. As the metal is quite solid at such temperature, the importance of the strains which are thus set up is readily appreciated. (*The Iron Trade Review*, vol. 59, no. 16, p. 782. October 19, 1916, 3 pp., 2 figs. Paper read at the Cleveland meeting of the American Foundrymen's Association. *te.*)

Investigations Conducted on Materials used in Aeroplane Construction, James S. Macgregor

Paper read before the Aeronautical Society of America on September 26, 1916. The author is in charge of the testing laboratory at Columbia University.

Table 2 gives results obtained from tests upon several species of wood, and records, in addition to the flexural and compressive resistances, the moduli of elasticity, number of rings per inch, and moisture content.

The author believes that the curing of timber and curing methods should be decided upon subsequent to an examination of the anatomical structure of the timber to be cured. The rapidity with which it can be kiln-dried, the permissible drying temperature, and the permissible rapidity of variation in temperature, are all dependent upon structure.

TABLE 2. PHYSICAL PROPERTIES OF WOODS USED IN AEROPLANE CONSTRUCTION

Material.	Rings per in., over.	Per ct. moisture, under.	Wt. per cu. ft. lb.	Modulus of rupture.	Compressive strength, lb. per sq. in.	Modulus of elas. (flexure).
Virginia spruce..	12	15	21	7,460	4,720	1,289,000
Cedar white.....	15-25	5-7	25	16,010	9,050	1,920,000
Alaska spruce...	16	..	..	11,200	7,510	1,512,000
Sitka spruce....	10-25	5-13	28	11,000	6,610	1,538,000
Tamarack		8	29	....	6,649	.....

TABLE 3. DATA OF TESTS ON STEEL TUBING

3½ Per Cent. Nickel Steel

Torsion tests.

Specimen No.	Tube diameter.	Wall thickness.	Fiber stress at E. L.	Fiber stress maximum.	Modulus.
1	1.180	.022	....	38,820	9,900,000
2	1.180	.040	39,200	52,920	11,600,000
3	1.182	.061	41,000	61,210	11,700,000
4	1.184	.076	49,700	74,000	11,000,000
5a	1.185	.096	43,500	75,620	11,900,000

Specimen No.	Flexure tests. Fiber stress at E. L.	Flexure tests. Fiber stress maximum.	Tension tests. Yield point.	Tension tests. Ultimate resistance.
1	45,100	68,400	57,540	83,285
2	69,000	127,100	68,470	102,800
3	85,790	127,920	80,570	100,400
4	78,380	136,000	76,510	116,580
5a	94,300	139,400	75,700	117,220

As regards various kinds of timber, Sitka spruce has comparatively high compressive and transverse resistance, and also a high modulus of elasticity. Specifications covering its purchase should always include limitations as to the number of rings of growth per inch, as very coarse material carries very heavy medullary rays, is subject to checking, and is not as strong as the material having a larger number of rings.

Another material which is rapidly finding its way into use in aeroplane construction is steel tubing. There has been a tendency to use tubing of extremely small wall thickness, and apparently it has been assumed that the greater the radius of gyration of section the greater would be the resistance to stress, regardless of wall thickness. Table 2 shows the results of a number of tests in which the outside diameter of the tube was kept constant, and the wall thickness, starting with approximately 0.02 in., was increased by increments of 0.02 in. up to 0.10 in. It was found that the fiber stresses developed by the tubing increased with increase of wall thickness. A wall thickness of about 5 per cent of the outside diameter develops the full strength of the material of which the tubes are composed.

The use of very-thin-walled tubes with wall thicknesses less than 5 per cent of the outside diameter is objectionable, because it disposes the material in a manner which does not permit of the development of the full fiber stress, because the chances of local deformation are very great in such cases, and finally because light-walled tubes might fail with particular ease if rusted.

As to the material used for tubing, the author does not believe that 3½ per cent nickel steel makes the tubing much better than a 0.35 per cent carbon steel with, say, 0.6 manganese.

Tension tests upon tubing of this latter analysis have shown them to have a high yield point, comparatively high ultimate resistance, and a high percentage of elongation.

In connection with the question of heat treatment of tubes after drawing, the writer describes the process developed by Snead & Co., of Jersey City. Another investigation was made upon steel wire and wire connections for tie rods, both unsoldered and soldered joints of various lengths having been tested. The results are reported in the form of a table. (*Aero World,* vol. 1, no. 3, p. 46, October, 1916, 5 pp., 8 figs. *eA.*)

The Effect of Cold-Twisting on the Properties of Mild-Steel Bars, P. B. Whitney and G. K. Dohner

Cold-twisted bars are extensively used for concrete reinforcement, but have been sometimes found objectionable because of their brittleness. The authors have carried out, at the laboratory of the University of Colorado, a series of tests, the object of which was to determine the effect of twisting upon the properties of steel.

The material used had the following analysis: Carbon, 0.22 per cent; sulphur, 0.039 per cent; manganese, 0.34 per cent; and phosphorus, 0.032 per cent. The bars tested were ⅜-in., ½-in. and ⅝-in. plain square bars. They were 30 ft. in length and were cut so that the whole series of tests could be performed on specimens cut from a single bar, thus assuring uniformity of composition and treatment. The specimens were 16 in., 20 in., and 18 in. long. Half of the specimens were tested unannealed and half annealed. The following results were obtained:

1 *The Effect of Twisting Upon the Elastic Limit.*—The elastic limit was determined from Fig. 5A, it being taken as the first perceptible point of bending in the curve. The results (given in a table in the original article) show that the elastic limit is increased by amounts varying from 10.5 per cent for ⅜-in. bars with one twist in 12 *t* (*t* = size of bar) to 80.45 per cent for ⅝-in. bars with three and one-quarter twists in 12 *t*.

2 *The Effect of Twisting Upon the Yield Point.*—There was no perceptible yield point in any of the twisted bars, although in the plain bars it was very pronounced.

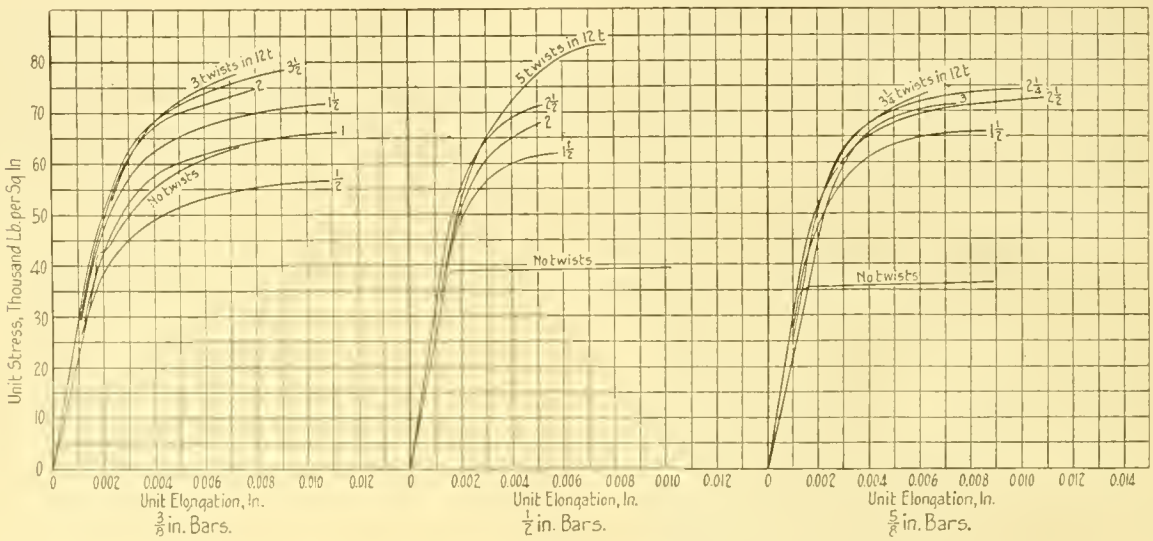


Fig. 5A Partial Stress Deformation Curves

3 *The Effect of Twisting Upon the Ultimate Strength.*—The ultimate strength was increased by amounts varying from 2.27 per cent for ⅜-in. bars with one twist in 12 *t*, to 37.86 per cent for one ½-in. bar with three and one-half twists in 12 *t*, as shown in Fig. B.

4 *The Effect of Twisting Upon the Ductility.*—Ductility is indicated by the per cent ultimate elongation and the per cent reduction in area. The per cent elongation for ⅜-in. bars was reduced from 25.37 per cent for plain bars to 3.25 per cent for bars with four twists in 12 *t*. For ½-in. bars the reduction was from 28.7 per cent for plain bars to 0.87 per cent for bars with four and one-half twists in 12 *t*. For ⅝-in. bars the reduction was from 28.5 per cent for plain bars to 3.75 per cent for bars with three and one-quarter turns in 12 *t*.

The per cent reduction in area was reduced from 56.0 per cent for plain bars to 3.7 per cent for bars with three and one-quarter turns in 12 *t* for ⅝-in. bars.

It was found that as soon as a permanent set has been created by torsion there is a noticeable increase in the ultimate tensile strength and elastic limit, but a limit is reached in the number of turns, beyond which the tensile strength is reduced by further twisting. The twisting greatly reduces the ductility. The work required to rupture a twisted bar is much less than that for a plain bar, and decreases very rapidly as the

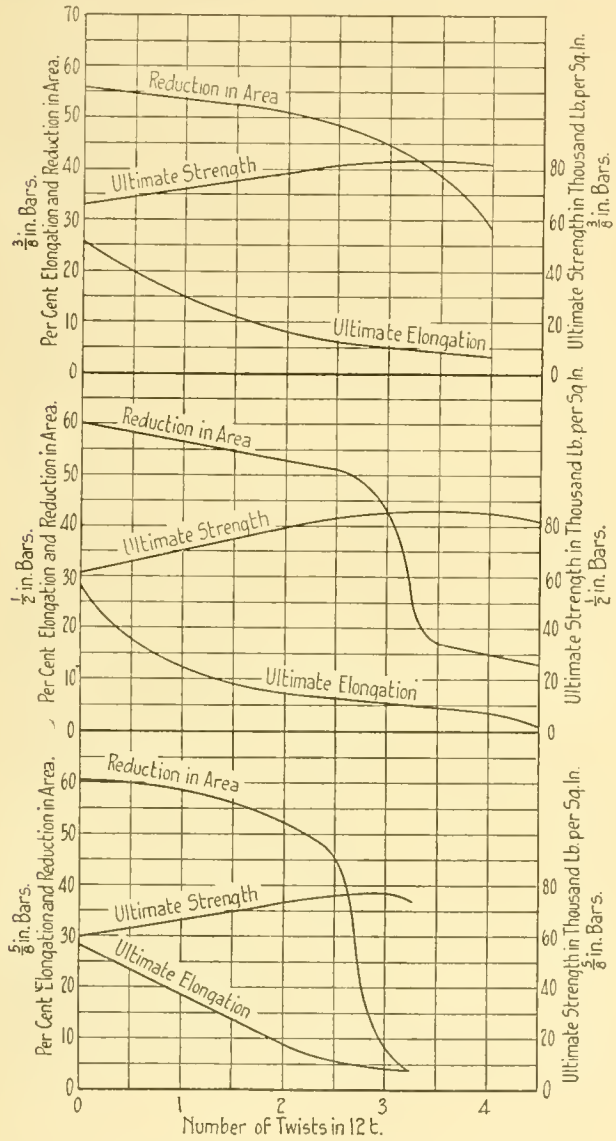


Fig. 5B Curves for Ultimate Strength, Ultimate Elongation, and Reduction in Area

number of turns increases. These results depend upon the size of the bar. (*Journal of Engineering, University of Colorado,* vol. 12, no. 2, p. 48, February, 1916, 8 pp., 3 figs. *e.*)

Foundry

Influence of Gating on Castings, B. D. Fuller, A. M. Fulton, W. J. Gilmore, and R. R. Clarke

Symposium of four papers read at the Convention of the American Foundrymen's Association at Cleveland, Ohio.

There is an intimate relation between the location of the gate and the shrinkage problem. When castings are properly gated and are provided with suitable heads, there is very little trouble from shrinkage, and it is possible virtually to eliminate the use of chills in malleable practice. The correct gating of any casting is just as important as a proper mixture of metal. In designing any gate, two points should be considered, first, can the casting be fed from the proposed gate, excluding slag and preventing misruns, and, second, can the heavy portion be fed by a riser located at the top of the casting. Proper gating is specially important in the production of non-ferrous-metal castings, on account of the difficulties resulting from oxidation of the metal and the comparatively low temperature at which the metal freezes. (cp. *Canadian Foundryman,* vol. 7, no. 10, p. 147, October, 1916. *p.*)

Fuels and Firing

Specific-Gravity Studies of Illinois Coal, Merle L. Nebel

Report of an investigation carried out at the Engineering Experiment Station of the University of Illinois, with an object to determine first the effect of moisture upon the specific gravity of coal, and second, the methods of determining this specific gravity.

As regards terminology, the present investigation follows the practice of the United States Bureau of Mines in distinguishing between the apparent and the true, or real, specific gravity of coal, the apparent specific gravity being the specific gravity of the coal including the moisture or air contained in its pores, while the true, or real, specific gravity is the specific gravity of the actual coal substance corrected for air and moisture content.

For purposes of comparison of the thermal quality of various coals of the Illinois type, the writer uses the "unit coal" basis developed by Parr. Parr, in a previous investigation published by the Illinois State Geological Survey, has shown that if the effects of all the impurities, such as ash, sulphur, and moisture, have been taken into account, the unit B.t.u. is remarkably constant for the coal from a given bed over a considerable area.

A further distinction is made between the fresh specific gravity and the true specific gravity, the former designating the value of the apparent specific gravity of the coal in its fresh condition, that is, the condition in which it exists in the ground.

The writer shows that the hindered settling ratio (for a discussion of the hindered settling ratio, see Bulletin No. 69, University of Illinois Engineering Experiment Station, paper on Coal Washing in Illinois, by F. C. Lincoln) for air-dried coal is just twice that for the same coal when fresh, and, theoretically, the coal when air-dried can be washed with a range of sizes twice as great as when fresh, or with a much cleaner separation for the same range of sizes. From this point of view, the writer advises not to wash fresh coal, or, in other words, not to wash coal at the mine, and not to feed wet coal to jigs or other washing machines.

Practical Uses of the Specific Gravity of Coal. There are several practical uses to which a knowledge of the specific gravity of coal may be applied, chief among which are the following:

1 The calculation of the tonnage of coal in the ground over a given area.

2 The calculation of the tonnage of quantities of broken coal, such as the coal stored in large bins or in stock piles.

3 The comparison of coals by the rapid estimation of the ash and moisture content.

4 The determination of the adaptability of coal to the removal of its impurities by washing processes.

Because of lack of space only the conclusions of this interesting investigation can be here reported.

1 In general, no fixed value, such as can be given for mineral substances of definite chemical composition, can be given for the specific gravity of coal. Different types of coal, such as anthracite and bituminous, have different specific gravities, and even coals of the same general type may have quite different specific gravities, due to differences in content of ash and moisture.

2 Fresh coal of the Illinois type is probably saturated with moisture, most of which is held mechanically in the pores of the coal.

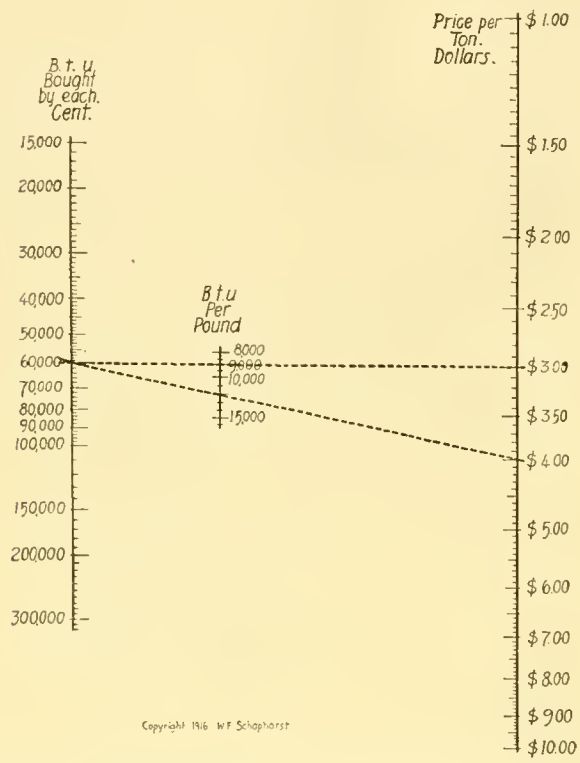


Fig. 6 Chart for Determining the Cost of Coal on the Heat Value Basis

3 The specific gravity of fresh coals of the same general types should be about constant if the content of ash is about the same. The specific gravity of coal in the fresh condition has been called the "fresh" specific gravity.

4 If coal has dried to any extent its specific gravity will vary, depending upon the amount of moisture lost. As the moisture content decreases, the specific gravity should decrease (the ash content remaining the same), but not necessarily in a direct ratio. The specific gravity uncorrect for moisture or ash content has been called the "apparent" specific gravity.

5 By calculating values of specific gravity to exclude the effect of moisture, values may be obtained which have been called the "real" or "true" specific gravity, and which might well be called the "dry" specific gravity to correspond with analyses of coal which have been calculated to the "dry" or "moisture-free" basis. By excluding both ash and moisture, values might be obtained which could be referred to as the "unit" specific gravity, to correspond with the unit coal B.t.u. of Parr.

6 By saturating air-dry coal with moisture before determining its specific gravity, a value can be obtained which represents quite closely the "fresh" value of the specific gravity, or the specific gravity of the coal in its fresh condition.

7 The fresh specific gravity of coal from different counties in Illinois was found to vary from 1.28 to 1.33, with an average of between 1.30 and 1.31. These values, excepting those for Vermilion and Montgomery counties, were obtained from air-dry coal by the approximate method described on page 20 of this bulletin.

8 In computing tonnages, it is suggested that (*a*) for coal in the ground, the fresh specific gravity is the proper value to use, (*b*) for broken coal stored under water, the fresh specific gravity should be used, and (*c*) for broken coal stored in bins or in open piles, the apparent specific gravity should be found for the average condition of the coal at the time the computations are made, and that value used.

9 In coal-washing operations the coal, theoretically, should be as dry as feasible when fed to the washing machines, since the settling ratios are considerably greater for dry than for wet coal, and dry coal can consequently be washed more efficiently. (*University of Illinois Bulletin*, vol. 13, no. 44, July 3, 1916, 49 pp., 9 figs. *e.*)

Clinkering of Bituminous Coal, F. C. Hubley

Discussion of the factors that influence results of laboratory fusion of ash.

The writer states that the use of varying amounts of dextrin as a binder for the test piece appears to have considerable effect on the nature of the fusion and the final melting point. To investigate this factor thoroughly, a number of ash samples representing coals from different localities were mixed with various amounts of dextrin, and fusion curves developed along with the binder-free ash fusion. From these tests it would appear that if these fusiometer tests are in any way comparable with the Seger cone tests, the result of using binder in these cones is of so variable and marked a nature as to make the use prohibitive in fusion work.

In the specifications for a standard test, some mention should be made of the maximum amount of carbon to be allowed to remain in the sample after incineration, since comparatively small amounts appear to change the position of the final melting point, and the nature of the fusion. (*Power*, vol. 44, no. 17, page 591, October 24, 1916, 3 pp., 7 figs. *e.*)

Chart for Determining the Cost of Coal on the Heat-Value Basis

By special permission of W. F. Schaphorst, M. E., by whom it is copyrighted, we are enabled to reproduce a chart from which direct readings showing the cost of fuel on the heat-value basis, may be taken. In using the chart it is necessary only to lay a straight edge across the points on the scales corresponding to the price of the fuel in dollars per ton, and the heat value of the fuel in B.t.u. per pound, its extension across the third scale intersecting at a point which indicates the number of heat units compensated for by each cent invested in the fuel, which is the important factor for determination. (Fig. 6.)

For example, if the price of a given grade of fuel having a heat value of 9000 B.t.u. per lb. is $3.00, the chart will show that each cent of investment will pay for 60,000 heat units. Again, if the price of 12,000-B.t.u. coal is $4.00 per ton, it will be found from the chart that the cost on the heat-unit

basis is the same as before, that is, 60,000 heat units for each cent invested.

The $4.00 coal is therefore just as cheap as the $3.00 coal, and is likely to be the preferred fuel from the fact that its higher price indicates the possibility of less ash and other deleterious content. Should the heat value of this latter fuel be anything in excess of 12,000 B.t.u. per lb., there can be no question as to selection from the standpoint of economy.

The range of the chart is such as to be applicable to fuels ranging in cost from $1.00 to $10.00 per ton and from 8000 to 16,000 B.t.u. per lb. in heat value. (The chart is actually reproduced from the *Railway Review*, vol. 59, no. 13, p. 422, September 23, 1916, 2 pp., 1 fig. *d.*)

Hydraulics

Hydraulic Flow Reviewed, A. A. Barnes

The book is in two parts, the first of which deals with the flow of water in pipes and channels. The author had occasion to investigate certain conditions of flow in the Thirlmere Aqueduct which supplies water to Manchester, England, and, finding the variation in the coefficient of accepted formulae unsatisfactory, was led to review the whole subject of the laws of flow, with the result that he has devised a series of formulae in which the coefficient is independent of variations in the size or gradient of the conduit.

He shows that the equations of five well-known experimenters are all of the form $v = Km^{1/2}i^{1/2}$. He then points out that the square-root indices of m (the hydraulic mean depth) and of i (sine of slope) are incompatible with the constant value for the coefficient K for a particular class of pipe or channel. He recommends, therefore, the adoption of the more general expression $v = Km^a i^b$, and from the analysis of a considerable amount of published data assigns a series of values to K, a and b which give consistent and satisfactory results when applied to a wide range of cases. The formulae thus obtained are sixteen in number, and, for example, for new asphalted cast-iron pipes the value is $v = 174.1m^{0.769}i^{0.529}$.

In the second part of the book, dealing with the measurement of water by means of triangular notches, rectangular weirs, and circular orifices, the author discards the basic expression in common use and advocates the application of the general formula adopted in Part 1, which he casts in the form $v = Km^a H^b$. For a right-angled V-notch this becomes

$$v = 2.462m^{-0.00703}H^{0.48703}$$

$$\text{whence } Q = 2.48H^{2.48}$$

This latter expression corresponds very closely with the results obtained quite recently by Gourley and Crimp in researches made on the River Alwen. Their formula reads

$$Q = 2.48nH^{2.4}$$

where n is the tangent of half the included angle of the notch and therefore is unity for a notch of 90 deg.

The following formulae have been determined:

for weirs with end contractions:	$v = 3.324m^{-0.11}H^{0.38}$
for weirs without end contractions:	$v = 3.324m^{-0.02}H^{0.51}$
for circular orifices:	$v = 4.652m^{-0.015}H^{0.5}$

The author claims that his formulae are proved correct by experiments for quantities as small as 0.0034 cu. ft. per sec. by means of weirs. (Book, XI and 158 pp., published by E. and F. N. Spon, Ltd., London, 1916; cp. *Nature*, vol. 98, no. 2449, p. 87, October 5, 1916, 2 p. *g.*)

Machine Parts

Notes on Piston-Ring Design, Gwilym Williams

Many facts enter into the attainment of the gas-tightness of piston rings:

1 The pressure per square inch exerted by the ring on the cylinder wall;
2 The uniformity of that pressure:
3 The practical degree of perfection obtaining in the manufacture of the rings.

Pressure per Square Inch. It is impossible to state definitely what pressure per square inch a given ring should exert under given conditions, as it is impossible to predict what part may be played by distortion of the cylinder and consequent leaks. Proper or improper fitting of joints, strain in springing over the piston, etc., have also to be considered. All that can be said is that 18 lb. is the upper limit today in aero engines working under high compression, and the average pressure of car-engine rings is 10 lb. per sq. in. What pressure is best suited to an engine is a matter to be decided by experiment. It is important because friction of the rings is roughly proportional to the pressure, and for instance, in an investigation of pressures exerted by the rings in a 3½-h.p. cycle engine, rings of 8 lb. per sq. in. were substituted for ones giving 11 lb. to the sq. in., with a resulting gain in speed of five miles per hour. The best is to adopt rings of minimum pressure compatible with gas-tightness, and many rings in use today are stronger than they need be.

The following formula for calculating pressures is accurate enough for all practical purposes and may be applied to concentric and eccentric rings alike. Let d be the outside diameter of the ring in inches, t the thickness opposite the joint, and l the length of the gap; then, assuming that the radial pressure of the ring is uniform,

$$\text{Pressure per sq. in.} = \frac{t^3\ l\ k}{d^4}$$

where k is an elasticity-section coefficient. For a ring of rectangular section of good cast iron it may be taken as 2,200,000.

From this it is evident that the pressure per square inch of the ring in designing may be varied in two ways, either by allowing a greater or less gap, or by proportioning the thickness. There is, however, a limit to the gap which a ring will stand, and it is desirable to avoid inordinately large gaps because the extreme fiber stress in the metal at the back of the ring, in closing, increases inversely as the square of the gap (there are also other reasons). What constitutes an average gap may be calculated from the formula:

$$\text{Length of gap in inches} = \frac{0.004d^2}{t}$$

It is misleading to arbitrarily proportion the gap as one-tenth or one-twelfth the diameter of the ring. The gap should be calculated on the basis of stress in the metal, which depends as much on thickness as on diameter.

The problem of adequate rings is of particular importance for aero engines, where thick rings cannot be used owing to piston weight. The rings must be of the thinnest permissible section, yet gas-tight; they must be flexible, to take up distortion of the cylinder, yet must exert sufficient pressure outwards to counteract centrifugal friction against the grooves in the radial types.

The author does not believe in the use of high-speed-steel rings in place of the ordinary obturator rings, even if liners are used in the cylinders, and thinks that the conditions that

give rise to these rings are being met by other means such as the adoption of aluminum pistons. These permit of deeper grooves than cast-iron or steel pistons, and with their overcoming of heat distortion, thin cast-iron rings, properly dimensioned to give the requisite pressure, will oust both obturator and high-speed-steel rings.

The even *radial distribution of pressure* exerted by the ring depends entirely upon the curve of the ring when free, and not upon eccentricity or concentricity. While eccentric rings do not fulfil the fundamental principle for which they have been originated, they have the advantage over concentric rings of flexibility towards the joints. The usual method of producing rings is by hammering, and internal hammering applied with the proper degree of precision will produce well-rounded rings; but as regards its effects upon the rings, the author states that internal hammering strains that part of the ring which is subjected to greatest stress when in the cylinder. It may be noted in this connection that the British Chuck and Piston Ring Co., of Coventry, have another method of hammering which is free from this objection. In their method the hammering is done on the part of the ring which is the least stressed when closed. The stress in the metal at the back of the internally hammered ring will be double that of the other. This point, however, must be borne in mind only in the case of special rings with large gaps. The majority of ordinary car-engine rings can be produced equally well by either method. (*The Automobile Engineer*, vol. 6, no. 95, p. 293, October, 1916, 2 pp., 3 figs., *g*.)

The Lateral Bending Resistance of Metal Bolts and Lag Screws, Prof. H. A. Thomas

Summary of tests recently made at the Rose Polytechnic Institute, Terre Haute, Ind., to determine accurately the resistance of bolts and lag screws in wood to being bent by transverse loads.

The lag screws and bolts used were ordinarily mild steel, commercial stock, or sizes varying from 3/8 in. to 7/8 in. in diameter. The woods in which they were imbedded for testing were yellow pine, oak, and white pine. In the majority of the experiments the bolts or lag screws were free to bend, as shown in Fig. 7A, with no constraint on the shaft or head. In those tests in which the load was applied by means of a metal plate, as in Fig. B, the holes in the plate were made a little larger in diameter than the lag-screw shafts, and the lag-screw heads were screwed down to a very loose fit only.

Most of the tests were not carried to final failure. When a complete test was made, the failure was found to occur in five stages, illustrated in Fig. 6, which is the load-deflection curve from the test on the joint represented diagrammatically in Fig. B.

During the first stage *ab* in Fig. C, the load concentrates itself at point *A*, Fig. B, and the bolt beds itself firmly in the bolt hole if the initial fit is imperfect. During the second stage *be* the increasing load is carried by the elastic resistance of the wood fibers at *D* and the metal at *E*. The load-deflection curve is approximately straight during this portion of the test. This stage is terminated at the yield point *c* by the simultaneous yielding of the wood fibers at *D* and the metal fibers at *E*. During the third stage the deflection continues to increase with little or no change in the load. At the beginning of the fourth stage *de*, the bolt makes contact at *B* or *C*. The load again increases during this stage up to the beginning of the final failure at *e*. The last stage *ef* represents the splitting of the wood or the parting or pulling out of the bolts or lag screws.

In removing the bent bolts and lag screws from the wood after testing, it was noticed that the bend, point *E* in Fig. A, was in every case quite abrupt and not a gradual curve. The straightness of the bolts between the bend and the surface of the wood suggested the possibility of writing algebraic expressions for the resistance of the bolts to bending against the wood fibers on the assumption of a straight-line distribution of the stress on the wood fibers between points *E* and *D* in Fig. A.

Under such an assumption the following expressions were obtained: The sum of the vertical forces acting on the bolt is zero, or

$$w = \tfrac{1}{2}npad \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

The point of maximum bending is where the shear is zero, at the inner end of the stress triangle, and the bending moment at this point is

$$M = wa - (\tfrac{1}{2}npad)\,(2/3a) = 1/32 f\pi d^3 \ldots\ldots [2]$$

Solving these equations for w gives

$$w = \tfrac{1}{8}d^2\sqrt{3\pi n}\quad\sqrt{pf} \ldots\ldots\ldots\ldots\ldots [3]$$

In order to adapt equation [3] to the use of the common safe allowable fiber stresses in wood and steel, a change in its form has been found desirable, due to the fact that if the ordinary safe allowable fiber stresses for metal and wood are substituted in equation [3] to obtain safe working loads for the design of connections, an unnecessarily large safety factor is secured.

Fig. D shows the moment-deflection curve from the test of a 7/8-in. round mild-steel bolt in cross-bending, and the stress-strain curve from the test of a similar bolt in tension. In a cross-bending test of a round bolt, the true proportional elastic limit will occur when the distribution of the stress on the governing section of the bolt is as shown by the straight line *aoa'* in Fig. E. At this instant the stress in the extreme fiber is equal to the tensile elastic limit *e* of the metal. When the loading has been increased until the distribution of stress approaches curve *abob'a'*, the bolt will deflect under a constant load; that is, the yield point of the material in cross-bending will be reached. In the first case, the resisting moment of the bolt is computed by

$$M_e = e\,\frac{\pi d^3}{32} \ldots\ldots\ldots\ldots\ldots\ldots [4]$$

In the second case, the resisting moment is computed by

$$M_f = f\,\frac{\pi d^3}{32} = 4e\int_0^r + \sqrt{r^2 - x^2}\,dx = 4/3er^3 = ed/6 \ldots [5]$$

Solving, $$f/e = 16/3\pi = 1.696 \ldots\ldots\ldots\ldots\ldots [6]$$

That is, the yield point in cross-bending is 170 per cent higher than the yield point in tension. Substituting in equation [3] the value of f from equation [6], we obtain

$$w = 0.500d^2\sqrt{n}\sqrt{pe} \ldots\ldots\ldots\ldots\ldots [7]$$

This equation gives the yield-point load carried by the bolt in terms of the end-bearing yield point of the wood fibers and the tensile yield point of the steel.

In order to make use of equation [3] or [7] in practice, it is necessary to know the value of n, that is, the ratio of the bearing resistance of wood against round pins to its resistance against square pins. A considerable number of tests were made to determine the value of this ratio. The values of n were found to be rather erratic, apparently depending much

on the friction of the wood fibers against the round pins, and being affected by the roughness of the pin, pitch or moisture in the wood, and the method of boring the hole. The average value of n in end bearing on the wood fibers from more than sixty tests was found to be 0.75. This value is used in equation [8]. To adapt equation [7] to the use of working stresses, let W be the safe load allowed on a bolt or lag screw bending against wood fibers, P the safe allowable bearing stress on wood fibers, and E the safe allowable tensile stress for metal. The final working equation for the design of bolted or lag-screwed timber connections may then be written

$$w = 433d^2\sqrt{PE} \quad \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

This equation should be used only for lag screws or bolts of circular cross-section, of metal having a well-defined yield point, and bearing endwise against the wood fibers.

The notation in the above expressions is as follows: d = diameter of the bolt in inches; a = distance from the surface of the wood to the point of maximum bending, inches; w = load carried by the bolt at the instant of yielding, pounds; f = fiber stress in the metal of the bolt at its yield point in cross bending, pounds per square inch; p = yield-point bearing stress of wood fibers, pounds per square inch; n = ratio of the yield-point resistance of wood fibers in bearing against the side of a round metal bar to their resistance in bearing against a square metal bar of the same diameter and length. (*The Rose Technic*, vol. 26, no. 1, p. 6, October, 1916, 5 pp., 7 figs. *de.*)

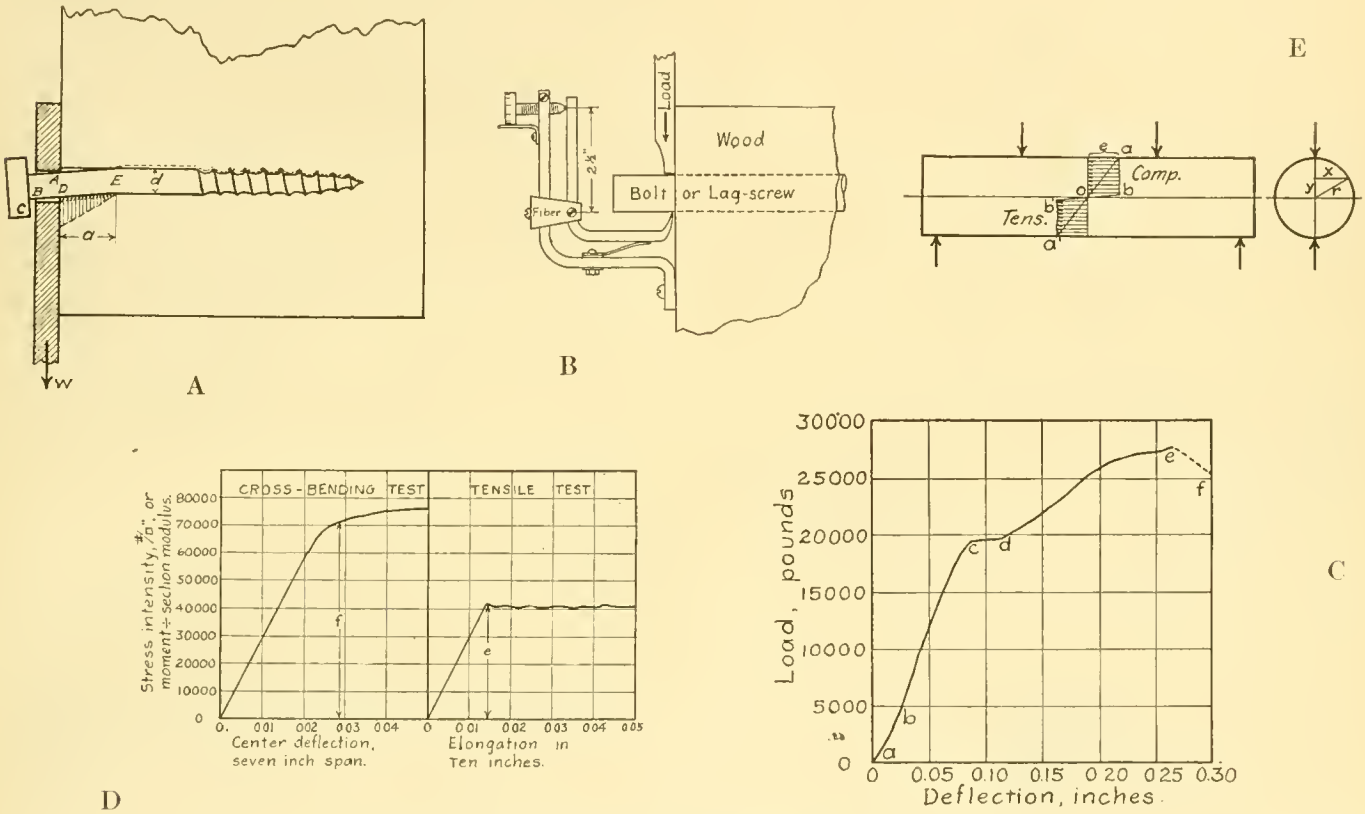


Fig. 7 Lateral Bending Resistance of Metal Bolts

The Vickers Surface-Hardening Process

The Vickers process of local surface hardening is comparatively little known. It consists of applying momentarily to the surface of the part to be treated an intensely hot flame from an oxy-acetylene blowpipe. The effect of this is to raise the surface of the object to a high temperature, it being then immediately quenched by the cold body of the metal beneath.

The equipment is only that usually provided for the oxy-acetylene welding process, but the temperature of the oxy-acetylene flame is higher than that used for the latter process, the increase being obtained by adjusting the flame as for welding and then slightly increasing the supply of oxygen. Arrangements should be made for keeping the work as cool as possible, so that the body of the work is maintained at a low temperature to insure that the quenching is sufficiently rapid. For small parts it is customary to immerse the parts in a tank of cold water fitted with an adjustable overflow pipe. Bodies of large parts may be left to cool off by themselves, but where necessary a supply of cold water may be allowed to flow over the work. In both cases the actual surface to be hardened is not submerged in water unless it is desired to give only a very shallow depth of hardened case.

The process is most suitable for dealing with parts of which it is desired to surface-harden only a small portion. It is being largely used at the present time in England for gear-tooth hardening. In calculating the cost of the process for the purpose of comparison with furnace-treated work, it must be recognized that—whereas for the latter process it is customary for the machining of the work to be carried out to approximate dimensions only, so that any distortion due to the heat treatment may be corrected by straightening and grinding, or grinding alone, as the case may be—by the local surface-hardening process the work is machined to the actual finished dimensions, since there can be no distortion during the process.

In a paper read before the Institution of Automobile Engi-

neers, Mr. J. H. S. Dickenson, in November, 1915, pointed out that he had made several experiments to show the value of the process as applied to the local hardening of radii in parts subjected to high alternating stresses, and pointed out that the results of these tests went to prove that the limiting range of alternating stress in parts thus treated showed a considerable rise. Mr. Dickenson stated that, as a result, he was of the opinion that in the production of automobile crankshafts such local treatment of the radii had some obvious advantages. (*The Automobile Engineer*, vol. 6, no. 95, p. 299, October, 1916, 1 p., 1 fig. *d.*)

Strainer for Suds Pumps

One outstanding feature of the usual troubles in supplying coolant to machine tools is the speed with which the usual

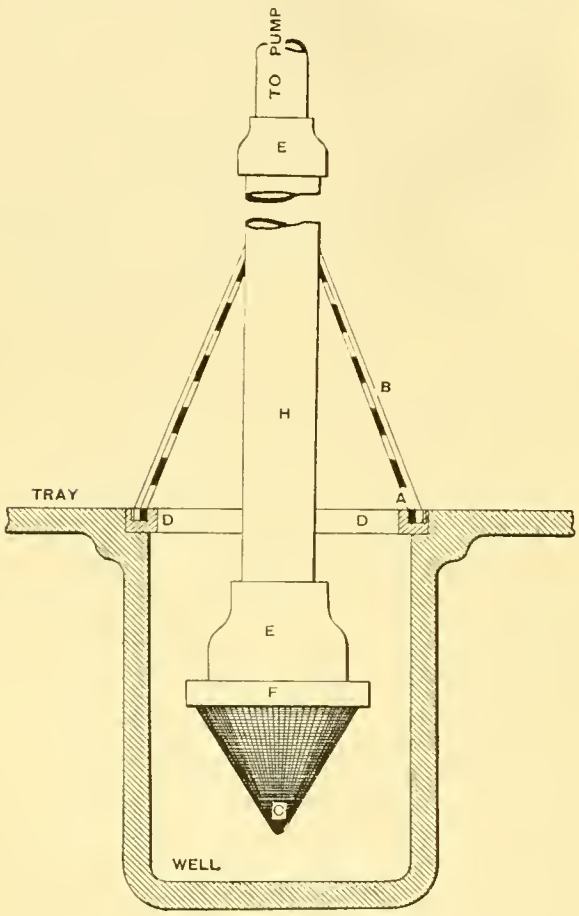


Fig. 8 Strainer for Suds Pump

type of pump fails, owing to grinding out. The majority of such pumps have little provision of an effective type to keep the fluid clear of particles of metal, and very often the straining devices are so troublesome that they have to be discarded entirely. Often the suction pipe draws from a shallow well in the suds tray, and a piece of $\frac{1}{8}$-in. or $\frac{3}{16}$-in. plate filled with a number of small holes and fitting the well opening is the only provision for straining. Such a design chokes repeatedly and is finally discarded, which results in transferring the trouble to the pump, now void of any protection whatever.

A plate laid horizontally is in the worst possible position for choking, in addition to which the holes provided are much too coarse, so that finer particles of metal may pass. What is necessary is that the strainer plate shall be vertical or inclined, and not laid flat. Further, since the holes now provided are too large, it is better to use fine wire gauze inclined at an angle of 45 or 60 deg., in which case choking would take place line by line, and clearing be less frequent. As gauze by itself is liable to damage, it has to be reinforced, which can be done by a small-mesh galvanized expanded metal known as cup lathing. The strainer can be either cylindrical, or, better still, an inverted cone. The accompanying sketch shows the writer's suggested solution. An additional improvement can be made to most pumps by an enlargement of the suction-pipe area. Suction head is harder on a pipe than delivery head, and for this reason most well-designed pumps have larger suction than delivery. In the sketch (Fig. 8) *D* and *F* are brass rings, grooved to receive the larger end of the cones made by the brass-wire gauze and galvanized expanded metal in combination. To give a neat appearance to the upper end of the cone, the points of the expanded metal can be cleated over the gauze, or a brass ring of similar construction to *D* and *F* can be used. The ring *F* is screwed internally, and connected to the reducing socket *E* by means of a short screwed nipple. In the tray strainer, *B* represents the gauze and *A* the expanded metal. The total clear head of the suction pipe, without obstruction, should be twice that of the strainer cone. Removal of the cone and suction pipe allows the well to be thoroughly cleaned out, and if such a removal is made an easy matter, it is likely to receive due attention. If the suds pump be fitted, say, 18 inches above the level of the well, the cone strainer can at any time be fitted for easy access to the wall for clearance. The suggestion has, moreover, the advantage that it is easily fitted to the majority of existing jobs at a trifling cost. *Machinery* (London), vol. 8, no. 211, p. 871, October 12, 1916, 1 p., 1 fig. *d.*)

Munitions

United States Munitions—The Springfield Model 1903 Service Rifle

Continuation of the article abstracted in The Journal, November, 1916, p. 936. This issue describes the manufacture of a fixed base and the final barrel operation. The article is profusely illustrated by drawings, and will be of great assistance to those who may have to engage in the production of the Springfield rifle.

Among other things is described in detail the operation of browning rifle barrels, as well as the making up of the so-called browning solution. The article also describes and illustrates special machines built to take care of operations which are difficult to perform on a standard machine tool, and also inconvenient to perform by hand. One such operation is the smithing of the bevel seat for the windage screw, for which a special machine has been designed and built at the Springfield Arsenal.

Some of the fixtures made at the Springfield Arsenal are, in fact, so elaborate in design as to approach special tools in complexity. The writer draws attention to the fact that it is hard to draw the line in some instances between a special tool and a complicated fixture. This is particularly true regarding the inspecting fixtures. Many of these are beautiful examples of the toolmaker's art, and require a high-grade skill on the part of the rifle-shop tool room. (*American Machinist*, vol. 45, no. 17, p. 725, October 26, 1916, 10 pp., 81 figs. *dA.*)

Railroad Engineering

What Effect Does the Mechanical Placing of Fuel in Fireboxes and Lubrication of Locomotives Have on the Cost of Operation?

Report presented at the Convention of the Traveling Engineers' Association, held at Chicago on October 24, 1916, by a committee—W. L. Robinson, chairman.

The average tractive power of all locomotives in the United States has increased in the past ten years 38.6 per cent, the heavy locomotives of years ago, ranging from 36,000 to 42,000 lb., having given place to those ranging from 54,000 to 160,000 lb., and the figures increasing yearly. The average of tons handled per freight train has increased 54.1 per cent in ten years. As the amount of coal consumed by a locomotive for a trip became very large, some roads using this heavy power found serious difficulty during the summer months in retaining experienced firemen in service. Therefore, if the heavy-tonnage trains were to be a success and the cost of operation held to a minimum, the necessity for the "iron fireman" was apparent.

The following figures covering the four railways using the largest number of locomotives with appliances for feeding fuel mechanically, and by which a large proportion of their freight traffic is handled, show interesting comparisons of average train loads. These figures are taken from reports made to the Interstate Commerce Commission, which, among other things, comprise figures showing that the locomotive fuel cost per ton-mile on each road shows a decrease for 1915 as compared with 1904.

TABLE 4. Fiscal Year Ending June 30, 1915, Compared with Fiscal Year Ending June 30, 1904.

	Increase in Average Tractive Power, Per Cent.	Increase in Average Number of Tons of Freight Per Train Load, Per Cent.
Road A	43	78
Road B	40	72
Road C	30.7	72
Road D	29	54

The report discusses further the firing of coarse and pulverized fuel by mechanical means, and concisely indicates the results that are being obtained. The following is of particular interest.

The experience of most roads is that better time is made with the same tonnage on the same grade than with hand-fired engines.

The necessity for shoveling coal ahead by laborers is eliminated at intermediate points where, during the warm months, it had been necessary with hand firing.

It has been the experience of some roads that when the appliances and fire are properly handled, grate shaking between terminals is not necessary. The thinner fire makes it possible also to save time in cleaning fires. Fewer failures are the rule, due principally to ability to largely overcome defects, such as leaky superheater units, firebox sheets, flues, cylinder packing, valves, etc., which often result in hand-fired locomotives setting off trains.

Grades of coal such as nut-pea-and-slack, or screenings, can be utilized successfully (cp. Table 5). However, except in the case when the haul would be small, the use of low-volatile screenings is undesirable, due to their slower-burning properties and resultant loss through fuel being drawn through the flues and out of the stack when the locomotive is being worked to capacity.

Maximum steam pressure can be maintained at all times. This has been stated by a railroad officer following up locomotive operations on a large road, in the following words: "The engineer does not have to consider the fireman, but can 'beat' the engine all he desires, as the fireman is made of 'iron.'"

The maintenance of the maximum rate of steam production, utilizing full boiler capacity over extended periods at points where the maximum effort of the locomotive is required, has been a most potent factor in the improvement in the handling of trains.

(*Railway Review*, vol. 59, no. 18, p. 588, October 28, 1916. 3 pp. *g.*)

Advantages of Superheaters, Brick Arches, and Other Modern Appliances on Large Locomotives, Especially Those of the Mallet Type

Report presented at the Annual Meeting of the Traveling Engineers' Association, at Chicago, last September, by a committee, J. E. Ingling, chairman.

The report covers a wide field in an interesting manner. Owing to lack of space, only the parts of greatest interest to the body of mechanical engineers can be abstracted. The report emphasizes the triumphant progress of superheating in locomotives, and especially the fact that the superheater equipment has been fully standardized and is almost identical on the 12,000-13,000 locomotives now operating in the United States and Canada.

TABLE 5.

	Gas. Nut-pea-slack.	Gas. Slack.	Soft or low volatile Run-mine.	Soft or low volatile Screenings.
Basis per h.p.-hr	3.88	4.23	4.32	5.17
Lb. coal—relative lb. coal	100.00	109.00	111.19	132.98

Note.—Nut-pea-slack—Coal, passing through a 1½-in. bar screen. Slack—Coal, passing through a ¾-in. bar screen.

The locomotive boiler, when considered for the application of a superheater, presented many limitations that necessarily had an important bearing on the design and the construction of the superheater. The locomotive boiler is in no case larger than is absolutely necessary, and, in the majority of cases, is even insufficient in evaporating surface. The application of the superheater necessitates a further reduction of about 15-20 per cent in the tube heating surface, occasioned by the use of the large flues in which the superheater units are located. In addition to this, a certain percentage of the gases which formerly were available for evaporation of the water must now be used for superheating the steam, since the superheater does not provide for any increase in the maximum rate of combustion. Nevertheless, with all these deficiencies, the superheater designer has been able to produce an economy of 25 per cent in fuel. The curves of Fig. 9 give an illustration of what has been done and may be expected to be done in the near future. The curves show cylinder tractive effort in per cent plotted against piston speed. The lowest curve represents the speed factor for an average superheated-steam locomotive. The next curve does the same for the average modern superheated-steam locomotive using between 200 and 250 deg. of superheat.

But the superheater engineer has only made use thus far of the same flue sizes as were used by the locomotive designer for tube sizes. With the use of a size different from the two present standards, it is, however, possible to obtain in a superheater boiler an evaporating surface practically as great as in the saturated-steam boiler. In this case the superheating

surface will be a net gain to the heat-absorbing surface of the boiler, and a greater capacity may reasonably be expected. The top curve shows approximately what may be confidently looked forward to in the near future. For some time past large passenger locomotives have been operated very successfully with steam-chest temperatures running between 750 and 800 deg. fahr. The top curve in Fig. 9 is representative of locomotives using this degree of steam-chest temperature, which means 350-400 deg. of superheat.

From superheater-locomotive experience it has been found that the pyrometer is a great aid to engineers and firemen in determining just how much superheat they are getting. In fact, as a railroad man states, what the duplex air-brake gage is to the brake system, the pyrometer is to the superheater. In one case, on an engine just turned out of the shop, where a superheater had been applied, during the first few trips there was no trouble to get a reading of 630 deg., but after a few trips the readings decreased until they finally fell back to 580 or 590 deg. This showed at once how necessary it is to keep the flues absolutely clean of all cinders and sparks in order to get the full benefit of the superheat. On another occasion the engineer who had a pyrometer on the engine was getting along nicely with a reading of about 600 deg., when the engine

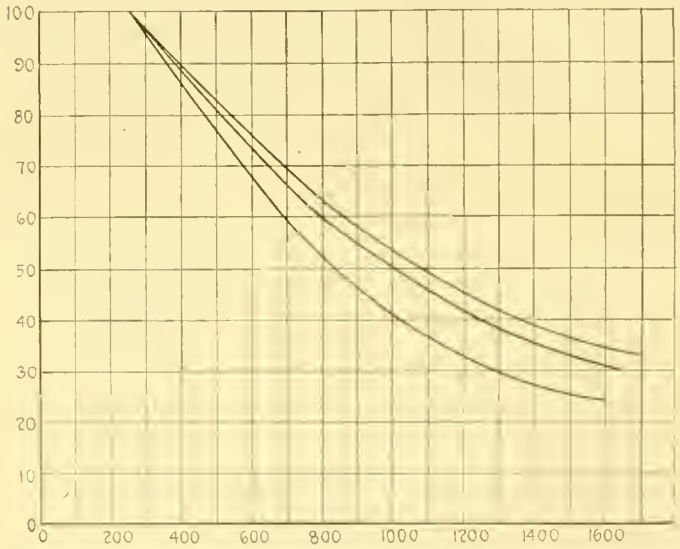


Fig. 9 Boiler Efficiencies with and without Superheater

started to foam and the superheater dropped back very rapidly. This indicated to the engineer the importance of keeping the water down to a safe level, to prevent the working of water through the superheater.

In the matter of brick arches, the committee states that the arches are now applied to get more power without increasing fuel consumption, whereas formerly they were used to reduce the fuel consumption for the same power output. The arch increases the boiler capacity directly by aiding combustion and by reducing the heat losses, and thus increases boiler efficiency, which latter is a thing that a superheater cannot do. The committee gives a chart indicating what efficiency may be expected when using a good quality of bituminous coal in a modern high-pressure superheater locomotive (Fig. 10). This chart shows that the efficiency of the arch increases as the rate of combustion or the amount of coal burned per square foot of grate area per hour. This is due to the fact that as the rate of combustion increases, the boiler efficiency decreases and the heat loss increases, thereby increasing the field of usefulness of the arch. The dotted line shows the boiler efficiency without arch, while the solid line above shows the boiler efficiency with the arch, the distance between the two measuring the efficiency of the arch as a fuel saver or capacity increaser.

As the chart shows, the heat losses due to imperfect combustion, or CO, range from 0.5 to 5 per cent, while the loss due to sparks varies from 2 to 16.5 per cent. These are the averages of a large number of tests. Tests indicate also that, at a rate of combustion of 100 lb. of coal per sq. ft. of grate area per hour, the arch will effect a reduction of 42 per cent in spark losses, equivalent to an increase of boiler efficiency of 7 per cent. As to smoke production, reports from many roads indicate that a decrease of 50 per cent can be obtained by the use of the arch, and on most roads the brick arch, with proper firing instructions proved sufficient to overcome objectionable smoke and to keep within the law.

Aside from this, the brick arch is now recognized as being an important factor in reducing flue failures due to flues

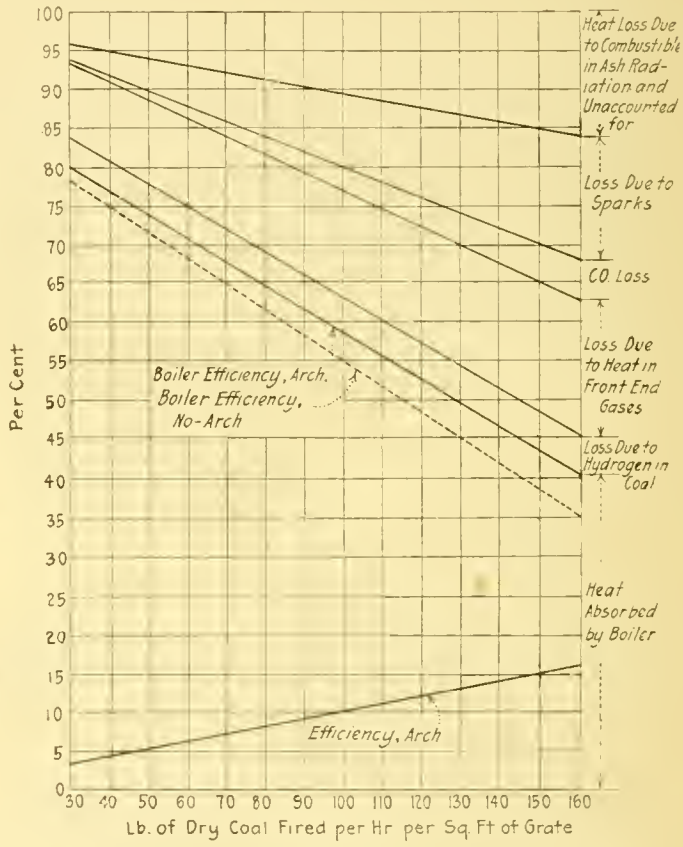


Fig. 10 Locomotive Boiler Efficiencies with and without Arch

plugging and honeycombing. (*The Traveling Engineers' Association.* Advance Copy of Committee Reports and Subjects for Discussion, 28 pp., 10 figs. *gd.*)

Steam Engineering

Standardization of Boiler Operating Conditions

Description of the Aurora, Elgin & Chicago Railroad power station, and the boiler-house operation and equipment of same.

The power station has a total capacity of over 19,000 h.p., and supplies current to several interurban railroad lines, and also light and power to a number of small cities lying along these lines.

Of particular interest in this description is the part refer-

ring to the operation and equipment of the boiler plant. Subsequent to the appointment of a boiler-room foreman three years ago, the boiler-room efficiency has been increased 40 per cent, a result all the more remarkable that it was attained practically exclusively by the application of good sense and system in operation.

Before any tests were attempted each boiler received a thorough scouring, and scale was removed completely—for the first time in some tubes. Combustion chambers and breechings were the next to receive attention, with the result that many barrows of soot and dust were removed. An inspection showed that the front baffles of several boilers had shifted, and these were correctly reset. Operating tests disclosed the fact that in some of the boilers combustion was imperfect. By adding one or two rows of tile to the first baffle, and thus reducing the flue-gas velocity, the combustion was materially improved.

Draft and CO_2 values and thickness of fire were investigated and standard values adopted. Differential draft gages were installed on each boiler, an Orsat instrument and a continuous CO_2 recorder were provided, which could be connected to any boiler, and portable steam-flow meters were placed on several of the boilers.

Extensive evaporation and fuel-consumption tests applied to all the boilers showed that the best results were obtained when the draft over the fire was approximately one-third that at the damper, or about 0.32 in. and 0.95 in., respectively. A fuel-bed thickness of 5 in., 12 per cent of CO_2 at the damper, and boiler operation at 200 per cent rating were standards adopted as a definite basis of operation.

All boilers are subjected regularly to an evaporation test to determine their condition, and a record of this test is placed on file in the boiler-room foreman's office.

On one-half of the boiler-room log sheet are recorded the customary data, such as line diagrams of boilers in full service and boilers banked, total number of boiler horsepower hours, boilers down for inspection and repair, details of repair and approximate time required, number of men working on coal and ashes, number of repair men, kinds of coal being used, tons of coal, total B.t.u., and weightometer readings.

Placed in one section of the remainder of the sheet are the hourly readings of stack draft, outside and inside temperatures, and minimum steam pressure. In another section are recorded such constants as total hours' run of coal conveyor, average tons of coal handled per hour by the conveyor, total lb. water, total lb. coal, total B.t.u., total kw-hr. output for the day, maximum ½-hour peak in kw., kw. per boiler h.p. rating at peak, lb. water per lb. coal, lb. water per kw-hr. output, lb. coal per kw-hr. output, B.t.u. per kw-hr. output, and average load factor based on ½-hour peak.

In the office of the boiler-room foreman, besides the usual indicating instruments, there is a six-pen graphic recorder which indicates when and how long the coal- or ash-system motors were in operation; when and how long pop valves and blow-off valves were open; when the damper regulator was shut tight, and when the heater overflowed.

A feature of great importance in the carrying out of the system adopted is its permanence, in that the system is enforced rigidly and all the time. (*Practical Engineer,* vol. 20, no. 21, p. 907, November 1, 1916, 5 pp., 7 figs. *d.*)

Safety-Valve Areas, J. E. Terman

This is part of a general article, Visits of Inspector Brown, and is devoted to the matter of safety valves. The writer discusses the various formulæ for safety-valve areas, and compares them by means of the diagram Fig. 11. The three lower lines represent the requirements of the Massachusetts formula, United States Government rule, and the Philadelphia rule, or on the basis of 9 lb. of water evaporated per pound of fuel, and 16 lb. of fuel burned per square foot of grate per hour. The heavy line above that represents the requirements of the Canadian rule for all conditions, regardless of how the possible rate of driving may vary.

The three top lines represent the requirements of the Massachusetts formula, the United States Government and Philadelphia rules, where 32 lb. of fuel are assumed to be burned per square foot of grate per hour, 9 lb. of water being assumed to be evaporated per pound of fuel as before. The heavy offset line running across the sheet represents the values as given by the Massachusetts tables for safety valves, which in reality is the Massachusetts rule for safety valves, since the formula on which these tabular values are based is never used for determining the size of safety valves for use on boilers in Massachusetts. The two dotted lines, the lower of which represents the values by the United States Government rules, as mentioned, and the upper represents the minimum

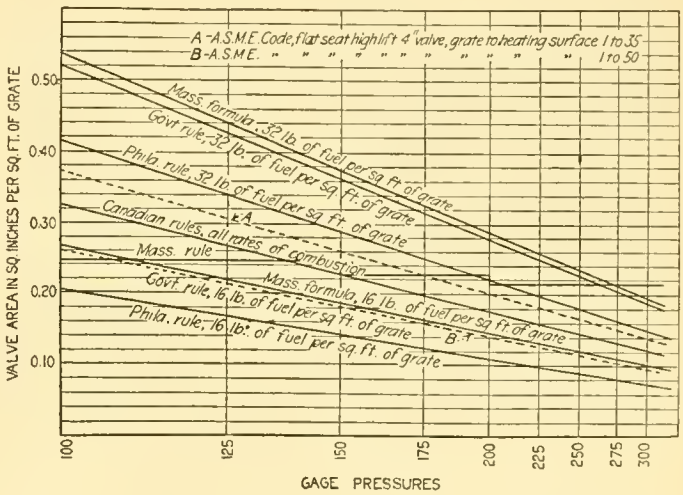


Fig. 11 Chart of Safety Valve Formula Requirements

valve area required per square foot of grate surface by the A. S. M. E. Boiler Code rule, on the assumption that a 4-in. valve with the maximum lift and with a flat seat is used, and that the ratio of grate to heating surface is 1 to 50 in. in the case of the top dotted line, and 1 to 35 in. in the case of the bottom dotted line, which coincides with the line representing the Government formula with an assumed rate of combustion of 16 lb. of fuel burned per square foot of grate per hour.

It is impossible to show a real comparison between the Code rule and the other rules, for the Code takes into consideration the actual discharge area of a valve—that is, how high it lifts—but all the other rules are based on the nominal area of the valve regardless of its lift. The Government rule and the Philadelphia rule take into consideration the actual amount of fuel burned on the grate, but the Massachusetts rule, as given in the table for determining the size of safety valves, arbitrarily fixes the amount of fuel with certain variations in pressure. (*Power,* vol. 44, no. 17, p. 587, October 24, 1916, 3 pp., 1 fig. *gc.*)

For the Cario formula for safety valves with high lift, the German police requirements, and a proposed improved formula see The Journal, August, 1915, p. 481).

Boiler Corrosion by Magnesium Chloride, James Scott

One of the substances occurring in water and either forming scale or directly attacking the metal, is magnesium chloride. This substance exists practically exclusively in a state of solution.

The primary sources of magnesium chloride are magnesium limestone (or dolomite) and magnesium carbonate (or magnesite), together with chlorine usually derived from the decomposition of animal remains. Such combinations can be carried dissolved in water for many miles. Rain in descending through the soil and sub-soil extracts these elements, which are then chemically resolved into magnesium chloride. This salt is particularly evident in sea water and spring water. Unlike other salts, magnesium chloride does not separate out of its solution by boiling; instead, when a solution of magnesium chloride is boiled, the salt is decomposed into its primitive constituents, magnesia and hydrochloric acid or chlorine, and that is what gives it the dangerous power of attacking the boiler shell. If a solution of magnesium chloride be heated or evaporated, there remains a white film which is practically magnesium oxychloride. This, too, at once begins to dissolve in the moisture it draws to itself.

When magnesium chloride held in solution in boiler water is heated, its magnesia combines with the oxygen of the water and releases the chlorine, which is expelled above the general surface and combined with the hydrogen of the ascending vapor, thus forming hydrochloric acid, which immediately on contact with the metal begins the process of corrosion.

To obtain magnesium chloride in a more stable condition it is necessary to mix with it another salt such as ammonium chloride (sal ammoniac). When magnesium chloride is present the boiler plates above the water line and the condenser tubes are the parts most likely to be affected. Usually the continuous attacks form a brownish-red ferric chloride, which is capable of crystallizing when quite pure. It resembles rust in color. There is, however, an intermediate stage in which the salt occurs as red-green crystals, which merge off into shapeless brown-green particles.

This particular corrosion would be conspicuous were the boiler emptied and the metal dried. As a rule it remains in solution, being then really even more active in an objectionable sense. The disturbed metal finally wears down into a fracturable state.

If given an opportunity the magnesia would settle as a white powder, but only a chemical test can distinguish it from lime, which is similar to it to the naked eye. A good test is to add to a solution of magnesium chloride a little silver nitrate. An insoluble precipitate of silver chloride is then formed, which turns purple or black in daylight. (*Railway Engineer*, vol. 37, no. 441, p. 235, October, 1916, 3 pp., 3 figs., *g.*)

New Fremont, Ohio, Power Plant, Warren O. Rogers

The new power plant of the Ohio State Power Co., near Fremont, Ohio, is practically completed. In the turbine room there are three 6250 kv-a. 4000-volt turbo-generators. The steam pressure carried is 250 lb., superheated 125 deg. The main turbines are operated without providing an atmospheric exhaust in case the vacuum should be lost. The turbines and condensers are protected against excessive steam pressure, in case of the vacuum falling below about 8 in., by a specially designed balanced valve, automatically controlled by the vacuum in the discharge outlet of the turbine. The operation of the valve is simple, the vacuum acting against the pressure of a spring. The vacuum acting on a diaphragm holds the valve open while the turbine is running. The spring holds the valve closed when the turbine is not running, or in case the vacuum falls below that necessary to hold the valve open. In order to start the turbine, the condenser air pump must be got up to speed so as to create a vacuum sufficient to open the automatic valve. If the vacuum is lost, the valve immediately stops the flow of steam to the turbine.

Each boiler furnace is equipped with a four-retort underfeed stoker. In the general design of these stokers, an improvement has been incorporated in that an automatic self-cleaning clinker attachment has been applied. It consists of a revolving ash grate operated by a ratchet, the speed of which is adjustable so that any desired regulation can be made to the movement of the cleaning device.

A network of piping for the condenser system has been eliminated by putting in a simple system by which the turbine driving the condensing apparatus receives steam from the 8-in. steam line that supplies the main turbine through a 1½-in. steam pipe that is tapped into the main line above the throttle valve.

Operated in connection with the steam units is a water-power plant containing three 4000-volt three-phase 60-cycle generators, driven by a 1900-h.p. water turbine operating with a 40-ft. head. (*Power*, vol. 44, no. 17, p. 576, October 24, 1916, 7 pp., 13 figs. *d.*)

Varia

The Employment of Women in Great Britain

The data in the article abstracted here are taken from a book entitled Credit, Industry, and the War, containing reports and papers presented to the Section of Economic Science and Statistics of the British Association at its Manchester meeting in 1915.

It contains the results of inquiries arranged by the same Section during the current and past year, and is of particular interest because of the great care taken in the carrying out of the investigation.

As regards the work of women under war conditions, the committee which dealt with this subject writes:

"Summing up on this whole question of the extent of the replacement of men by women, it may be said that only in rare instances are women actually to be found performing the same work as was done by highly trained and specialized men. In general, the employment of females is confined to work of a repetitive or routine kind, the degree of skill necessary for which can be acquired after a short period of training. But the ability which has been shown by women on such work shows that, under different conditions, they might be able to do much more responsible work."

TABLE 6 EMPLOYMENT OF WOMEN ON SCOTTISH RAILROADS

Company.	Number of women employed before war.	Number employed since August, 1914.	Total number now employed, Oct. 30, 1915.
A	733	451	1,184
B	393	265	658
C	120	30	150
D	41	27	68
E	473	205	678
Total	1,760	978	2,738

SCOTTISH RAILWAYS AND THE EMPLOYMENT OF WOMEN

Dealing with the replacement of men by women in industry, the committee report appeared in Table 6 in regard to the Scottish railways.

"From statistics supplied by companies A and B, it is clear that the numbers have largely increased since October 30, 1915, and it may be accepted that the employment of women has advanced by 100 per cent from what it was before the war.

"The following figures may be given as making clear the general position in the railways:

COMPANY "A."

Department.	Women employed previous to war.	Number employed since outbreak.	Total number employed on May 8, 1916.
Accountants	14	7	21
Audit	23	4	27
Canal	4	5	9
Coaching	175	346	521
Joint line	7	...	7
Engineering	4	4	8
Factors	4	...	4
Goods	47	103	150
Head office charwomen	67	...	67
Hotels and refreshment rooms	246	58	304
Laundry	56	7	63
Locomotive	7	25	32
Solicitors	4	1	5
Stores	18	29	47
Telegraph	57	50	107
Total	733	639	1,372

"'Coaching' is the only department that relates definitely to transport: it comprises ticket collectors, booking clerks, carriage cleaners, and porters. Of these, carriage cleaners and booking clerks are the only grades not included in the agreement come to on August 16, 1915, between the companies and the National Union of Railwaymen: there were women carriage cleaners before the war, and there were a few booking clerks. Other grades are paid at the minimum rate paid to men: in one company the carriage cleaners are all paid at the old rate—12s. for a working week of fifty-four hours, with a war bonus of 3s.; while in another they are now paid the minimum men's rate. The same applies to booking clerks in the same companies. But ticket collectors and porters are paid all over at the minimum rate at the men's grade, the former receiving in a representative company 21s. per week, with a war bonus of 4s. In the "A" company there are now 54 women serving as ticket collectors; in the "B" company, 57. They work the same hours as men, and have early and late duty. In company "A" there are now 93 women porters, in "B" there are 58. These are said to be largely drawn from the class of women accustomed to heavy work, such as farm servants and fish girls; while the ticket collectors and booking clerks are drawn from warehouses and shops. There is a large demand for work in connection with these two railway companies that have their headquarters in Glasgow. In company "A" there were 58 women carriage cleaners before the war; now there are 191. They work from ten to eleven hours per day, with two hours off for meals; the working week is six days. At one station there are day and night shifts; elsewhere there are day shifts alone. The quality of work done is stated to be as good as the men's, but the quantity is not the same, especially that in the inside of the carriages. In company "B" there were 31 women carriage cleaners before the war, while there are now 115 (May 31, 1916). They work ten hours, less two meal hours, taking early and late duty alternately. At present they have no night duty. The quality of their work is said to be an improvement on the men's, but the quantity is a little less. Twenty-four are now cleaning the outside of locomotives 'to the satisfaction of the company.'

"Opinions differ as to the work of women on the railways. One authority of wide experience expressed his conviction that three women are needed for every two men employed in a work like carriage cleaning—not that three women would take the same time as two men, but two women would not suffice, and a third would need to be employed. The same authority also held to it that women could not, for physical reasons, work the same hours as do men in strenuous employment; and would prefer, as experience had taught him, shorter hours and less pay. But others again stated their conviction that what women lacked in quantity of work they made up in quality; and expressed their surprise at the amount of work women could get through, if they had sufficient wages to feed and clothe themselves properly.

"As in the case of the tramways, time is needed to show whether women can undertake the same hours and duties as men as carriage cleaners, ticket collectors, and booking clerks; or whether changes must be made to allow of their partial employment. It is hardly likely that they will wish to continue as porters; the work is too heavy even for the few.

"Women were admitted to the Railwaymen's Union two years ago, and 'quite a few' have joined." (*Railway News*, vol. 106, no. 2752, p. 401, September 30, 1916, 2 pp., *gs.*)

It is announced that the six leading engineering societies of the German Empire, with a collective membership of about 44,000, have amalgamated "for the purpose of confronting the great new tasks which now so urgently require to be coöperatively solved." The new association will be known as the Deutscher Verband technisch-wirtschaftlicher Vereine.

Detecting the presence of internal defects in iron and steel castings is accomplished by a current which is supplied from a small alternator to the primary of an induction coil, and which induces in the secondary a current which is passed through the coils of two horseshoe magnets mounted at a fixed distance apart and movable to and fro over the surface of the casting. The fields of both magnets will be affected uniformly if the structure is homogeneous. Defects, however, will disturb the lines of force from the nearest magnet. In a vibrating sounder, connected to a secondary coil on the magnet, the tone produced will differ in pitch from that given out from the corresponding sounder on the other magnet. Amplification of sound is secured by microphone attachments, enabling the observer, by means of telephone receivers, to detect the locality of hidden flaws as the magnets are moved over the casting.—*Mechanical World*, Oct. 6, 1916.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

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